"Down to Earth": Design Considerations for AI for Sustainability from the Environmental and Climate Movement

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Abstract

As the Earth's temperature continues to rise, increasing investments are being made to develop artificial intelligence (AI) technologies to address the current climate crisis. Through interviewing 19 participants—comprising climate and environmental advocates and developers of AI for sustainability in the US and Canada—we examine how advocates perceive and use these technologies, and how their perspectives converge and diverge from practitioners developing AI for sustainability. We identified three key findings: 1) while approaches differ, developers and advocates expressed care for people and the planet; 2) the developers' and advocates' values and perceptions of AI technology varied, especially around ethical issues; and 3) developers and advocates had distinct approaches to using and designing AI and digital tools. Our findings, guided by a climate justice lens, underscore the need for decision-makers to: engage with advocates from intended beneficiary communities early in the design process; prioritize the urgency of the climate crisis; and emphasize the tangible environmental and societal impact of digital systems.

CCS Concepts

• **Human-centered computing → Empirical studies in HCI**.

Keywords

Climate, Sustainable HCI, AI for Sustainability, Community Organizers, Environmental Justice

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1 Introduction

According to recent headlines, we are approaching a "golden age of Climate AI" [52]. In fact, "[c]limate tech start-ups built around AI raised US$1 billion more in the first three quarters of 2024 than they did in all of 2023" [39]. However, front-line communities experiencing the impacts of the climate crisis are rarely consulted about these technologies [27, 35]. Human-computer interaction (HCI) literature has shown "AI for social good" initiatives can reinforce harmful gender [48], racial [93], and ableist stereotypes [46]. Recent studies have also shown that AI for sustainability is not immune to these concerns, as it replicates patterns of surveillance and green-washing by large technology companies [41, 79]. A recent report on climate tech funding–encompassing AI for sustainability systems–revealed that existing funding structures and development pipelines are poorly aligned with the needs of climate justice, despite its crucial role in ensuring equity in tackling the climate crisis [28].

Advocates have always been central to shaping the agenda and priorities of the environmental and climate movement [74]. Their insights have revealed that traditional climate change data sometimes fails to meet grassroots needs [43]. As the climate crisis intensifies, it is essential to consider the perspectives of advocates, particularly those working with marginalized communities–often the hardest hit by the climate crisis–on emerging technologies aimed at supporting climate action. AI for sustainability has faced criticism for lacking climate justice consideration [28], highlighting the importance of including advocates in these discussions. Building on recent calls to engage with climate action in HCI [51, 58], we seek to understand how AI for sustainability design can incorporate perspectives from advocates.

We sought perspectives from both the advocates and developers, who are often studied separately [41, 43, 79, 117], to draw insights from different aspects of the AI and sustainability community. In this study, we define environmental and climate advocates as a diverse group of individuals working in environmental non-profits and grassroots activism. Developers refer to those involved in developing and conducting research in AI for sustainability, which we broadly characterize as AI technology aimed at addressing environmental or climate concerns. We conducted semi-structured interviews with nine developers of AI for sustainability and ten climate and environmental advocates. We specifically sought to: 1) understand the design and development processes of AI for sustainability from the perspective of developers; 2) catalog the advocates' usage of digital tools—particularly AI tools; 3) explore motivations and goals of developers and advocates regarding AI for sustainability; and 4) identify design insights for AI for sustainability to align with the needs and realities of advocates if such tools were desired.

Our work reveals that current design processes used by developers often fall short in addressing the structural issues underlying the climate crisis (cf. [15, 16, 21, 43, 49]). Contextualizing our work within the literature on climate justice and sustainable and ethical

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AI development, we found that participants were commonly motivated by care for people and the planet, though advocates tended to link their concerns to broader social justice issues. Despite concerns about potential harms from the training and deployment of AI technology, concrete actions addressing ethical issues and the sustainability impact of AI were often ad-hoc or absent. Most advocates encountered friction when using digital tools and did not find AI tools meaningfully helpful for their day-to-day operations. However, many advocates saw the potential of AI to help speed up data-intensive tasks, improve understanding between human and non-human entities, and advance climate research.

Taken together, this work contributes empirical understanding of the perspectives on AI use in the environmental and climate movements. Situating these findings in the climate justice movement and literature, we discuss how current design tools struggle to reach developers of AI for sustainability due to systemic constraints and barriers. Focusing on those with decision-making power in AI for sustainability, we offer these design guidelines: (i) meaningfully engage advocates throughout the development process; (ii) acknowledge and prioritize the urgency of the climate crisis; and (iii) incorporate evaluation of environmental and societal impacts of their technology.

2 Related Works

We draw on research at the intersection of HCI and environmental justice. First, we look at the literature on the environmental and climate justice movements, emphasizing how they intersect with broader social issues. Second, we explore the current research and practices of AI for sustainability. Finally, we draw from literature on the environmental impact of AI development and recommendations to mitigate negative effects.

2.1 Environmental and Climate (Justice) Movements

2.1.1 Environmental and Climate Movement in the US. The modern environmental movement in the United States is largely credited to increasing pollution events in the post-war period and Rachel Carson's 1962 publication of *Silent Spring* [57]. These events helped usher in an environmental and conservation movement during the 1970s, marked by significant legislative advances such as the creation of the Environmental Protection Agency (EPA) [57]. During this era, communities of color began organizing for environmental justice, highlighting their disproportionate environmental burdens [74]. A pivotal catalyst for environmental justice advocacy was the 1982 protest by Black activists against a polychlorinated biphenyls landfill in Warren County [74]. Other communities across the US also advocated against environmental racism and injustice, like Chicago's Hazel Johnson, who spoke out about the "toxic donut" of factories and landfills surrounding her Black community [59].

Environmental justice developed through the late twentieth century, including seminal academic work documenting environmental racism [22] and formalized principles from the First National People of Color Environmental Leadership Summit in 1991 [108]. Environmental justice, prior to recent federal cuts in the US [44], was formalized by the EPA as "*the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment*" [40]. While the environmental movement and climate movements are closely related, they do have distinct focuses at times, with the former addressing environmental concerns, and the latter focused on climate change [95].

