

# Interaction for crisis: a review of HCI and Design projects on climate change and how they engage with the general public

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Climate change is arguably the most urgent crisis of our lifetimes, and the Design community has been continuously exploring how to respond to this complex challenge. However, the past few years have demonstrated just how difficult climate change communication and engagement can be. As a response to the Anthropocene challenges, HCI and Design researchers have been debating the need for a shift from user-centered design to more inclusive, multispecies perspectives that also focus on systemic change. This is, therefore, an opportune moment to question how Design researchers have been approaching climate change and its interaction challenges, supporting the discussion on where the field should go. We present a literature review of HCI and Design research projects on climate change that target the general public. The result is the analysis and discussion of a corpus of 74 projects through the grounded theory review method. From our findings, we propose implications for design that take advantage of diverse interaction strategies and hope to inform future applied research on this pressing topic.

***Keywords: Human-computer interaction; Design; Communication; Interaction; Visualization; Literature review; Sustainability; Climate change***

## 1 Introduction

In recent decades, our society faced many crises: from the financial crash to migration, from climate change to the COVID-19 pandemic. In the past year, the latter two have been constantly in the media, and both are the consequence of the Anthropocene, in which the impact of humanity on the planet is blowing back on us in catastrophic and unpredictable ways. They equally represent massive challenges for our society and for collective action, but also opportunities for better futures that

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require study and intervention from Human-Computer Interaction (HCI) and Design research. From philosopher Bruno Latour to science reporter Gaia Vince, many claim the COVID-19 pandemic is an opportunity to rethink how we respond to the larger climate crisis threats. Latour was one of the first to declare the pandemic as a “*global catastrophe that has come from within*” (Watts, 2020) but that it could “*lead us to experience a new Renaissance*” (Latour, 2020). As Gaia Vince puts it: “*How we respond to this unique opportunity could set our climate trajectory for thousands of years to come*” (Vince, 2020). These calls to action are echoing regulations in political institutions worldwide. The European Commission announced a New European Bauhaus “*to imagine and build together a sustainable and inclusive future that is beautiful for our eyes, minds, and souls*” (European Commission, 2021). The International Energy Agency (IEA) stated the pandemic is a once-in-a-lifetime opportunity to reboot economies and create new employment while simultaneously shifting to more resilient and sustainable solutions (IEA, 2020). Inspired by this context, we saw an opportunity to examine how the HCI and Design communities approached climate change.

This research is situated at the overlap of sustainable HCI (Blevis, 2007, 2006; DiSalvo et al., 2010; Fallman, 2008; Mankoff et al., 2007; Silberman et al., 2014; Wakkary et al., 2013; Yang et al., 2014) with climate change communication (Anderson, 2011; Chadwick, 2017; Corner and Groves, 2014; Dulic et al., 2016; Koteyko et al., 2015; Levine and Kline, 2017; Moser, 2010; Nerlich et al., 2010; Russill and Nyssa, 2009; Schäfer, 2012). Sustainable HCI is a broad topic that generally refers to designing systems that either reduce environmental impact, influence people or groups to behave and live more sustainably or assist in some form of climate action. Conversely, climate change communication aims to bring knowledge via experimentation about the phenomena, making them visible and actionable in everyday life. Common to these two areas is the social and political contexts that affect mobilization and the scale of interventions. The two fields are interrelated from an HCI perspective to how climate change communication can use (but is not limited) to the design of digital devices and services and the communication exposure and experience through digital media. Design emerges as an overarching discipline increasingly concerned with the design of digital devices, services or experiences, but also of the digital content used in multiple media to convey a message or simply afford interaction and promote engagement and delight.

This paper provides an overview of HCI and Design projects from the past decade (2010-2020) that tackle climate change communication and analyses some conceptual and practical choices. By doing so, we intend to understand how these fields are treating the topic, aligned with the latest recommendations regarding climate change communication, and discuss possible improvements and suggestions for future work. This survey will also help position recent research in the critical discussion around designing in the Anthropocene (Forlano, 2016; Light et al., 2017a; Nisi et al., 2020), decentering the human in design or non-anthropocentric design (Akama et al., 2020), the concept of nature-culture (Liu et al., 2019; Smith et al., 2017), and other perspectives that advocate for a shift towards systemic change and collective mobilization (Blevis et al., 2015; Brynjarsdottir et al., 2012; Forlizzi, 2018; Fritsch et al., 2019; Knowles et al., 2018, 2016). We found particularly pressing Knowles et al.’s (2018) call for HCI to “*orient around climate change rather than sustainability*”. As the theme of IASDR’21 proposes, this is the critical moment to “*reinvent design modes*”, not just in design theory but also in practice – to apply design research towards more inclusive, socially relevant, open and impactful interventions. An overview of what has been done in HCI and Design research will inform and influence future work in light of these proposed shifts in perspectives.

Throughout our selection and analysis of the corpus of 74 projects, we used the Grounded Theory Literature Review method (Wolfswinkel et al., 2013). Through this systematic process, we compiled a list of data by analysing the paper’s keywords and asking certain questions of the set. We then discussed these results and derived five implications for design: a) Choose topics based on impact and audience; b) Explore interactive engagement in daily routine places; c) Help the user take action by proposing actionable solutions; d) Positively frame the message with a narrative adapted to your audience; e) Explore alternative and more inclusive perspectives.

