CLIMATE INNOVATION AND TECHNOLOGY: COMMUNITY PERSPECTIVES ON ADVANCING SOCIAL EQUITY

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A Research Paper Submitted to the School of Computing Faculty of

Middle Georgia State University in

Partial Fulfillment for the Requirements for the Degree

DOCTOR OF SCIENCE IN INFORMATION TECHNOLOGY

MACON, GEORGIA

2023

Climate innovation and technology: Community perspectives on advancing social equity

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Abstract

Climate change is an existential threat that disproportionately impacts structurally marginalized communities, exacerbating health, economic, and social inequities. It is an issue that requires structural changes across the global society and ensuring social equity considerations are incorporated regardless of climate action pathway. Despite its ultimately limited impact, one of the popular climate action strategies in the United States is technology-based climate innovation, which often does not include the voices of communities most impacted by climate change that it professes to serve. To that end, this project deployed a qualitative approach, using semi-structured interviews with 14 stakeholders in climate leadership positions, most of whom identified as women and BIPOC, through the thematic framework method, aiming to explore ways to make technology-based climate innovation more socially equitable. All interviews were recorded over Zoom and transcribed verbatim. Utilizing the thematic framework, data were coded that resulted in the following themes: (1) Enabling Action-Oriented Ecosystem for Climate Innovation, (2) Unintended Consequences' Accounting, (3) Accessible Participation, (4) Power Sharing and Equitable Decision-making, and (5) Diversity and Inclusion in Climate Innovation. These results serve as guiding principles for any stakeholder interested in equitable technology-based climate innovation. Implications for practice, the study's strengths and limitations, and concluding thoughts are also included.

Keywords: climate change, technology, climate innovation, social equity, community

Introduction

Climate change is the defining crisis of our times and an existential threat to life as we know it (Huggel et al., 2022; Iacobucci & Trebilcock, 2022; Kumar et al., 2021). This is in part because of its role in operating at multiple levels across social, geographic, disciplinary, and sectoral boundaries and creating and exacerbating social and health inequities (Friel, 2022; Rudolph & Gould, 2015; Schmeltz, 2021; Smiley et al., 2022). The role of innovation as the key to climate action and response strategies — climate mitigation and climate adaptation (Landauer et al., 2015) — across the board has been well recognized (Matos et al., 2022; Zilberman et al., 2017). Specifically, the role of technology as the key component in innovation, including climate innovation, has been well-documented, debated, contested, and acknowledged from social, technical, economic, and so forth perspectives, over the decades (Geels, 2004; Grubb, 2004; Repetto & Austin, 1997; Sovacool, 2021). There remain considerable challenges to ensuring social equity — given that climate change impacts those at the margins of society the most — in technology-based climate innovation strategies since the intersection of climate innovation and technology is as crucial as it is overlooked from a social equity and justice perspective (Sovacool, 2021). A closer examination of technology-based climate innovation, hence, becomes imperative. This is particularly true given the centrality of technological transitions, defined as "long-term technological changes in the way societal functions are fulfilled" in human existence (Geels, 2002).

The Problem

Technology continues to be seen as the silver bullet to solve complex social challenges. Climate change is no exception. For instance, the United States government's techno-optimism — however fallacious — is best summed up by the U.S. Special Presidential Envoy for Climate and former U.S. secretary of state, John Kerry's comments at the United Nations climate conference (Glasgow COP26) that as much as 50% of U.S. climate action policy is relying on "technologies that we don't yet have" (Murray, 2021). This reductive thinking defying rationality is also reflected in the U.S. oligarchs such as Bill Gates' investments in climate tech (CatClifford, 2022), a critical perspective to note given the billionaires controlling the political and policy orientation in the U.S., including climate policy, through a variety of pathways such as philanthropy, business investments, and, most importantly, socially acceptable form of bribery and corruption: lobbying (Halper, 2022; Page et al., 2018). Whether one agrees or disagrees with techno-optimism — defined as "the belief that science and technology will be able to solve the major social and environmental problems of our times, without fundamentally rethinking the structure or goals of our growth-based economies or the nature of Western-style, affluent lifestyles" (Alexander & Rutherford, 2020) — it is here to stay despite the limitations of technologies and innovation (van den Bergh, 2013). Unfortunately, historically and contemporarily, technologies — digital or otherwise, across their innovation cycles — have not centered on social equity, and this ends up creating and furthering social, racial, and health inequities (Bozeman et al., 2011; Kavanagh et al., 2021; Storeng et al., 2021). This is also applicable to technology-based climate innovation, hence, necessitating a deeper examination and understanding of infusing social equity in climate innovation and relevant technologies.