As the climate crisis has become increasingly urgent, as demonstrated through extreme weather events like Hurricane Katrina [95, 119], the environmental and environmental justice movements have become deeply intertwined with the climate and climate justice movements. The climate justice movement focuses on addressing the global climate crisis by "paying attention to how climate change impacts people differently, unevenly, and disproportionately, as well as redressing the resultant injustices in fair and equitable ways" [106]. The climate and climate justice movement in the US and Canada include demonstrations such as: Indigenous-led anti-pipeline protests [2, 77], Fridays for Future [68], climate strikes [98], Sunrise Movement [9], among others. Indigenous voices have also become increasingly centered in the climate justice movement [7, 76] urging reckoning with colonialism [115] and encouraging relationship-building and kin-centric approaches to the climate crisis [112].

Our advocate participants are rooted in this rich movement history. Additionally, our analytical framework and design guidelines are informed by environmental and climate justice literature, which emphasizes "equity in the distribution of environmental risk, recognition of the diversity of the participants and experiences in affected communities, and participation in the political processes which create and manage environmental policy" [94]. We orient our analysis around environmental and climate *justice* because it acknowledges the systemic nature of climate and environmental issues and how they intersect with other forms of social injustice.

2.1.2 HCI and the Climate Movement. The field of sustainable HCI (SHCI) aligns with the climate movement. Scholars in SHCI have called for more engagement with the climate movements [51] and for HCI research to "orient around climate change" [58]—a call that is receiving increased engagement and discussion as demonstrated by recent workshops [34, 67, 71, 83, 91].

Prior work in SHCI has engaged with climate activists and environmental nonprofits. Flawn and Soden [43] interviewed climate justice activists in Toronto on their data needs and practices, finding that data in grassroots climate organizations serve to aid collaboration between groups, administration of groups, amplification of data's reach, localization of relevant data, and designation that shapes who gets to participate in the climate movement. They highlight climate activists' role to "build autonomy, harness affect, and reframe how we understand climate data" [43]. Additional efforts have also involved the design of public-facing tools to make climate change data more actionable and personable [42] and to incorporate different types of climate knowledge [102]. Prottoy et al. [84] showed that Bangladeshi environmental justice activists often appropriated dominant technologies for their own use. In contrast, Wong et al. [117] conducted a study with people of color in the United Kingdom who participated in climate activism to inform the design of new, more inclusive platforms for climate activism recommending: technologies that address power relations; shift decision-making power to individuals; and use co-created, transparent algorithms to amplify content from people of color, personalize it for participants, and enable diverse storytelling to reflect values, address local concerns, and establish inclusive norms. Soden and Kauffman [103] argue that community organizations that aim to reframe issues like sea-level rise should consider larger justice issues using an environmental justice imaginary framing, requiring "prioritiz[ing] values of justice and equity over narrowly focused technical expertise."

We contribute to this line of work by shedding light on how SHCI and AI for sustainability developers can leverage insights from climate and environmental advocates to center justice in their work.

2.2 AI for Climate and Sustainability

As the climate crisis accelerates, so too has the interest in developing machine learning and AI tools to tackle the climate crisis. For instance, researchers from Climate Change AI [4] proposed areas of machine learning applications, such as forecasting electricity generation and sea level rise, monitoring biodiversity, identifying carbon sequestration sites, and estimating forest carbon stock [90]. Prior work proposed using AI to support climate risk assessments [96]. A recent workshop on data science for climate and social issues specifically focused on environmental justice, emphasizing the importance of integrating justice into climate mitigation and adaptation efforts [6]. AI technologies for sustainability galvanize interests from several academic labs (e.g., [14, 109, 110, 116]) and international organizations and investments [81]—including the 2024 Bezos Earth Fund $100 million AI for Climate and Nature Grand Challenge [45].

Recent work has started to investigate the usage of AI in climate and environmental advocacy. For instance, Cao and Jian found that the use of AI chatbots and VR could strengthen college students' environmental awareness and motivation for activism in China [23]. Eilstrup-Sangiovanni and Hall investigated the use of digital technologies for climate action campaigns by non-governmental and civil society organizations such as *Fridays for Future* [38]. The authors found that AI could potentially be used to draft campaign messages or tailor outreach strategies to maximize public engagement [38]. However, there are also concerns about AI-generated materials being "inauthentic" and the risks of overreliance on biased AI algorithms [38]. The real-world usage of AI tools in climate advocacy remains in its infancy, and the perspectives of committed climate and environmental advocates on AI are not yet well understood.

Prior work has also explored designing AI and technologies for audiences concerned with climate. For example, Deng et al. developed an interactive tool to help AI artists assess the environmental impact of their art process [31], finding that artists responded positively—often viewing it as a co-worker or assistant. Reyes-Cruz et al. [89], with input from environmental organization members, developed a personal citizen carbon budget app to deploy with the general public in the United Kingdom. This work uncovered ethical and fairness challenges, including potential surveillance of personal dietary and transportation choices. The authors also highlighted unintended consequences, such as incentivizing possible dishonesty in reporting. Furthermore, distributing carbon budgets without considering socioeconomic factors can limit access to sustainable lifestyles.

Other research has focused on the socio-political impact of AI for sustainability. Espinoza and Aronczyk examined the Data for Climate Action (DCA) campaign, which called for legitimate and safe public-private partnerships to use Big Data to respond to the climate crisis [41]. The authors found that many actors, primarily those within large NGOs, research institutions, and businesses, used "climate change... to maintain the legitimacy of Big Data" [41]. As Espinoza and Aronczyk [41] succinctly put it, responding to the climate crisis requires "a transformed nature of being; and this is not possible in a data-delimited commons, where sustainability is more likely to refer to the legacy of data-driven problem-solving than to the commitment to environmentally safe futures." Nost and Calven analyzed the political economies of climate AI through case studies of Microsoft's AI for Earth and the Rockefeller Foundation's 100 Resilient Cities program in New Orleans [79]. They posit that climate AI often "waver[s] from its stated goals of supporting climate adaptation, instead bolstering technology companies' reputation and technical prowess, furthering state surveillance at the expense of community adaptation, and fueling the climate crisis while diminishing adaptive capacity" [79]. They also highlighted how climate justice research exposes the social inequities embedded in the climate crisis, which are often overlooked by efforts in climate AI. Applying a climate justice lens reveals that AI for sustainability is not a neutral endeavor but one that replicates existing power relations.