During the past decade, interest and focus on climate change-related research has risen considerably. For example, searching the ACM Digital Library for the term “climate change” returned 295 results before December 2009 and 2,282 results from January 2010 to December 2020. We decided to focus on how they approached the general public. Despite the aforementioned discussion about the merits of incremental versus systemic change, this audience has an important role in either approach as “individuals play a crucial role in driving wider social change” (Climate Outreach, 2021). With this in mind, our survey centres on academic projects targeting audiences outside academia. We argue that HCI and Design have a crucial part in helping diverse audiences interact with climate change related issues, be it in transforming complex data into understandable experiences (Moere et al., 2011; Nisi et al., 2011; Schneider et al., 2012; Smith et al., 2017), nudging behaviours (Barreto et al., 2011; Huizenga et al., 2015; Moere et al., 2011; Nisi et al., 2013), promoting community engagement/action and amplifying under-represented voices (Giusti et al., 2013; Le Dantec, 2016), fostering debate (Hesselgren et al., 2018; Mauri and Ciuccarelli, 2016), support individuals in pushing for systemic change (Dourish, 2010; Fritsch et al., 2019), or other forms of intervention.

## **2 Related Work**

### **2.1 Climate change communication and its challenges for HCI and Design**

Climate change is a human-made problem, and only global, systemic solutions can hope to mitigate its impact (IPCC, 2018; Wuebbles et al., 2017). This means that every group of society has its part to play, from individual citizens to major multinational companies, to governments. Therefore, it is paramount to question how this topic is being communicated and test new approaches if we find them lacking. Nevertheless, this is a very complex issue that represents a vast challenge. To understand the gravity of the situation, audiences need to be informed of this urgency and the science behind it, ideally accompanied with suggestions or resources to assist in action. However, the dire scenario can lead people to not see “a light at the end of the tunnel” and conclude there is no point in actually taking action (Beehler, 2019). We argue that it is our responsibility as Design researchers to assist these socially responsible messages through thoughtful interactions. Especially with such a complex issue with so many consequences, needed solutions and involved stakeholders, communication strategies like framing, storytelling, visualization, and so on, as well as the type of audience, medium used, context and approach, need to be carefully considered.

In recent years, most climate change communication has focused on increasing the amount of quality information around the topic, approaching communication as a transmission process where the facts speak for themselves. This approach relies on the idea that the data is somewhat self-explanatory and that the public will change their mindsets by merely being exposed to it (Nisbet,

2009b). Furthermore, this approach usually engages with an already informed public, the remainder either ignoring the information or reinterpreting it based on their beliefs or self-interests. Suppose specific recommendations or actionable steps do not accompany the alarming details. In that case, the audience might just accept the situation's fatalism and won't be propelled for action (Maibach et al., 2008). To successfully communicate scientific data, one needs to hold to the underlying scientific facts while simultaneously adapting the message to different audiences' values, attitudes, and perceptions (Nisbet, 2009a).

## **2.2 Framing climate change in Design and HCI**

Considering the urgent and global nature of the climate crisis, the discourse around climate change has mostly been one of urgency and in many cases “end-of-the-world” rhetoric (Beehler, 2019). Recent reports show that people are worried about climate change and see it as a serious problem (European Commission, 2019; Leiserowitz et al., 2019), in some cases even leading to anxiety and depression (Clayton, S., Manning, C.M., Krygman, K., Speiser, 2017; Knight, 2019). This highlights the importance of how we frame the message when planning interactions.

“Frames” are typically unconscious structures that offer perspective and salience that then influence judgment (Lakoff, 2010) and, ultimately, how the information is perceived (Nisbet, 2009b). Every time we are faced with a message, our brain triggers the systems of frames we associate with it and, therefore, the emotions connected with those systems. By solely focusing on the data of the current situation and how daunting the task is, the frames of “environment” and “climate change” are being associated with “fear,” “guilt,” even “dejection”. Presenting climate-change *“in a positive way it creates hope”* as opposed to communicating *“about it in a negative way it creates feelings of hopelessness”* (Corner et al., 2015).

As examples of framing in climate change messaging, we present two studies highlighting the proposition that audiences interpret scientific facts according to their political views and peer groups (Corner et al., 2015; Kahan, 2012). The first study examined how people with conservative political stances were less supportive of low-carbon energy policies when framed as solutions to climate change than when they were formulated as solutions for energy security or air pollution (Feldman and Hart, 2018). Another study about message framing in policy communication on climate change suggests that framing the message in terms of positive outcomes, or avoiding negative ones, is more persuasive (Bertolotti and Catellani, 2014). (Corner et al., 2018) also highlights the importance of framing by suggesting a focus on real-world ideas that are more relatable with the audience in question. Another factor to consider is people's need to feel efficacy to solve complex problems. Framing the issue as something solvable may be as important as a warning about the dangers (Mayer and Smith, 2019). The focus can lie on what becomes possible, not the perceived sacrifices (Tonkinwise, 2011).