The Purpose of the Study

This project aims to elucidate the ways to make technology-based climate innovation more equitable through social equity considerations and develop a set of guiding principles for technology-based climate innovation that centers social equity by engaging a diverse set of multi-sectoral stakeholders working in climate change, innovation, social justice, and public health fields. Some of these potential stakeholders include community leaders, federal climate leadership, state and local leadership, and private industry. These key policy-focused guiding principles identified in this study will also help decision-makers ensure that such interventions are rooted in social justice concepts and focused on dismantling structural inequities as opposed to just maintaining the status quo, by being inclusive of community voices from 'cradle to grave.'

Research Question

The key research question this project aims to answer is as follows: "*What are the ways social equity can be centered in technology-based climate innovation*?"

Literature Review

The role and necessity of climate innovation as the driving force and key strategy behind averting the climate crisis have been discussed for decades now (Paul, 1997), with the consensus, arguably, could be summarized as technology-based climate innovation being of "vital importance, but incomplete effectiveness" (Moscona & Sastry, 2022, p. 1). There is plenty of literature on climate innovation, climate technology, and even some at the intersection of innovation and technology; however, much of this exists disjointly. There is limited scholarship exploring the critical intersection of *climate innovation*, *technology*, and *social equity,* pertinent to this project's key research question. Relevant literature to the study research question is quite expansive and falls within the broader themes of international governance, patent-related

discourses, policy innovation at the institutional level, and climate innovation case studies from a breadth of disciplines, expressing the magnitude and scope of technology and climate innovation when defined broadly. Further, for the sake of this project, innovation is defined as "the introduction of something new," technology is defined as "the practical application of knowledge especially in a particular area" (Merriam-Webster, 2023), and social equity is defined as an approach where "community members can participate, prosper, and reach their full potential" (APA, 2023).

Within the global governance theme of climate innovation and technology, some of the key scholarship related to technology and climate innovation focuses on the United Nations Climate Technology Centre and Network (CTCN), an entity that exists "to support developing countries' climate change responses through innovative technologies to achieve the goals of the Paris Agreement." Scholars have highlighted the role of digitalization in climate technology transfers as an effective strategy facilitating innovation and CTCN's role as an "innovation matchmaker" on the global stage (Lee & Mwebaza, 2021, p. 1). Others have highlighted the need for strengthening public-private partnerships and collaborations within the UN infrastructure, such as CTCN, as the key to technology-based climate innovation, in addition to "technology–push and market–pull innovation" (Lee et al., 2021). Other scholars have called for establishing "climate relevant innovation-system builders" — defined as "key institutions focused on nurturing the climate-relevant innovation systems and building technological capabilities that form the bedrock of transformative, climate-compatible technological change and development" — in the so-called low-middle income countries, relying on other existing UN systems such as UNFCCC Technology Mechanism as a key strategy for climate innovation (Ockwell & Byrne, 2015, p. 836).

Some of the literature also highlights the role that patents play in technology-based climate innovation. Much of this literature points to patents being a hindrance to climate action and social innovation and "may block innovation and create barriers to the transfer of technology to developing countries" while inviting us to engage in a deeper conversation and re-think intellectual property rights (Correa, 2013, p. 54). Scholars have found patents to be a significant driver and incentive for innovation while also finding their influence on limiting the commercialization of relevant climate technologies, concluding "to restrict development and are perceived as an obstacle to climate change mitigation" (Raiser et al., 2017).