We draw on this body of work and environmental and climate justice studies to provide design recommendations that incorporate environmental justice principles. These recommendations aim to tackle ethical issues and power imbalances in AI technologies developed for sustainability.

2.3 Considerations of Sustainability and Ethics in AI Development

While existing work continues to explore AI's potential *for* sustainability, recent studies examine the environmental impact *of* AI development, as it could undermine its positive contribution to sustainability work [64, 70, 72, 111]. The growth of AI models and training data sizes contributes to an exponential increase in computing power demand. For example, Strubell et al. [105] found that the estimated carbon footprint of training NLP models like BERT on a GPU is equivalent to a trans-American flight. Training of AI models is environmentally and financially costly, creating barriers to AI research and widening the AI research equity gap. The reproducibility crisis (the lack of open source documentation, codes, and datasets) in AI research further exacerbates the increasing environmental impact of AI [98], as researchers need to retrain existing models [97]. Besides the computing energy cost, the development of AI research also spurs an increase in new constructions of data centers that demand a large amount of water and electricity resources [47, 64]. While the environmental cost of AI is not central to this paper, our participants questioned how this cost affects the impact of the AI they developed and their decision to use AI or not.

Recommendations for reducing the environmental impact of AI, particularly focusing on those who develop and use AI models, have mainly been motivated by the energy-accuracy trade-off in AI algorithms, where small changes in algorithmic designs could lead to great energy savings [20, 70, 97]. For example, Brownlee et al. [20] demonstrated that a 1.1% reduction in accuracy could lead to a 77% reduction in energy consumption. Prior work urges practitioners to avoid aiming for minimal gains in state-of-the-art results by using large amounts of additional computing and data [53, 97]. There are also calls to include energy use and carbon footprint measurements alongside the model's accuracy results in research papers and AI leadership boards [53, 97, 105].

To facilitate standard measurements and reporting, scholars have developed calculators, with limited stakeholder engagement [50], for environmental costs of algorithm development and training, including the Machine Learning Emissions Calculator [61], a python package *experiment-impact-tracker* that also generates carbon usage statements for research papers [53], Code Carbon [30]—a Python package that tracks and visualizes power consumption, and *carbontracker* that predicts emissions before training starts [8]. With these calculators, the authors suggest that AI practitioners can be better informed and choose to run experiments with more efficient hardware (e.g., GPUs instead of CPUs for computing vision algorithms) and algorithm settings (e.g., random search instead of grid search when tuning hyperparameters) [8, 61, 105], train models in low carbon intensity time periods and regions whenever possible [8], choose cloud provides whose data centers use greener grids [61], and publicly release pre-trained models to save others the costs of retraining them [53, 97].

Despite efforts to nudge behavioral change in individual practitioners, existing literature in HCI sheds light on what ethical concerns practitioners consider in their workflows, the value tensions between multiple ethical issues they face in their work, and the barriers they face when considering and mitigating these concerns. Environmental impact remains a less-discussed concern, compared to concerns about fairness [33, 54, 114], transparency and explainability [72], and challenges in participatory AI [16, 72]. Widder et al. [114] conducted a survey of software engineers and found that only four out of 115 respondents expressed concerns about the environmental impact of their work. Focusing on AI experts and practitioners in a field more relevant to sustainability (disaster risk management and response), Moitra et al. [72] found that issues with bias in data, privacy and security, transparency, explainability, and accountability are the practitioners' primary concerns. Other research has also demonstrated that considerations of ethical issues and unintended consequences do not necessarily translate to behavior changes [33, 54, 82, 114], despite a wide variety of resources available, such as toolkits [118], checklists [65], value cards [101], and conference ethics statement requirements [12]. For practitioners in the industry, prior work has pointed out that practitioners often lack the power to challenge institutional incentives [54, 82, 86, 114]. Other barriers to behavior changes include the emotional labor of caring and financial and immigration precarity of AI workers [62, 114]. On the other hand, practitioners in academia face challenges from a lack of formal requirements and processes and a fast-paced publication culture [33]. Overall, prior work shows that a sociotechnical approach that contends with power is necessary to achieve a meaningful reduction in the environmental impact and unintended consequences of AI development [72, 82, 114].

We contribute to this body of research by providing insights into AI developers' and climate advocates' considerations of sustainability and AI ethics, showing how care for people and the planet shapes their motivations and perspectives on AI, as well as how these considerations influence their lived experiences with developing and using AI.

3 Method

We conducted semi-structured interviews with 19 participants to gain a nuanced understanding of the AI for sustainability development ecosystem and its perception and use within advocacy circles.

3.1 Participants

We recruited adult developers of AI for sustainability and environmental and climate advocates through personal networks, professional channels, interest mailing lists, and targeted recruitment. Participants recruited through public channels filled out a screener survey prior to selection to aid in choosing geographic and experience diversity. We chose to recruit both developers and advocates to take a multi-stakeholder approach to understand both the design process of current AI systems for sustainability and how advocacy and organizing take place today. This approach has been used before to understand the integration of AI in existing systems [55, 100] and how discussions of sea level rise differ between technical experts and advocates [103]. We also wanted to understand the perceptions and values of both groups to contextualize the current and future hypothetical ecosystems for AI for sustainability. We recruited participants in the US and Canada to recognize the shared geographic and political similarities between the countries [24].

We interviewed a total of 19 participants from the US and Canada, comprising nine developers (*D*) and ten advocates (*E*). There were a total of 18 interviews, with one interview involving two participants from the same organization. The developers included participants with diverse backgrounds in AI for sustainability, such as an undergraduate researcher, a start-up founder, a graduate student, a software developer for a climate technology company, and an industry researcher-manager. The advocates included a grassroots activist, a rank-and-file member and leader of an international climate movement, a local environmental non-profit employee and founder, and an advocate-aligned researcher. Additionally, some participants had overlapping experiences in advocacy and AI development, such as an advocate with a computer science background and a developer who created an online account advocating for plant-based food. Due to the sensitive nature of some of our conversations regarding direct actions and employment, in some cases, we have chosen to omit participant IDs from certain quotes to enhance privacy protection and to avoid linking specific participant details with their occupation. Participants were also given the chance to review their quotes and the paper before submission.