Since framing is crucial in the way the audience approaches and interprets information, the way researchers are using it to address the general public is a relevant aspect to analyse in order to inform future work, especially in light of recent shifts inside the community, discussed below.

## **2.3 A shift in Sustainable HCI (SHCI) and Design for Sustainability (DfS)**

Concerns about sustainability, inclusion, the environment, and climate change have resulted in a proposed shift in SHCI and Design perspectives that needs to be considered. There has been a growing interest in the idea of decentering humans in design and posthumanism (Forlano, 2017,

2016; Smith et al., 2017). The field has been grounded on the concept of human-centered design, and it might seem counterintuitive to now advocate for non-anthropocentric design practices. However, these approaches do not intend to remove the human from the equation but consider a multispecies worldview that questions their interaction and cohabitation (Kobayashi, 2014; Light et al., 2017a, 2017b; Mancini and Lehtonen, 2018; Roudavski, 2020; Smith et al., 2017), moving humans from their view of superiority. The Anthropocene signifies new challenges and opportunities that require new perspectives (Bai et al., 2015; Haraway, 2016). Designers are now required to look beyond products to work on services, networks, and experiences that consider complex socio-technical systems (Ceschin and Gaziulusoy, 2016). These systems demand a shift from traditional design practices that focus solely on “the human” to inclusive methods with diverse perspectives. Smith et al. (2017) even suggest that this union of human-natural systems might be design’s greatest and most urgent challenge. Researchers are proposing plural and more inclusive avenues, like nature-culture (Smith et al., 2017) and more-than-human participation, for broader possibilities in participation and co-production (Bastian, 2017; Clarke et al., 2019), or decolonising design for more inclusive and plural research environments unshackled from current notions of “modernity” (Tseklevs et al., 2020; Wong-Villacres et al., 2020).

Furthermore, the complexity of the climate crisis cannot be mitigated by changing individual action alone (Project Drawdown, 2020). A growing faction of the HCI community argues that the onus needs to shift from the individual user to broader concepts and applications (Blevis et al., 2015; Brynjarsdottir et al., 2012; Dourish, 2010; Forlizzi, 2018; Fritsch et al., 2019; Hazas et al., 2012; Knowles et al., 2018, 2016). Diverse approaches are being debated, such as design futuring (Fry, 2019), sustainment (Fry, 2017), civic and participatory design (Clarke et al., 2018; DiSalvo, 2014; DiSalvo and Dantec, 2017; Le Dantec, 2016), transition design (Irwin, 2018; Irwin et al., 2015; Tonkinwise, 2015; Tonkinwise et al., 2015), focus on community and social interaction (DiSalvo, 2011; Lou, 2018), on collective action (Le Dantec, 2016), political mobilization (Knowles et al., 2014; Nardi, 2019), challenging current economic systems or pushing for other system changes (Boehnert, 2018; Dourish, 2010; Fritsch et al., 2019), to name a few. In 2018, Knowles et al. (2018) proposed a new vision for SHCI that is radical enough to actually affect the causes of unsustainability, advocating for the community’s focus on systemic change.

Besides the challenges that diverse, sometimes polar perspectives might bring to the table, this prolific activity represents designers’ interest in climate change and the continuous search for better applications. The challenge now comes in translating these theories into actionable design practice (Liu et al., 2019; Smith et al., 2017). It is then imperative to question how climate-related topics have been dealt with and discuss how they could evolve in light of these new theoretical perspectives. We propose to do so from a communication and interaction perspective.

### **3 Methodology**

We adopted the Grounded Theory Literature Review method (Wolfswinkel et al., 2013) to analyse HCI and Design literature on climate-change projects. Grounded theory (Glaser and Strauss, 2009), in which the method was based, has developed in the social sciences to rigorously analyse a particular set of studies to derive new themes, issues, or opportunities.

### 3.1 Work scope and data collection

The first stage focuses on defining the work scope by delineating the criteria for inclusion or exclusion in the corpus. Considering our focus, we restricted the search to academic projects on climate-change targeting users outside academia. The area of research centres on HCI and Design, and the interaction and communication approaches used in applied projects.

The data selection criteria were: (1) the project's research topic: climate change – for example, during our search, we came across the project Pixeldust (Drew and Drew, 2019), an interactive video that takes portrait images of people and creates animations. While it could portray personalities related to environmental topics, climate change is not the project's focus, so it was discarded from our listing. (2) the project's target-audience: a general public outside academia. Lifestyle change and system change both need to be addressed and the general public is also a propeller for social shifts, government influence and wider climate advocacy (Climate Outreach, 2021). (3) projects that have an interaction component, either through an artifact or in person exchange – we intended to analyse communication approaches so projects that are tools, systems or frameworks were excluded. Two examples: (Simpson et al., 2016) describe the prototype of a system that can potentially inform the environmental decision-making of non-experts. However, it was then in a prototype stage with no clear definition of its interaction features, so it was excluded from our set. Timestreams (Blum et al., 2013) was also not included as it is a tool for artists and serves as an intermediary in the interaction process, not as the final interaction output.