Considerable literature also exists on policy innovation and urban governance as a salient form of climate innovation, including as it relates to technologies. For instance, scholars have explored institutional innovation within the climate change adaptation of urban water governance in Santiago, Chile, as a form of climate innovation (Patterson & Huitema, 2018). Other examples include highlights of the local level governance innovation at the organizational and city level (Gordon, 2013), a comparative study highlighting trans-local climate innovation as an enabling but insufficient factor (Corcaci & Kemmerzell, 2023), and climate innovation opportunities bore by community level efforts in Mumbai, India (Boyd & Ghosh, 2013).

Some of the literature also shows certain technology-based case studies as highlights of climate innovation across the disciplinary spectrum ranging from agriculture to the financial development sectors. These studies include the wine production case study in Australia highlighting knowledge exchange as a climate innovation strategy (Galbreath, 2015), Indigenous innovation related to agricultural technology (Nzeadibe et al., 2012), technological innovation being "imperative to neutralize the negative consequences of financial development on climate change" (Jinqiao et al., 2022, p. 3940), technological innovation having "a significant negative effect on CO2 emissions" within the public-private partnership context related to energy investments (Ahmad & Raza, 2020, p. 30638), the need for "radical social-institutional changes for adaptation uptake and interventions" within the coffee production, especially for smallholders (Verburg et al., 2019), factors such as technological dynamism and specialized assets for commercialization informing corporate climate innovation (Pinkse & Kolk, 2010), the role of startups in climate innovation (Hakovirta

et al., 2022), and the liberal market economy of the U.S. hampering hindering climate action (Mikler & Harrison, 2012).

Despite the kaleidoscopic nature of the literature highlighted above, there is a severe gap in the literature related to highlighting community voices in technology-based climate innovation discourses. The limited literature and critique related to social equity highlight that innovation, as conceptualized and operationalized at the moment, is "severely limited by its exclusion of the roles of social knowledge and citizen participation" (Adkin, 2019, p. 603). Some studies highlight the challenges poor farmers face when it comes to new technologies (Lybbert & Sumner, 2012) and the men-centered nature of technological development that continues to ignore the voices of women, especially rural women (Milne, 2005; Skutsch, 2002). This review of the existing literature further highlights the urgency of exploring technology-based climate innovation from a social equity perspective.

Methodology

Data collection and participants

A total of 14 semi-structured interviews were conducted, between March 2022 and May 2022, with professionals representing expertise in climate change, innovation, technology development, public health, and community-engaged research and practice. A comprehensive interview guide (appendix 1) was developed, based on the literature and input from experts in climate technology, public health, and community leadership through two rounds of consultations. Additionally, the interview guide was pilot tested with three experts in the field, and their input on questions was incorporated into the final version of the guide used for this study. Interviews were conducted over Zoom, recorded, and transcribed using the transcription service rev.com. Study sampling took a non-probability, purposive sampling approach to recruit participants for the study. Participants were recruited from the Principal Investigator's extensive network as well as through snowball sampling. Additionally, in an intentional effort to reject positivist thinking and quantitative sciences' epistemological supremacy, the key metric for determining the number of total interviews was saturation which was closely observed throughout the data collection phase and is also supported by the existing evidence (Guest et al., 2006; Namey et al., 2016).

Data analysis

The philosophical approach to this thematic analysis was inductive and interpretive since the purpose of the study was to excavate the many challenges and solutions to centering social equity in technology-based climate innovation. Themes were developed and interpreted through a self-reflexive approach that was rooted in a critical iterative examination of the data from the onset of the data collection process all the way through to the analysis. Data analysis was performed using a thematic analysis approach based on Braun & Clarke's six-phase framework for conducting a thematic analysis (Braun & Clarke, 2006). Specific steps include the following: Step 1: Become familiar with the data, Step 2: Generate initial codes, Step 3: Search for themes, Step 4: Review themes, Step 5: Define themes, Step 6: Write up. The inductive coding process (Thomas, 2006) was used to develop themes manually with some assistance from the data management software NVivo (NVivo, 2020). Initial codes were generated through a combination of printed transcripts, NVivo, and the hand-typed interview notes that accompanied each interview transcript. These initial codes were closely examined and read in the context of the study questions while re-examining the transcripts in the process. These codes were then used as the foundation to generate the initial set of themes. Through an interpretive lens and iterative process that involved multiple rounds of examining, creating, and re-creating themes before finalization, these first-order themes were further consolidated into the second-order themes and eventually collapsed into the final set of themes presented in the results section. Finally, to ensure participant anonymity in reporting, participants' name initials were reversed, and a letter (a-n) was added