3.2 Interviews

We interviewed participants on Zoom and recorded both video and audio. We honored one participant's request to only retain the audio record of their interview. The study was deemed exempt by the first author's university Institutional Review Board, and each participant signed a consent form before the interview. Any clarifications or questions regarding consent were answered before the interview started. The first author conducted interviews using semi-structured interview guides intended to probe the participants' role responsibilities, perceptions of climate justice and environmental justice, and attitudes towards technology and AI informed by literature discussed in 2.1 and 2.2. The developer interviews also focused on the architecture and goals of their models and how sustainability appeared in model design. The advocate interviews included questions on what digital tools they used, how climate change was addressed in their work, and future goals of climate technology. The full interview guides are provided in the supplemental materials. Interviews lasted between 40 and 66 minutes, and after each interview, the first author memoed. Each participant was compensated with a $40 Tango gift card.

The interviews were transcribed with a mix of Zoom, noScribe [37], and OtterAI. The first author then manually reviewed and corrected the transcripts. Some quotes used in this paper were lightly edited for clarity and anonymity. The first and second authors met regularly throughout the interview process to engage in peer debrief and interview review; the first and third authors also regularly met separately to discuss interviews.

3.3 Analysis

The analysis of the interview data involved thematic analysis [17] using techniques from grounded theory [26, 73]. We analyzed the interviews together to gain a comprehensive understanding of the AI for sustainability ecosystem and used environmental and climate justice (2.1) as guiding lenses for our analysis. All authors initially coded the same two transcripts to confirm the method and approach, utilizing grounded theory's gerund and in vivo coding methods [92]. We divided up another seven transcripts to conduct individual in-depth initial coding. The first author used these nine transcripts to generate initial codes, which were reviewed with the third author. The first author conducted light initial coding for any new codes in the remaining ten transcripts. Then, the first and third authors met to finalize a code list based on the initial coding. After this step, all authors met to discuss and create a general thematic map to define and name themes that are presented in the findings [80]. The first author then produced a thematic map and a codebook, both of which are available in the supplementary materials. We then split up the interviews to be coded with the codebook using Taguette [87]. Another author reviewed each transcript, and additionally, all authors memoed on insights from the interviews. During this coding process, we iteratively added new sub-themes to the codebook. Finally, the authors met to resolve any remaining conflicts and to discuss insights from the coding.

4 Findings

In what follows, we outline the main thematic findings from our interviews with advocates in the climate and environmental movement and developers of AI for sustainability. Our participants expressed deep care for people and the planet as a motivator for their work (Section 4.1). They shared their perceptions of AI and technology, including the differing approaches to thinking about ethical dilemmas (Section 4.2). We then examine how these motivations and perceptions influence the actual usage of AI and digital tools, including ethical considerations involved in the design processes (Section 4.3). Finally, we report on advocates' visions for the potential of AI in their work (Section 4.3.3).

4.1 Care for People and Planet

Every participant we interviewed expressed concern about sustainability and the climate. Their recognition of the need for change in our world stemmed from diverse sources, including personal experiences with nature and academic backgrounds in conservation prior to transitioning to computer science. We report on why participants choose to work in the environmental and climate sector and the complications that come with their motivations. Their perspectives underscore the interconnectedness of social issues and solutions required to address the climate crisis effectively.

4.1.1 Caring As Motivation. For some, the issue of climate was deeply personal. As D04, who had an advocacy background, recounted:

> *"I think environmental issues and climate problems are some of the most pressing problems in the world nowadays. And I come from a country that suffers a lot from climate change issues and from pollution. So I really want to make a positive impact, whenever I can, either in my personal life or in my career or academic work."*

For many participants, working on the climate crisis was an intentional choice. D06 noted he turned down other work opportunities while job searching and said, "*if I didn't work on climate change, I would look back at this time and feel like I didn't do enough.*" For some, working in the environmental movement aligned with their interests and values. For example, after graduating from a doctoral program, E06 decided to work in an advocacy-aligned non-profit because,

> *"I really care a lot about people not being poisoned in their everyday lives. So I really wanted to do something with environmental health, studying chemicals that contribute to diseases [...] I definitely didn't want to work for a profit driven company. I didn't feel comfortable with that, like just from a values standpoint."*

Some participants, most often developers, got into the environmental and climate space without a specific vision of what environmental subject they would focus on. When building a start-up, D07 and his business partner "*wanted to work on ML for sustainability in some way*" but weren't "*coming in with a product idea.*" For some participants, environmental issues slowly became a part of their careers, even though these issues weren't the original focus, and they found the problem space interesting. D09, who originally studied physics, remarked how increasing digitization has made him "*interested in understanding what can we learn about climate*" over his career.

4.1.2 Caring for Wider Changes. While all participants recognized climate and sustainability as critical issues, some participants additionally observed that creating genuine solutions to the climate crisis requires substantial changes beyond our environmental practices. Climate justice is perceived to be a multi-pronged issue that requires social and economic structural changes.

> *"[This is] a symptom of a lot other issues we have [and] how extractive we are with our resources, how we don't value a lot of people's, especially marginalized people's, lives because they face the brunt of the impact from climate change. But the reason we don't do anything it is because we devalue those people. Capitalism continues to extract for the profit of very few... in addressing climate change, we really have to address the root of it, which isn't just an environmental problem." – E01*

E01 and other advocates involved in the justice side of the climate movement emphasized how climate and environmental issues were merely parts of the larger problem of how the broader society functions. This perspective reveals an interesting contrast with some developers' perspectives, who often framed environmental justice as a separate issue from the technical aspect of AI development. For example, D02 attributed the main responsibility of ensuring environmental injustice to the government, stating that it was up to policymakers to "*create better policies to ensure that people aren't receiving the adverse effects.*"

4.1.3 Motivating Emotions. Regardless of their motivations for working on the climate domain, most of the developers expressed how working on climate and environmental issues brought them emotional relief. D03 shared that they "*found it more fulfilling to work on a project in machine learning dedicated to this purpose than on some other purposes.*" D08 similarly said, "*... the best part [of]...work[ing on] climate [is that it] gives a lot of inherent stress relief.*"

Advocate participants shared additional emotions related to working on climate. For advocates, this largely played out with climate anxiety becoming a potentially debilitating feeling. E09 spoke to how anyone cognizant of the climate crisis can experience "*climate anxiety for the future, [and] climate grief [for] what we've already lost and might continue to lose.*" He continued on explaining how artists in the climate movement channel this feeling to make "*beautiful and inspiring [art to help] make the movement more accessible to everyday people.*" E05 additionally expressed how personal joy at protests can also entice others to join the movement, as it did for her. They explained how protests "*should also be a celebration of what we have to offer and what alternative narrative we're pitching to the world.*" Advocates highlighted how personal fulfillment and a deep connection to climate and environmental issues can be powerful motivators.