This study focuses on HCI and Design research so we decided to centre our analysis on the ACM SIGCHI proceedings, IFIP-13 Interact proceedings, the Design Research Society proceedings, The Design Journal, the Journal of Design Research, Design Studies journal, and She Ji journal. These sources were chosen for the high quality of the work, their comprehensive database covering computing technology and design, and their international representation.

We restricted the search to the last decade – January 2010 to December 2020. This parameter was added to make the results relevant and more useful for current and future work. The search was conducted through the search terms “climate change,” “climate crisis,” and “global warming”. These terms were chosen to focus the search specifically on climate change and not sustainability in general.

Our initial search returned the following results: SIGCHI: 395; Interact: 38; DRS: 102; TDJ: 58; JDR: 17; DS: 16; She Ji: 47. Each result was examined through its title and abstract to gather if it mentioned one or more HCI or communication project(s). If so, it was added to our list. We then refined this data set by analysing the papers to gather if the project(s) fulfilled the selection criteria. This refinement of the data and deletion of duplicates resulted in 74 final entries (Appendix): SIGCHI: 43; Interact: 9; DRS: 12; TDJ: 6; JDR: 1; DS: 2; She Ji: 1.

### 3.2 Analysis and presentation

This survey is intended to understand how particular projects on climate change tackled interaction and communication aspects. First, we analysed *what* topics they focus on. Then we asked:

1. *Who is the target audience – a) Children/Teens (up to c. 18 years old), b) Specialised (projects to help adults with a particular profession, for example, science communicators), c) General public (adults over 18 years old);*

2. *Where was the project applied (context)* – a) *Personal* (home context or personal/wearable device), b) *Institution* (e.g., museum, school, company), c) *Place of passage* (e.g., street, station, public park), d) *Virtual* (website, app, not bound to one particular location/institution);
3. *How was it applied (media used)* – a) *Physical* (tangible object or public installation) , b) *Digital* (app, web, or public display), c) *In person* (lab, workshop);
4. *What was the scope of the message* – a) *Microscale* (personal, local, regional coverage), b) *Macroscale* (national or global coverage);
5. *What was their framing* – a) *Negative* (loss outcomes: what will be lost or what will be the negative consequence of not changing; and avoid adverse effects: change to prevent loss or negative effect), b) *Neutral* (no particular framing, more a neutral exposition of the issue), c) *Positive* (gain outcomes: what can be achieved with change);
6. *How was this framing conveyed (what data or examples were used as message)* – a) *Data* (presentation or gathering of data), b) *Data visualization* (display of information through a visualization), c) *Examples* (presentation of information through examples, e.g., showing the consequences of an activity), d) *Analogy/Metaphor* (representing information through comparison, e.g., with a story or personification);
7. *Did they present straightforward solutions or actionable steps* – a) No, b) Yes.

The data was gathered by reviewing the full papers and analysed through “open coding” to identify the concepts of each article according to our questions. Later, these concepts were organized into categories through “axial coding” – to identify relations between the information and understand what clusters emerged. Moreover, we collected the keywords of each paper and examined their changes over time. With this step we focused on understanding the topics’ trends and their related theoretical frameworks (Fig. 2).

## 4 Findings

Based on the aforementioned analysis, we examined the data through varied visualizations (Fig.1, 2, 3). Here we present the findings from this process.