in the middle of the reversed initials. Further, when reporting quotes, quotes were slightly edited with filler words ('umms and ahhs'), noise descriptions ('laughs'), and repetitive words were removed from verbatim transcripts for clarity (Eldh et al., 2020).

Ethical approval and consent

Participants had an opportunity to read and sign an informed consent form (appendix 2) online before they proceeded with completing the sociodemographic survey and the interview (appendix 3). Participants were given verbal reminders about the Zoom recording, transcription, the utility of their de-identified quotations, and aggregated data in the presentation of the final results. The Institutional Review Board approval was obtained from the Middle Georgia State University (IRB approval#20221-K) in February 2022.

Results

The sociodemographic profile of the participants is listed in table 1. The majority of participants were below 50 years of age, identified as women, ~43% were racialized (self-identified) as white followed by 28.6% reporting as Black, majority (50%) had a global scope of work, and represented BIPOC serving organizations (~86%), and most represented the nonprofit (42.9%) or academic (35.7%) sectors.

Table 1: Sociodemographic Table of Study Participants (n=14)

Characteristic	**Percentage (Number)**
Age Range	
26-30	7.1% (1)
31-35	14.3% (2)
36-40	35.7% (5)
41-45	14.3% (2)
46-50	7.1% (1)
61-65	7.1% (1)
Over 65	14.3% (2)
Gender	
Woman	85.7% (12)
Man	14.3% (2)
Sex	
Female	85.7% (12)
Male	14.3% (2)
Racialized Identity	
Asian or Pacific Islander	14.3% (2)
Black	28.6% (4)
Other	14.3% (2)
White	42.9% (6)
Hispanic Identity	
Yes	14.3% (2)
No	85.7% (12)
Geographic Focus of Participants' Work	
Global	50% (7)
International (Non-U.S.)	7.1% (1)
United States	42.9 % (6)
Midwest	7.1% (1)
Northeast	14.3% (2)
South	7.1% (1)
West	14.3% (2)

Employment Sector	
Academia	35.7% (5)
U.S. Federal Government	7.1% (1)
Non-Governmental Organizations	7.1% (1)
Nonprofit	42.9% (6)
Private Industry	7.1% (1)
Participant Experience	
1-3 Years	28.6% (4)
4-5 Years	14.3% (2)
6-10 Years	7.1% (1)
Over 10 Years	50% (7)
BIPOC Serving Organization	
Yes	85.7% (12)
No	14.3% (2)