4.1.4 Barriers to Materialize Care. Participants also described roadblocks they faced in translating their care into practical work. For instance, ambition and work could conflict with the intent of working on sustainability. D01 described the difficulty in finding work during the pandemic, which led to their decision to pursue a degree in AI rather than a graduate degree in sustainability. Another participant noted that their employment and immigration status could be jeopardized if they joined a climate protest where participation could result in arrest. There were also worries that working on important issues that they cared about might not directly impact their loved ones. D04 expressed concerns that her research wasn't going to be accessible by people back home, that "*like... sci-fi movies, only those people who know the science can avoid the consequences [of climate change] and the people who don't know will suffer from it.*"

Caring about people and the planet was a universal motivating factor for all of our participants. Whether advocating, researching, or developing, they wanted the world to be habitable for future generations. However, individuals faced barriers when attempting to translate their care for people and the planet into career and work decisions. This tension underscores that while individual actions and care are essential, they are insufficient to address the climate crisis, which requires systemic changes driven by higher-level actions from policymakers and institutions.

4.2 Perceptions and Values about AI and Technology

In this section, we report on participants' perceptions and values regarding AI and digital technologies as a solution for the climate movement. We also explore participants' awareness of the ethical issues and potential harms associated with AI, while considering the necessity of addressing the climate crisis with or without technology.

4.2.1 AI as a Solution. Some developers viewed AI as a solution for addressing the climate crisis, emphasizing its potential utility and the sense of agency that developing solutions could provide. For example, D02 shared their thought process when choosing between earth science and computer science as their undergraduate major.

> "*I hadn't taken many earth science classes at that point, but it seemed to me like earth science was a lot about thinking about the problem and figuring out what's wrong. I didn't feel like that was something I could do long-term and I felt it could perhaps be not fun and kind of limiting and depressing almost. If I were to spend a whole career in earth science, it seemed like it was a lot of like, oh, stuff is not going well and let's measure how not well it's going. And so I thought about it and I thought, hey, I would like to create solutions to these problems. And so that's how I got into CS [computer science].*"

Participants with varied experiences with AI found the technology fascinating and inspirational. One of our participants, D05, who started her own company at the intersection of AI and media, described how she was able to use a custom chatbot of her late mother, who was an Islamic scholar. She remarked how, during the interview, it was "*Ramadan and there's people talking to this custom GPT, mostly because she was an example of somebody who believed in gender equity and her translation of the Quran was gender neutral.*" In other instances, these viewpoints sometimes veer into technosolutionism. Many of our developer participants perceived technology and computer science as their primary fields of passion and found climate to be an interesting problem space.

4.2.2 AI Ethics and Harms. Ethics emerged as a key common concern and was often conceived of as an abstract, perceived issue that was not grounded in a particular experience or project. Developers speculated on ethical issues, from data governance to bias created from absent data, but rarely made direct connections between these issues and their own projects. A number of developers mentioned ethics classes they had undertaken: D02 describing how his "*undergrad has done a decent job in introducing us to ethics and having it be something in our mind*". The advocates shared a range of views based on previous encounters of hearing about ethics and AI, anticipating the impact on their field:

> *"I like to imagine that people studying environmental health are going to take steps and try to use AI ethically and... that will not exacerbate existing disparities and disadvantages that certain communities face... with a long history of racism and sexism in biology and science in general, I always worry about those being exacerbated and expanded." –E06*

The idea of AI being "weaponizable" arose from the interviews. D06, reflecting on their early career several decades ago in natural language processing, found it at the time to be a "*fun, interesting set of problems [...] [c]ertainly not weaponizable*" compared to current-day large language models (LLMs). This contrasts with views expressed by E08, stating "*'dangerous' is absolutely one of these first words [about AI] that pops to mind.*" This concern also shaped E05's view, who speculated "*AI data [could be] weaponized against [climate activists] in the form of messaging that they encounter through ads or other platforms that will disillusion them from the movement,*" a concern that also impacted their actions—E05 would not use AI video services "*as a class solidarity piece [with video editors]* ." These types of perceptions prompt some advocates such as E02, who also worked as a full-time AI developer outside the climate space, to qualify their involvement in AI: "*AI is a dirty word... I don't like when [other advocates] people ask me what I do. I just tell them I'm in tech because I feel like if I tell them in AI, I have to explain my entire research and why what I do is not bad for the world.*"

Some advocates also perceived the use of AI and technologies in the climate movement as inevitable, despite their harms. E01 observed advocates could "*utilize these tools in order not to get left behind [and] be the victim of harmful uses of these tools.*" E02 similarly expressed that "*I am of the belief that we can solve climate change without technology if we really wanted to, but I also am of the belief that we won't,*" showcasing the advocates' ambivalence to AI and technology.