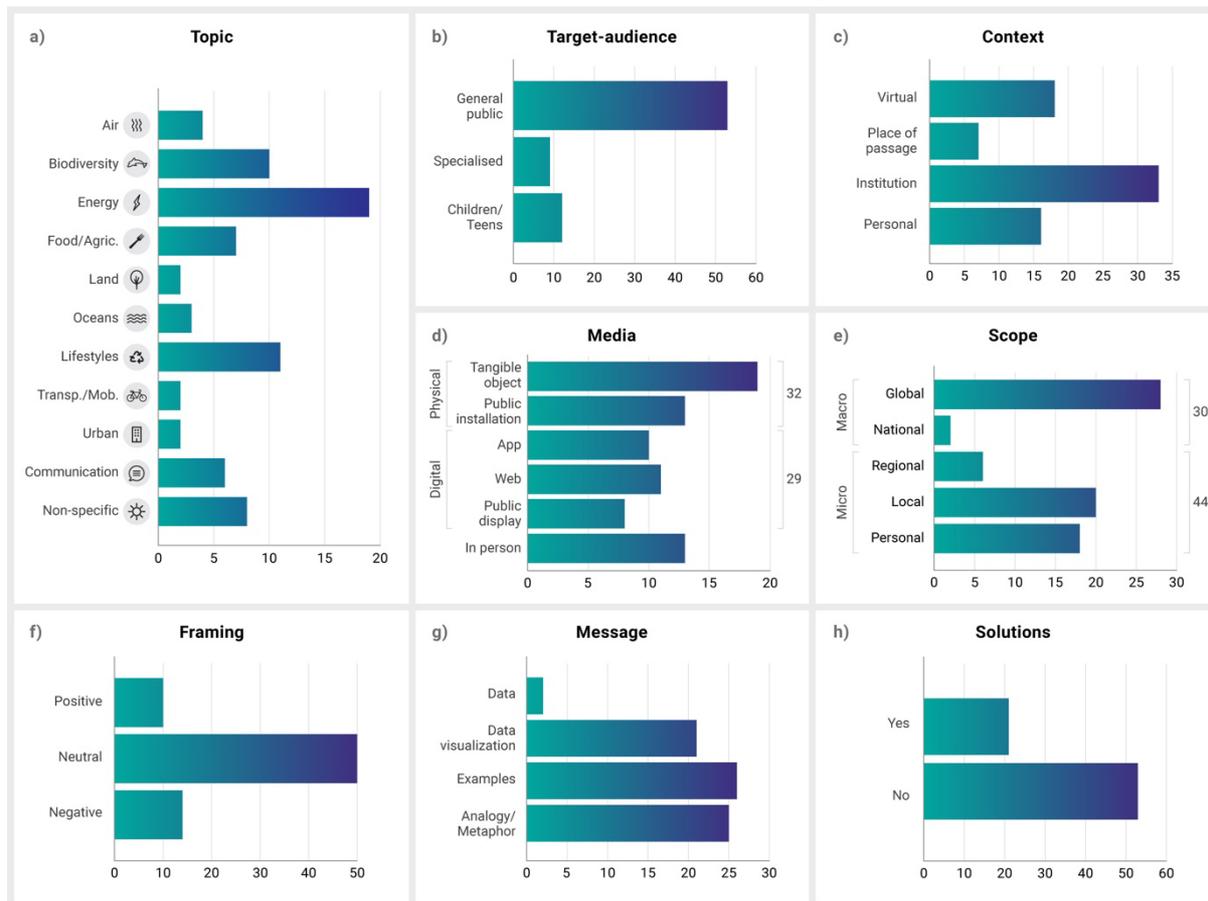


Figure 1: Data visualizations for each of the questions asked of the data set.

#### 4.1 Topic

From our analysis, eleven final topics emerged, distributed as follows (N=74, Fig.1a): a) *Air* (air pollution), n=4; b) *Biodiversity* (animal and plant conservation), n=10; c) *Energy* (energy consumption and production), n=19; d) *Food and Agriculture* (food production and consumption), n=7; e) *Land* (land conservation and management), n=2; f) *Oceans* (ocean and marine conservation), n=3; g) *Lifestyles* (sustainable habits and production), n=11; h) *Transportation and Mobility* (vehicles and infrastructure, mobility habits), n=2; i) *Urban* (sustainable cities and buildings), n=2; j) *Communication* (how the topic is communicated), n=6; k) *Non-specific* (projects that focus on climate change in general with no specific topic), n=8.

By further analysing these results, it became clear that the topics followed trends based on societal issues. The most explored topics are *Energy* n=19, *Biodiversity* n=10, and *Lifestyles* n=11. Noteworthy is their date distribution: fifteen of the *Energy* projects are dated from 2016 and prior, while eight of the *Biodiversity* projects are dated from 2017 onwards (three from 2020), and seven of the *Lifestyles* projects are from 2016 and onward (three projects from 2020). Earlier projects had a greater focus on energy consumption and eco-feedback, while in recent years there has been a shift towards biodiversity and sustainable living. It's essential to keep track of culture, societal issues, and technology's developments as these affect the field's evolution. Designers tend to follow "the wave of current times" and not "sit on the old", looking ahead to bring new themes to the foreground. However, this also raises the discussion about being mindful of the tendency to follow trends. Most

addressed topics might not be the most urgent or impactful, as also pointed out by the aforementioned call inside the community to focus on systemic change.

## 4.2 Target-audience, Context and Media

Regarding the target-audience, the projects were divided in (Fig.1b): a) *Children/Teens*, n=12; b) *Specialized*, n=9, c) *General public*, n=53.

As for the *context* in which the projects operated (Fig.1c), the result was: a) *Personal*, n=16; 2) *Institution*, n=33; 3) *Place of passage*, n=7; 4) *Virtual*, n=18.

Following the previous inquiry, we looked at how the interaction was performed in each project (Fig.1d). Considering we are analysing HCI and design projects, most of them have a digital component. We decided to make this media categorization by focusing on the most characterizing element. For example, some projects have a physical component (e.g. a statue or object) that is accompanied by a digital one (e.g. screen visualization), but we labelled them as physical projects. These were the results: a) *Physical – tangible object*, n=19; b) *Physical – public installation*, n=13; c) *Digital – app*, n=10; d) *Digital – web*, n=11; e) *Digital – public display*, n=8; f) *In person*, n=13.

## 4.3 Scope

The scope classification resulted in (Fig.1e): a) *Macro – Global*, n=28; b) *Macro – National*, n=2; c) *Micro – Regional*, n=6; d) *Micro – Local*, n=20; e) *Micro – Personal*, n=18. The projects tend to focus on climate change as a global issue or on personal behaviour and local issues. If we look at the dates, *Personal* projects are more prevalent up until 2016, with n=15 against n=3 for 2017 onwards. Meanwhile, *Local* and *Global* projects are prevalent in the second half of the decade, with n=8 / n=11 until 2016 and n=12 / n=17 for 2017 onwards, respectively. There seems to be a recent decrease in focusing on individual behaviour (*Personal*) which was influenced by *Energy* as a topic (n=11, with n=10 from 2016 and prior).