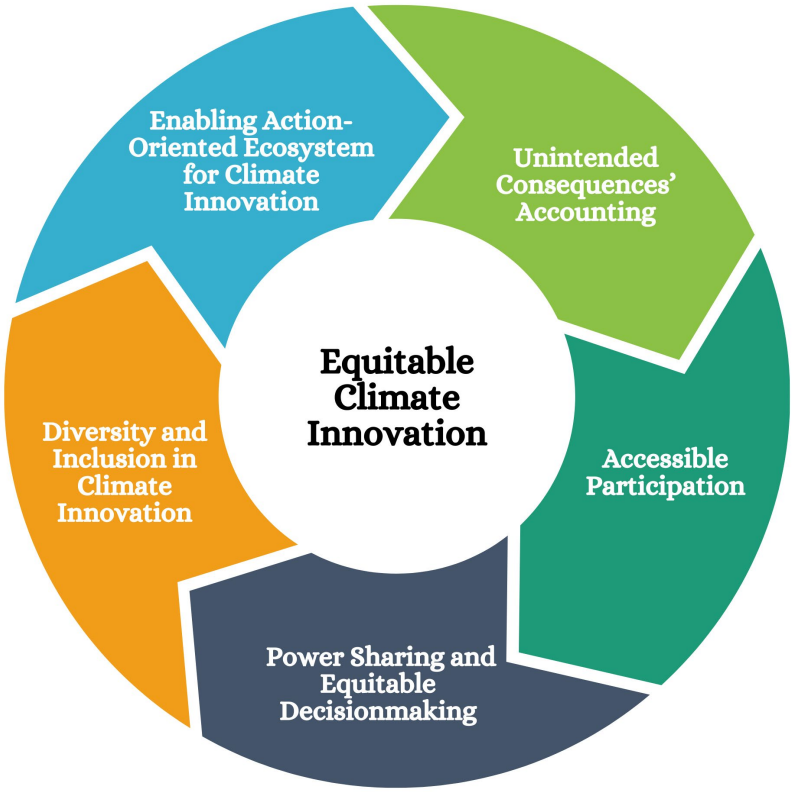

Figure 1: Equitable Climate Innovation Thematic Framework

Five broad themes emerged from the thematic analysis (Figure 1): (1) Enabling Action-Oriented Ecosystem for Climate Innovation, (2) Unintended Consequences' Accounting, (3) Accessible Participation, (4) Power Sharing and Equitable Decisionmaking, and (5) Diversity and Inclusion in Climate Innovation.

1. Enabling Action-Oriented Ecosystem for Climate Innovation

Study participants highlighted the need for ensuring that technology-based climate innovation (TBCI) is not treated in isolation and will never be able to achieve social equity goals. The key strategy for ensuring that TBCI is equitable is to change the social systems in a way that enables climate innovation. As opposed to coming up with top-down programs and officers at the federal level or small divisions within the private sector — which participants felt were ineffective, if not performative — the focus should be on active deployment and implementation of technologies, that were developed with community input, in a way that these action-oriented approaches cultivate an agile culture of TBCI where communities are organically more receptive to such interventions while taking a systems approach that is ensuring that these conversations transcend the narrow, vertical approaches and focus on the overall ecosystem in which the TBCI operates, rooted in a commitment to concrete climate action that ensures TBCI serves its purpose "*before it's too late*."

"*Like, "Okay, what did we do wrong? What do we need to sort of change? How do we tweak it? Who else needs to be involved as opposed to using these, these policies or programs or these offices as window dressing, right?....so don't fill me with talk, actually show me the actions. The things, the steps that you're taking to actually make the change or stop what's happening from coming, right? So that sort of mindset around less sort of politicking and posturing and demonstrating to actual action and implementation. I think that needs to shift a lot before it's too late. Before we have run out of time.*" (HNT)

"*Technology can potentially solve a specific engineering problem and can be mobilized in a way that can solve a social problem. But, yeah, I think one of the reductive things that often comes up in our field is the sense that technology will just solve the problem. I think that there is a layer... there is a step before technology solves the problem. And it looks like deployment and optimization and understanding of who has access to the technology, and how does it play out in our lives and what are the impacts of the greater deployment of that technology by them or by others around them.*" (VHN)

2. Unintended consequences' accounting

Accounting for the unintended consequences resulting from TBCI was one of the other important findings from this study. Participants felt it was critical to ensure that all TBCI took an intentional approach to think through the complex unintended consequences. This theme specifically highlighted the importance of being cautious around TBCI within the context of major societal realities in the U.S., such as individualism and differential in who — often poor and Black and Brown communities — bears the consequences and risks stemming from poorly developed and implemented TBCI.

"*There's always either anticipated or unanticipated negative impacts from that. So in some cases, it might just be something like it was just wasted money. Like it, it could have gone towards something that would have protected health in a, you know, better. So that would be kind of a negative side of it, but on the other hand there, there definitely are technologies that can be implemented that do have a benefit. I think that one of the things that I worry about most is the potential negative consequences*." (SBP)

"*I think it has a huge role to play, but it can't just sort of be done in a vacuum. It can't be done without sort of the connections to people and the consequences that people are gonna face*?" (VHN)

"*Once you become individualistic, you have really missed the point of, I think, what's going on with climate change, which is people, community. Folks are being encouraged to be individualistic and have more for themselves without thinking about the consequences on others*." (TDB)

3. Accessible participation

The need for ensuring accessible participation by socially marginalized communities throughout the TBCI lifecycle was another major theme that appeared in this study. Participants acknowledged that often it is less of a matter around whether or not community members want to participate or realize existential threats of climate change, and more of a matter of whether or not the TBCI process itself is designed in a way that allows for communities to participate in the process which is critical from a procedural justice perspective. Ultimately, a process that is "*engaged, participatory, and appropriate*" and meets the community's needs for equitable participation throughout the TBCI lifecycle is a crucial step for equitable TBCI.