4.2.3 A "Down to Earth" Climate-centered Approach. Some participants emphasized a nuanced and problem-oriented approach to the variety of mechanisms it will take to combat the climate crisis. E04 highlighted that technology is only useful when it is "*down to earth*"–when it is useful for the on-the-ground frontline work like generating digital content. D01 mentioned "*how much like everything, AI isn't just gonna solve climate change. It's not like we're gonna deploy Vision from the Marvel universe and it's just gonna solve everything. So, I think AI can be part of the solution much like many other things.*" Most advocates, and some developers, remained focused on the climate crisis rather than technology. For example, E03 had spent significant time using AI tools, but emphasized that "*the only way we are going to solve the climate emergency is people taking to the streets.*" Many of the advocates expressed a willingness to use AI if it was found to be a useful tool, but it was not their main focus. E08 saw hope for AI to have "*interesting applications and... definitely save a bit of time but I don't see them as a sort of transformative usages that could actually really change the way we're working.*"

The problem-centric mindset towards the potential use of AI in the environmental and climate movement put care for people and the planet stays at the forefront of approaching the climate crisis. E09 highlighted the importance of resource allocations towards a climate-centered approach, proposing what if "*all the venture capital going into AI was going into energy instead?*" Focusing on climate as the problem also begets the impact technology has on the environment. D07 described this dilemma as "*[p]eople who work on AI and climate change have to reckon with how much carbon are we emitting in order to supposedly stop emitting carbon.*" Additionally, AI often promises solutions in the future, but advocates noted the immediacy of the climate crisis. As E09 points out, "*[w]e need immediate responses now, and mitigation to make sure [the climate crisis] doesn't get worse*", while D04 urged other developers to "*think more about [how] they can contribute to solving these immediate problems as a part of their work.*"

4.3 Usage & Design of AI and Digital Tools

This section reports on the lived experiences of our participants in developing and using digital and AI tools. We examine how advocates engage with digital tools–revealing the lack of practical use of AI. We highlight gaps in the AI for sustainability design process, where developers were often disconnected from the specific needs of users and considerations of the potential harmful impacts of their models. Finally, we present specific examples that reflect advocates' visions for AI tools in their day-to-day work, specifically for (i) accelerating data and time-intensive tasks, (ii) encouraging connection with the natural world, and (iii) supporting climate science.

4.3.1 Advocates' Use of Digital Tools and AI. Many advocates used digital tools in ways that promoted inclusivity, privacy, and networking (cf. [43, 49]). Participants used similar tools like *Action Network* [1] and *Mobilize* [2] to coordinate with large groups and less active supporters. Some advocates also used legislative tracking software to keep up with the latest updates from policymakers. We observed reliance on free software due to budgetary constraints. As E09 noted, "*we don't have this national org to give us paid access... so that's a lot of Google Sheets.*" Even for advocates who used specialized scientific tools like E06 and E07, they emphasized resource constraints and said, "*we're a nonprofit, we mostly stick with open source, open access stuff because there's a lower barrier for us to use it. All of our funds are precious.*" Other advocates were deeply concerned with privacy and security, especially those involved with

[1] www.actionnetwork.org
[2] www.mobilize.us

riskier activism activities. For example, one participant noted, "*anything that even has like a whiff of sensitivity*" goes onto private software or messaging platforms.

Several advocates also noted how they had tried using AI and digital tools to supplement their other digital practices but were largely disappointed by the results. E10 tried to integrate an app for collecting environmental data, but she had to drop the app because it was no longer maintained regularly:

> "*I was just like ripping out my hair because I am a busy person. I have a gajillion things to do. And the high tech world is not making it easy for me... I was hoping to use [this app] for many other things. And really all that I've been using it for is to enter data about our pollution reports and it's on our website, but now I can't do any of the other things that I wanted to do with it. So problematic.*"

A few advocates reported using LLM chatbots to help write reports or scan PDFs, but noted that the technology did not significantly impact their workflow, leading them to discontinue its use eventually. E08 described one AI tool as a "*glorified find function and not a full tool.*" Other advocates mentioned that they did not use AI because it did not significantly enhance their advocacy efforts. E09 said,

> "*A lot of the issues are political, and a lot of the things that we can quantify I can do in an evening with Microsoft Excel. I don't need to process massive amounts... [I] grab emission values from campuses and put them in a figure to compare them to each other. It's pretty simplified analysis of many summarized values. And maybe a machine learning model can make a more accurate emissions figure, but at the end of the day, that doesn't matter as much as me being able to show that to decision makers, this is bad. We need to get it to zero as fast as we can.*"

Overall, we found limited practical use of AI tools in advocates' existing workflows. In order for AI tools to be useful for environmental and climate advocates, the design process must consider their specific needs and constraints.

4.3.2 AI Design Gaps. Developers' AI design process was often ad-hoc and had limited considerations of ethics and edge use cases due to existing barriers like organizational constraints (cf. [54, 82, 86, 114]). For example, multiple participants mentioned that they cared about ethics, but their team or managers did not consider it a priority. D04 mentioned how "*my professor and my team [at the] lab were really focused on the [AI topic] itself.*" At times, ethics were only addressed towards the end of a project, prompted by external requirements such as ethics statements, which D02 described as a "*good exercise.*" Often, when building the models, the developers rarely considered possible malicious uses for a model. D02 shared that "*throughout building the whole thing [model] we're like this could be used for great things,*" focusing on the positive potential of the models.

Moreover, developers reported rarely engaging with the potential end-users or the wider impact of the models they were developing. Notably, only one developer directly partnered with a community organization using a bottom-up approach for climate resilience work. Another developer mentioned that while he valued community partnerships and involvement, it was ultimately not his role (but another department's) to liaise with communities. Several participants, when directly asked about connecting with potential users, confirmed they did not speak to potential end-users or intended beneficiaries. Sometimes, this was because the model was meant as an internal tool for very few users, or the model was thought to be so far upstream that the impact was hidden behind several layers. As D02 put it, "*I'm hoping that this model and models built on top of this model could help those people.*" Developers in corporate settings, who interfaced with end users and clients more than developers in research settings, often provided more concrete examples of ethical considerations in their work, such as privacy, encryption, data availability in lower-income areas, or trustworthiness of results. This may be because their users depend on their products for "*24/7 mission-critical applications*" (D09) or because of potential business liability concerns. When we mentioned some existing design tools for engaging with end users and ethical considerations of technology designs (such as the *Tarot Cards of Tech* [10]), participants were intrigued about using them for deeper reflections. As D07 noted, "*[t]hat's great idea we should do that.*

4.3.3 Advocates' Visions for AI. Considering the existing design gap of AI identified above, advocates shared their visions for what AI could practically help them with, namely: 1) expedite current processes already in action that require large amounts of data or time, 2) help communities connect with non-traditional entities, and 3) aid in climate science. These visions come with caveats, such as hesitancy around AI due to potential harms and ethical challenges, and instances where advocates did not find AI applicable to their work. We summarize the visions and examples in Table 1.