## 4.4 Framing, Message and Solutions

Concerning the framing of the interaction (Fig.1f): a) *Negative*, n=14; b) *Neutral*, n=50; c) *Positive*, n=10.

As for how this message was conveyed, we arrived at the following division (Fig.1g): a) *Data*, n=2; b) *Data visualization*, n=21; c) *Examples*, n=26; d) *Analogy/Metaphor*, n=25.

Following this analysis, we thought it was essential to gather if the projects explicitly presented or discussed actionable steps to help the audience in further action. If the paper didn't expressly describe solutions or steps, we considered it as not presenting them. The results were (Fig.1h): 1) *Yes*, n=21; 2) *No*, n=53.

By comparing these three axes – Framing, Message, Solutions (Fig.3a, Fig.3c) –, a primary cluster emerged: projects with a neutral framing that focused on examples or data visualizations, and that did not present actionable solutions. This result supports the idea that most projects present the facts and examples as the message itself and, in a way, expect the user to show interest in the data and search for practical actions themselves, as they are not part of the interaction. This *modus operandi* aligns with the approach discussed previously used by most media outlets – that the “facts speak for themselves.” For us, the particularly striking aspect is the lack of suggestions for future action. Even if the interaction stimulates the audience, most projects do not explicitly showcase

actionable paths to help in action. Furthermore, from the fourteen projects from 2020 (the most prolific year in our set), seven discuss steps for further action. It is too soon to tell if this “helping in action” is a trend, especially since 2019, for example, had no projects with this characteristic.

Another revealing result is that from the twenty-one projects that did present further steps, seven had a neutral framing, nine a positive framing and five a negative framing, four of which with a focus on avoiding adverse consequences. The fifty-three projects that did not showcase further action, forty-three had a neutral framing, and six had a negative, loss outcomes framing (four had either a “gain outcomes” or “avoid adverse effects” framing). These results suggest that the clear presentation of actionable steps goes hand-in-hand with how the interaction is framed.

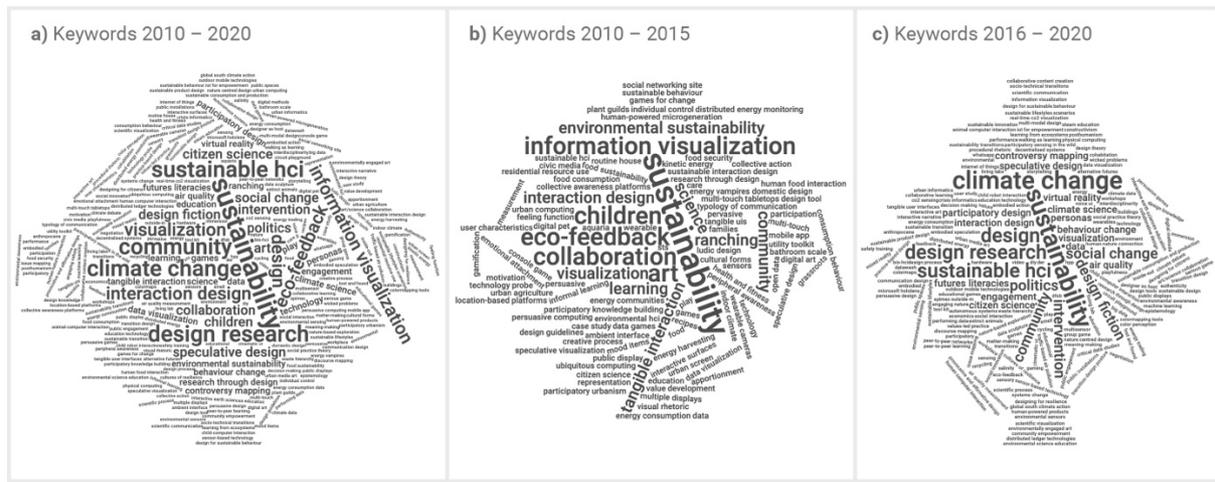


Figure 2: Data visualizations (word clouds) of the keywords gathered from the papers in the data set.

#### 4.5 Keyword analysis

Alongside the previous analysis, we gathered the keywords of the papers in our set, analysed their preponderance and compared them through the use of word clouds (Fig.2). Overall, “sustainability” is the most used keyword with  $n=17$ , followed by “community”, “design research”, “sustainable HCI” and “climate change” with  $n=5$  each, and then with  $n=4$  each: “design”, “eco-feedback”, “information visualization”, “interaction design”, and “visualization” (Fig.2a). Considering our focus on applied projects with an interaction component, most of these results are not surprising. Interestingly, comparing the result for “sustainability” and “climate change” highlights Knowles et al.’s (2018) call to orient HCI research on climate change rather than sustainability.