"*I think people care. I think from an equitable standpoint, communities realize that they're getting impacted and that they're getting disproportionately impacted. They know it. You know, they see it. They feel it. They live it. And they want to be engaged, they want to be part of the solution. You know, they don't want their homes flooded, you know, et cetera, et cetera. So, I think that there's a large incentive to want to be at the table if they could find the bandwidth for it, and there is trust there to make it happen*." (WAS)

"*...a lot of public hearings and things like that conducted over Zoom, it's more accessible and so thinking about, you know, how can we collect public input, whether written or oral, via these video conferencing platforms, rather than requiring people to come in person to testify on a bill or on a, you know, whatever public comment is being discussed, but I think access to decision-making is another piece of the climate puzzle*. (RMR)

"*I think it should be a source of access in that it enables people not only to access information, access data, but access safety, access protections, access safe spaces. It should increase the community's resilience, and in a way that is not exclusive. That is engaged, participatory, and appropriate…it should increase the ability to get to the source.*" (HNT)

4. Power sharing and equitable decisionmaking

Power sharing and equitable decision-making was another theme that emerged, similar to the accessible participation theme, but with a more pronounced focus on economic systems and specifically naming power sharing in decision-making as the heart of centering social equity in TBCI. Participants felt that without sharing power — often held by government officials, policymakers, or tech entrepreneurs — there is no sustainable way of making TBCI equitable. The critical need for "*having that seat at the table, having that decision-making power*" along with "*equal voting power and equal voice*" as TBCI decisions are made is the absolute necessity for anyone serious about making the process equitable because otherwise, as one participant noted, "*Communities have this saying, if we're not at the table, we're on the menu*" (HJA).

"*I'm a firm believer that power should belong to the people. So, I mean, if you're talking about sharing between like people, I'm absolutely for it. If you're referring to there being some kind of equitable process…as long as we're operating within a capitalist process or a capitalist society, we're always gonna have these kinds of issues. Period. Capitalist society is an inherently destructive, violent economy, in my opinion. And somebody has to lose in a capitalist society*." (ALE)

"*Communities often have been told what their problems and solutions are, when, in fact, they are aware, whether it's through tribal ecological knowledge or just passing word of mouth, observations, the teachings of parents and grandparents passed down through generations. And it's having that seat at the table, having that decision-making power.*" (PGS)

"*So essentially, the first step would be putting those individuals with technical expertise as well as those community leaders that serve as the voice for their community at one table together with those that might be decision-makers, and have everyone have equal voting power and equal voice at the table, to be able to discuss some of these challenges that each person faces. Scientists will face challenges as well. Policymakers will face them as well as community members as well so that they can have an open platform to discuss.*" (CCH)

5. Diversity and inclusion in climate innovation

Participants also highlighted the necessity of integrating intentional diversity and inclusion efforts throughout the TBCI process to ensure not only that the process is inclusive and accounts for diverse perspectives and the needs of the communities most affected by climate change but also that the future decisionmakers and TBCI innovators reflect the diversity of the communities these advances are intended to serve. This theme, too, emerged within the context of differentials in climate exposures and differentials in access to both benefiting from or contributing to the development of TBCI.