Many of the advocates noted they would want AI to take over data work that involved large amounts of manual work, emphasizing specific time-saving and data-processing benefits to their day-to-day work. For example, when identifying chemicals that might be harmful, E07 said, "*I see the most potential in AI and ML as sort of a screening tool, because there's far too much to process for individual people otherwise.*" E10 also noted that an AI tool could help a team better process data already in a clunky database. She observed

> "*if you can get [the government] to give you a data dump of everything they have in the database, you could have an AI tool go through that and you could ask questions and the tool would do that all the work for you because right now it has to be you know, a bunch of lawyers and maybe a couple technical people searching and reading a gajillion reports.*"

Another potential use of AI was connecting communities to natural entities. E08 envisioned how AI could be used to "*kind of hijacking that sense of connecting to something that's not human [like chatbots] and using it to get people to connect more freely with natural entities,*" like a river. E04 imagined "*a farming assistant [app], right in the field, being able to tell you how to do certain things.*" These examples demonstrate how technology and AI could be used to aid empathy and skill-building in the natural world [36].

Table 1: Advocates' visions for AI and examples

Vision	Examples
Expedite current processes already in action that require large amounts of data or time	Screening for toxic chemicals, combing government databases for environmental regulation infractions, developing localized environmental justice curriculum for teachers
Connecting communities to natural entities	Creating personas for natural entities to interact with community members, diagnosing issues in the field while for urban farming
Climate science advancement	Finding patterns in large climate data sets, modeling the future of a local watershed

Advocates also felt more comfortable with AI being applied to power climate science advancements compared to their advocacy work. E05 observed and appreciated how "*AI is already robustly used in science for spotting trends or axes of [climate] data that people wouldn't necessarily see themselves.*" E02 agreed by noting that "*better climate research leads to better climate activism, because more concrete results and more agreement amongst the scientific community is better for activists to organize around.*" In these cases, there was less hesitancy around applying AI as long as the results were trustworthy.

Many of these visions stemmed from advocates' aspirations for usable AI for their day-to-day work. For teams that are focused on the climate crisis and environmental concerns today, they need tools that come in the "*box pre-made*" (E10)—tools that are readily deployable and easily customizable to their needs. E03 also shared that if he were "*not retired, I couldn't be doing that [learning a new AI tool]*," since advocates often had limited time and resources to learn or adapt to new tools.

5 Discussion

Our findings highlight both climate advocates and AI developers' care for the environment and their motivations for working in the environmental and climate movement. Advocates especially emphasized the interconnectedness of the climate crisis with other social issues. When it comes to AI, participants were cognizant of its potential harms, though concrete considerations and actions addressing ethical issues and the sustainability impact of AI were often ad-hoc or absent. Many advocates experienced challenges with incorporating AI into their work and did not find existing AI tools particularly useful. However, they remain interested in AI's potential to accelerate data-heavy tasks, enhance understanding between humans and the environment, and advance climate research.

In this section, we discuss how current design processes of AI for sustainability fall short of meeting climate advocates' needs. We argue that designing for the climate crisis requires a climate justice lens that addresses systemic issues. Based on these insights, we offer design guidelines for AI developers working on sustainability and the broader AI for sustainability community.

5.1 Current Design Practices Are Not Enough For Climate Change Design

Our interviews revealed a disconnect between AI developers' aspirations for their models (4.1.3 and 4.3.2) and actual outcomes due to structural roadblocks (4.1.4). We highlight how this disconnect could be addressed using a justice-based approach to AI for sustainability.

Many of our developer participants had aspirations for their work to benefit advocates and communities facing environmental concerns [28], but few reported engagement with the end beneficiaries and existing tools for user engagement and reflection toolkits in the design process. This showcased the limited reach of design tools intended for developers like *Tarot Cards of Tech* [10], *Building Utopia* [1, 18], or *The Feminist Tech Card Deck* [60]. Similarly, while developers were cognizant of the environmental impact of AI development (4.2.3), none mentioned nor used existing tools ([8, 30, 53, 61]) to measure carbon or energy usage in their design process. Researchers have shown that using these tools in practice could introduce new algorithmic challenges [104]and have not been robustly evaluated with users [50]. However, developers clearly desire to better incorporate these design tools into their processes and engage in deeper reflection of societal impacts, beyond dataset fairness and user privacy (4.3.2) [28]. Design tools have the potential to provide support to developers, but future research in HCI should further understand the causes of the disconnect between practice and aspirations of design tools and attempt to bridge the gap.

Our findings (4.1.4) suggest broader structural forces such as organizational priorities, resource constraints, and pressures for rapid development present barriers for AI developers to consider ethics and implement existing tools meaningfully [33, 72]. In *Data Feminism*, D'Ignazio and Klein argue that the framing of ethical issues in technology development could lead to "locat[ing] the source of the problem in individuals or technical systems" [32], which maintains existing power imbalances that benefit those with technical expertise [103]. D'Ignazio and Klein [32] propose designing for justice (instead of ethics), which requires a systemic examination of power and challenges to power imbalances. This justice lens aligns with many of our advocate participants, who see the climate crisis as a part of interconnected social issues (4.1.2). Our participants advocate for a "down to earth" climate-centered approach that is grounded in a deep understanding of the problem and motivated by the problem itself (4.2.3). As Soden and Kauffman [103] point out, we must ask more localized and justice-oriented questions about the climate crisis and "mobilize alternate sort of publics around the issue." Our advocate participants' considerations of AI went beyond AI carbon emissions and engaged with larger systemic issues (4.1.2) and potential harms from using AI (4.2.2).