Going further, by analysing the first half of the decade against the second, we see some interesting variations. Up until 2015, “sustainability” is still the most used keyword ( $n=6$ ), followed by “art”, “children”, “collaboration”, “eco-feedback”, and “information visualization” with  $n=3$  each (Fig.2b). From 2016 onwards, “sustainability” has  $n=11$ , followed by “climate change” and “design research” with  $n=5$  each, “design” and “sustainable HCI” with  $n=4$  each, and then “community”, “intervention”, “politics”, and “social change” and “design fiction” with  $n=3$  each (Fig.2c). The comparison cannot be linear as there are more projects after 2015 (49 against 25 up until 2015) and the number of keywords varies between papers. Nevertheless, it is revealing that from the four “eco-feedback” keywords, three are from before 2016. This result sustains the previous result about the shift in topics over time and a bigger interest in energy and eco-feedback earlier in the decade.

Also, all five results for “climate change” are from after 2015. The emergence of keywords like “politics” and “social change” and the continuous interest in “community” (n=3 each) after 2015 points to a shift caused by new SHCI and DfS research perspectives (section 2.3). At the same time, the only two “behaviour change” results are also from after 2015, indicating that individual behaviour is still an area of interest for researchers. Different perspectives are being debated and explored hand-in-hand.



Figure 3: Extending on previous work (Ferreira et al., 2021) this image proposes a visualizations of the corpus of data from HCI and Design, comparing the projects framing of the communication with the types of messages, context and solutions (matrix a, b, c). Moreover, matrix d visualizes target audiences against the scope of the projects. Projects cluster around certain areas of the quadrants, highlighting patterns discussed in detail in section 5.

## 5 Implications For Design

Derived from the previous compilation of findings and comparison between dimensions (Fig.3), we now propose five design implications for future applied research in HCI and Design on climate change.

### 5.1 Choose topics based on impact and audience

Climate change is a very complex phenomenon requiring a diverse range of solutions. The relative clustering of attention around *Energy* especially, followed by *Biodiversity* and *Lifestyles* can point us towards a gap in the diversification of approaches.

Project Drawdown points out that some of the most impactful solutions receive comparably little attention, and there is a need to “look beyond the obvious, to a broader suite of solutions” (Project Drawdown, 2020). Access to high-quality, voluntary reproductive healthcare and high-quality, inclusive education, for example, are pathways with potentially significant impacts that are not explored at all in the projects we analysed. Furthermore, many of the most impactful solutions are related to the food system and land management (*Food and Agriculture, Land*), also areas with potential for further exploration. The HCI and Design communities are already actively debating these issues, for example combining climate-resilient food practices with more-than-human concerns, and proposing the extension of human-food interaction research (Davis et al., 2020; Dolejšová et al., 2020b, 2020a). The challenge lies in transposing these concerns into design practice, as well as finding impactful areas of application considering the huge challenge that systemic change represents. There is opportunity for future research in these less developed themes precisely because they can be less obvious to most users and communities and have the potential for significant impact. These alternative paths of exploration can also align with the proposed “positive” framing of the message focused on better user, community and social engagement.

### 5.2 Explore interactive engagement in daily routine places

Public displays can contribute to the “attractiveness and positive experience of urban environments” (Veenstra et al., 2015). Their usage can be amplified with interactivity, attracting more engaged individuals and groups, stimulating social interaction and positively affecting memorability (Alt et al., 2013; Veenstra et al., 2015). Furthermore, these public interventions can be harnessed to design for collaboration and community building (Harper et al., 2011), interesting possibilities taking into consideration the calls-to-action mentioned in 2.3. Despite many of the displays in cities being used for advertising, David and Chalon (2015) suggest that information provision, including climate related, would be more useful.

Taking this into consideration, since only two media *Public installation* projects in *Place of passage* context came up in our corpus, we see an opportunity for future research on climate change interactions to use public spaces like streets, public transportation, stations, shops, for example, where casual audiences are. In some of these urban settings, people are more idle, with available “mental space”, and so there is the possibility of triggering their interest in ways they are not expecting – interactive displays are effective in capturing the attention of passers-by and provide a high converting rate to actual user interaction (Parra et al., 2014). Also, waiting areas afford more detailed information to be transmitted (Bendinelli and Paternò, 2014).

Challenges posed by public interventions need to be considered (Bendinelli and Paternò, 2014; David and Chalon, 2015; Huang et al., 2008; Veenstra et al., 2015) as it is difficult to hold people’s attention

or ask the user to accomplish more demanding tasks. Still, there are recommendations to deal with these challenges (Brignull and Rogers, 2003; Huang et al., 2008; Müller et al., 2010). Exploring engaging, educational, and action-focused interactions in day-to-day settings can help narrow the gap with particular audiences.

### **5.3 Help the users take action by proposing actionable steps**

Considering the complexity of the issue and the multitude of pathways possible, it is essential to help the target-audience in their path to more sustainable habits, community engagement, collective action, or other forms of climate action, depending on the intervention's purpose. DiSalvo (2010) pointed out that HCI research on sustainability frequently relies on users' moral concerns and that it needs to find different ways to engage with them. We need to explore methods of engaging users, communities, corporations, political agents, through actions.