"*One piece of it is really diversifying the workforce that would be involved in climate innovation. And then, again, the second is how are we thinking about who is benefiting from climate innovation?*" (RMR)

"*How do you develop the capacities in diverse communities or young people to be those developers? To be the technologists who in the future have the knowledge of some of the challenges in their communities, but you know, have the capacity to develop some of those solutions?*" (MFK)

"*First of all, the partnerships are diverse as they need to be? You don't miss those types of things in the beginning; in the incubation of whatever it is that a community is gonna first tackle.*" (WIN)

Discussion

"Privilege wants to protect privilege," — is a thought shared by one of the participants (DEN) that sums up much of the cumulative thought process and assertion in which the thematic framework, which serves as a set of recommendations and guiding principles (figure 1) for anyone interested in equitable TBCI, is grounded. The study purpose and questions were intentionally left quite broad to have this be the first step in TBCI conversation rather than focusing on one specific technology (for instance, digital technology) or one specific phase of climate innovation. This generated, unsurprisingly, themes with relatively broad, if not somewhat universal, applicability. These themes collectively serve as a useful framework for any organization interested in centering social equity and justice in TBCI, both philosophically and pragmatically. Philosophically, it allows for a methodical way to engage in a deeper reflection and a way to translate their stated, if any, commitments to justice and equity in their way of engaging with communities most impacted by climate change. Pragmatically, this framework serves as an analytical tool for climate tech organizations, policymakers, and funders to structurally analyze and scrutinize their decisions, programs, and policies from the ideation phase to implementation to evaluation.

The findings of this research largely conform with the existing literature. For instance, albeit in a different context, the action-oriented approach as a necessary condition for climate action is well-documented, which was one of the main findings of this research (Graham & Mitchell, 2016). Much of the existing TBCI-adjacent literature also highlights the absolute necessity for vigorously scrutinizing and accounting for unintended consequences to ensure that communities most impacted by climate change are also not the ones bearing the brunt of these unanticipated consequences stemming from rushed or poorly throughout TBCI outputs (Hills et al., 2018; Jacobs et al., 2022; Simon, 2012). Similarly, the theme of power sharing

and equitable decision-making also builds on the existing literature that highlights the necessity of such an approach for just and equitable outcomes in other scenarios and has parallels with the research findings of this study on sharing power with communities with the community knowledge (Brugnach et al., 2014). Along the same lines, existing literature also supports the themes of accessibility in participation and centrality of diversity and inclusion in climate action as a critical component of just and equitable approaches, which, of course, is also applicable to equitable TBCI (Aakre & Rübbelke, 2010; Pfeifer, 2020).

Implications for the practice

The key implications for the practice from this research and its findings are that there are ways — as suggested in the themes — to make sure that we can move past the current reality of innovations' modest contributions to solving the climate crisis (van den Bergh, 2013) and make the process of innovation much more equitable and impactful by engaging communities in a meaningful way. Specifically, there are important practice implications for policymakers and entities that are the primary beneficiaries of the root cause of the climate crisis, the capitalistic economic structure, such as techno-optimist venture capitalists and the philanthropic sector. Increasingly, these social groups are focused on social equity — at least in their words, if not, ever is rarely, in their deeds. The themes identified here can serve as the guiding principles to fundamentally shift their current approach to technology-based climate innovation and ensure that community voices are integrated throughout the process for impact innovation that serves the most marginalized communities without causing further harm to the said community. While the specific approaches will vary from organization to organization and project to project, the commitment to ensuring that community voices are centered, and power is shared in all decisions in such a way that it leads to specific, structural policy and practice changes (not performative, pretty words and events — there is a difference between holding a one-off community leader lecture versus giving them a vote in funding approvals, for instance) that are meet the community needs is the direction the people engaged with technology-based climate innovation should move towards.

Strengths and limitations

The study had several strengths and limitations. Several of these were standard strengths and limitations of qualitative research, as have been reported in the literature (Carr, 1994; Mwita, 2022; Yilmaz, 2013). Methodologically, some of the strengths include gaining rich and detailed data that captured the complexity of such a broad topic as climate innovation and technology. This approach provided a richer contextual understanding of the subject matter while also relying on the flexibility of semi-structured interviews that can be less rigid and allow for gaining even deeper insights from study participants. Additionally, this was one of the very first, if not the first, study to methodically explore the complex intersection of climate change and technology by engaging scholars, practitioners, and community leaders from a wide range of disciplines with the common thread of social equity across their work.