AI for sustainability presents a unique challenge due to its contradictory nature: it has a significant environmental footprint, yet at the same time, it offers possibilities for climate science advancement. As the dominant AI for sustainability practices reflect existing extractive and profit-driven power structures [41, 79], the HCI community has started to propose alternative high-level design frameworks that challenge the underlying economic growth-driven approaches [99] and consider more-than-human designs [25, 78]. Prior work has shown that using principles from sustainable HCI could lead to impactful technology [42]. While these frameworks guide us towards designing sustainably, we need to address the climate crisis more directly [58, 67, 69] and explicitly embrace an environmental justice lens [34, 36, 102]. An environmental and climate justice lens necessitates reframing technical issues as justice issues, with community empowerment at the forefront [103]. What might it mean for computing to design for the climate crisis, including human and non-human actors? Can we re-imagine how climate and environmental justice can be at the forefront of algorithmic design, not just auditing tools? We encourage fellow HCI researchers to strategize and develop design tools with the climate crisis in mind because our design tools are not enough for our urgent moment.

5.2 Design Guidelines: AI Design for a Planet in Crisis

> *"Artificial intelligence is reined in, and its computing power helps to optimize energy efficiency, maintain electricity grids, and generally advance climate solutions–and to free us from administrative tasks. Design is planet-centric, not human-centered."* – Dr. Ayana Elizabeth Johnson, *What If We Get It Right?: Visions of Climate Futures* [56]

To move towards a planet-centric future centering environmental justice in the design process for AI for sustainability, we propose three design guidelines that draw inspiration from the climate and environmental movement principles [58, 108]. We target our design guidelines towards decision-makers and project leads who often possess more power over important design choices, acknowledging that AI developers are constrained in the design choices they can make [62, 72] and the implementation barriers they may face [88]. Additionally, we note these design guidelines require the AI for sustainability community to reckon with its own embeddings in an unequal system [41, 79].

1. Engage advocates who represent intended beneficiaries in design and conversation. Recent work emphasizes the importance of co-designing with climate organizers [43, 117], yet existing practices in AI with sustainability often leave communities and advocates out of early decision-making stages of projects [41, 79]. The environmental justice principle of "the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement and evaluation" [108] is particularly relevant and can be applied to the development of AI for sustainability. AI developers should meaningfully engage with those most affected by the problem before attempting a solution, to ascertain if AI is the necessary tool to address the problem in the first place. Developers with significant decision-making power (e.g., managers or start-up founders) could start applying existing tools for engaging with communities in the design process, such as scenario cards as mentioned earlier [10, 18, 60], AI design frameworks for engaging with communities [63], or more general design principles for technologists [5, 11, 29, 75]. One developer participant mentioned that collective learning opportunities, such as reading groups, have the potential to lead to a wider cultural shift in their teams or organizations, especially for developers facing structural barriers to consider ethical frameworks [33, 54, 82, 86, 114].

2. Design for the urgency of the climate crisis. Our participant advocates underscored the urgency of the climate crisis and demanded solutions that work for them *now* [113]. However, AI solutions often contend with predictions and are developed as proofs of concept that might be useful in the future. While working on AI for sustainability could provide short-term emotional relief from climate anxiety (4.1.3), AI developers should confront the urgent nature of the climate crisis and consider whether the systems they are building could contribute to climate action now and immediate emission reduction. Developing tools that expedite current processes that require large amounts of data or time, build connections between communities and the natural world, and advance climate science research and communications are three tangible directions that our participants advocated for (4.3.3).

3. Build in evaluations of environmental and societal impacts. Over a decade ago, Mankoff et al. proposed that design projects "must be explicit about the potential for both direct and indirect impact" to make sustainable HCI projects accountable, [66]. We join calls to include quantifiable metrics on carbon emissions in AI for sustainability projects and publications [53, 97, 105]. We also encourage broader assessment metrics such as impact on advocates' time or ease of work, place-based approaches, and multiple modes of evaluation [85, 107]. In its best forms, AI for sustainability should remain clear in its objective and reflect this objective into evaluation: to ameliorate a planet already in crisis.

6 Broader Impacts: It's Not Just About Climate; It's About Everything

Our advocate participants highlighted that environmental and climate issues are symptoms of broader systemic issues that cause injustice. Many climate solutions mentioned by the advocate participants were rooted in policy solutions such as affordable housing, valuing people over profit, and following Indigenous stewardship of lands [95, 106, 115]. As Bremer et al. pointed out, "technologists cannot be expected to do the work of policy makers" [19]. In considering AI in the context of the climate crisis, we need to reflect on how AI can be helpful—if at all—in achieving these policy and structural goals, which are some of the most effective climate solutions. In many cases, AI cannot address the underlying systematic issues of the climate crisis [13, 84]. In service of driving meaningful structural changes, we must reframe our design goals to focus on the structural issues that communities have identified as most important. Drawing insights from advocates from the climate movements and AI developers for sustainability, this work proposes a climate justice lens as the way forward for AI for sustainability.

7 Limitations

Despite attempts at recruiting from a variety of sources, the diversity of our participants was limited. Our participants were based in the US and Canada. We also did not explicitly collect demographic data to reduce the burden of participation. However, to the best of our knowledge, our participants had mostly finished college or were in college. More representation from BIPOC communities most affected by the climate crisis would have strengthened our findings. Future work could intentionally focus on specific BIPOC climate and environmental advocacy [3, 22] to learn about how climate technology development can be done with the most marginalized. Additionally, future work could examine tensions within the climate tech industry and include more industry participants.

8 Conclusion

Our study reveals a significant gap between the design processes of AI-for-sustainability tools and the needs of climate and environmental advocates, if such tools are to be useful to their movements. This research was motivated by the first author's ongoing research on technology use by activists and their work at an environmental non-profit experimenting with AI tools, and by the second author's experience as a researcher and practitioner in AI and sustainability. Through interviews with ten environmental and climate advocates and nine developers of AI for sustainability, we found that current AI for sustainability development practices could engage more with design tools for equity or sustainability. Despite well-heeded hesitations and anticipations of harms and environmental costs of AI, advocates retained a vision for AI for sustainability. To reorient AI for sustainability in addressing the structural issues underpinning the climate crisis, we suggest a justice-oriented approach to AI for sustainability design that connects developers with design tools and centers community empowerment. We propose design guidelines that encourage decision-makers to engage advocates impacted by their work, build for the urgency of the climate crisis, and create tangible climate action goals for their work. Future work could develop climate justice design tools for AI-for-sustainability practitioners, explore barriers AI for sustainability developers face utilizing AI ethics frameworks, and expand planet-centric design principles.

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