The great majority of projects analysed explore ways of presenting the facts, a crucial step in climate change interaction, but leave it to the user to then continue their journey if they are interested enough. With the multitude of information associated with this complex issue, we see the need for a more detailed presentation of actionable steps. HCI research in sustainability, including climate change, is a complex field that has sparked deep debate. The previous user-focused, individual behaviour change approach rooted in persuasive design is being contested for perspectives more focused on collective action, community politics, systemic change, more-than-human perspectives, and so on. Regardless of the approach taken, arguably the intention of these types of interactions with the general population is to spark their interest, educate, foster debate and instigate some form of action, be it individual or collective. We suggest making this process more effective by showcasing actionable steps that the user or group can take as part of the interaction.

### **5.4 Positively frame the message with a narrative adapted to your audience**

Accurate facts are the basis for good science communication, but they are not enough for effective public engagement (Corner et al., 2018). The significant cluster of neutrally framed projects is based on presenting examples or data visualizations. This indicates that most interactions from the set could be more effective if they framed the message in a more positive and actionable way (section 2.2) instead of just presenting information. Considerably fewer projects explored positive framing, propositions that can result in better engagement (Bertolotti and Catellani, 2014; Mayer and Smith, 2019). As suggestions for future work, we point to IPCC's recommendations (Corner et al., 2018): a) focus on the real world, not abstract ideas, to frame the message in a relatable way; b) be compelling by using stories more than statistics or graphs; c) connect with what matters to your audience – consider values and political views; d) include solutions on your narrative so the audience feels empowered instead of overwhelmed (Chapman et al., 2016). These suggestions can be used towards a more positive framing that works against the typical “doom and gloom” narrative associated with climate change (Beehler, 2019). Especially considering the toll that the Covid-19 pandemic represented to an already crisis-fatigued population, the framing of the interaction is even more relevant. (Webster et al., 2020) compiled findings and suggestions on how to communicate climate change during the pandemic, from which we highlight 6 particularly relevant for our discussion and the proposed shifts in the field: 1) Speak to altruistic community values; 2) Embed lifestyle change in the longer term; 3) Emphasise resilience, preparedness and support; 4) Build efficacy; 5) Highlight individual change as a part of wider social change; 6) Use narratives around ‘fairness’. Furthermore, audiences “filter” the information according to their values, beliefs, political

inclinations, etc., and these factors can become more critical in shaping their views on climate change than actual scientific accuracy. Therefore, if the intention is to engage with a possible uninterested or conservative user, for example, the interaction can be framed in terms of risk-aversion, security-related, or as a way to “conserve natural beauty” as these are essential features of conservative ideologies (Corner et al., 2015).

### **5.5 Explore alternative and more inclusive perspectives**

As discussed in section 2.3, the prevalent human-centered design regularly focused on individual action is being questioned in favour of more diverse, inclusive and impactful approaches. Our keywords analysis points to some applied research with a concern with “community”, and some limited concern with “participation” and “participatory”, “politics”, “collective”, “social change” and “transition”. However, there is only one occurrence of keywords related to systemic change (“systems change”), no keywords containing “species”, “inclusion” or “inclusive”, “decolonising”, “futuring” or “sustainment”. We find only one result for “posthumanism” and “cohabitation” from the same project, and another for “animal-computer interaction”. For keywords containing “human”, only “human-nature connection” points to these recently debated approaches.

From these results, we see the opportunity for design research to explore these theoretical perspectives in applied projects. There is prolific debate around approaches focusing on system change, nature-culture, nature-based, more-than-human, decolonising design, futuring, sustainment, among others, but the needed step now is to apply these concepts to design practice (Liu et al., 2019; Smith et al., 2017) and engage the public with them. In this study, we were particularly interested in interaction and communication, and there are many challenging pathways to tackle that Design and HCI could help develop. As mentioned in section 2.1, climate change related interactions to the general public are saturated with negative and often repetitive messages. These alternative perspectives could bring a much needed shift in the dialogue towards unexpected, more impactful and more inclusive interventions geared towards mitigation of the Anthropocene.

## **6 Conclusion**

This paper aims to create an overview of HCI and Design projects on climate change from the past decade, analysing how they dealt with particular interaction and communication aspects. We analysed a corpus of 74 projects focusing on the general public. We found that: a) topics follow trends over time; b) most projects have a neutral messaging (neutral framing, based on examples and data visualisations, with no suggestion of actionable steps for after the interaction). This analysis and findings informed the proposal of five implications for design: a) Choose topics based on impact and audience; b) Explore interactive engagement in daily routine places; c) Help the users take action by proposing actionable steps; d) Positively frame the message with a narrative adapted to your audience; e) Explore alternative and more inclusive perspectives.

This survey does not intend to be a definitive list of what has been done in these fields. We do hope to further the discussion about the current landscape of HCI and Design applied research addressing climate change, more particularly concerning communication and interaction approaches, and assist in the scholarly pursuit of new or less explored pathways.

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## Appendix

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*Idem*

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