In the same vein of qualitative methodology, some of the key weaknesses included the Principal Investigator's subjectivity — although, arguably, there is no such thing as objective scientific enterprise as all of our perspectives are uniquely situated in the specific context, including our own situatedness and the sociopolitical ecosystem in which we exist (Haraway, 1988). Additionally, the scope of the research and its implications remain limited as the participants were all U.S. based — despite some of them having a global scope in their work portfolio — so one of the biggest weaknesses is the scope of understanding of the climate innovation-technology-social equity intersection and its applicability to the global context since it may vary drastically elsewhere in the world. Furthermore, the definitions of climate innovation or the scope of technology were intentionally left open-ended, as the purpose of this study was to serve as an exploratory first step in opening this dialogue, which may have limited the preciseness of participant responses. Finally, given the limited time for project execution, several themes were collapsed through a parsimonious

approach, and a re-analysis of the data might generate an even more vibrant thematic framework and themes.

Conclusion

This study serves as the first step towards a broader understanding of climate innovation as it relates to social equity. Several of the findings and themes identified in this study provide some broader guidance for decision-makers across sectors (philanthropic sector, governmental agencies, NGOs, climate technology companies, and so forth) to make their technology-based climate innovation work more equitable from funding to policy and programmatic development and implementation to technology deployment. This also has potential implications of opening a broader social dialogue on the subject matter that is fundamentally about systems change as a part of equitable technology-based climate innovation as opposed to performative checklists highlighting adulterated versions of social equity as a marketing stunt without a material, tangible, and philosophical paradigm shift. Though unfortunate — as it reifies the ideas of technology being the silver bullet as opposed to structural changes such as rethinking our destructive economic system, capitalism — technology-based climate innovation is here for now within the violent market-based ethos of the United States. To that end, while the findings of this study should guide an equitable approach to technology-based climate innovation, the broader goal of changing, abolishing, and reimagining the root cause of climate crisis — capitalism and neoliberalism — should always be a constant part of the conversation for anyone committed to social equity.

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Appendices

Appendix 1: Interview Questions

- Could you briefly describe your background in climate change, technology, innovation, and/or social equity and justice?
- What is your understanding of the term "climate innovation"?
    - Probing Questions
        - Do you think there is a need for it?
- How do you think climate innovation is connected to social equity?
    - Probing Question
        - It could be any aspect of society intersecting with social justice, such as climate justice, environmental racism, health equity, etc.
- Do you think technology has a role to play in climate solutions? Technology is broadly defined and includes information technology, clean tech, sustainable energy, and so forth.
    - Probing Questions
        - What role does technology play in climate innovation/solutions?
        - Has this role been mostly positive or negative from a social equity perspective? Why or why not?
        - How big of a role do you think technology plays in climate innovation for equity-centered climate solutions?
        - What role should technology play in equity-centered climate innovation?
- How do we engage in technology-based climate innovation that centers social equity?
    - Probing Question
        - Could you elaborate further on this?
        - Do you have any examples?
        - What factors could facilitate or hinder this approach?
- What are your policy and systems change recommendations for equity-centered climate innovation in technology development and implementation?
    - Probing Question
        - Could you elaborate further on this?
        - Do you have any specific examples?
- What structural changes are needed to ensure equity-centered technology-based climate innovation?
    - Probing Question
        - How do you envision this different, equitable world that is based on social justice and centering the margins?
        - Could you elaborate further on this and share specific examples?
- Is there anything else you would like to share?

Appendix 2: Consent Form
Middle Georgia State University (MGA)
School of Computing — Department of Information Technology
Research Participant Information and Informed Consent

Title of the Study
Climate Innovation and Technology: Community Perspectives on Advancing Social Equity

Principal Investigators

□□. □□□ □□□□□, □□, □□□, □□□□, □□□, Environmental and Occupational Health, George Washington University Milken Institute School of Public Health

□□. □□□□ □□□□□□□, □□□, □□□, □□, Dean & Professor | Peyton Anderson Endowed Chair in IT, School of Computing, Middle Georgia State University

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□□□ □□□ □□ □□□□□ □□ □□□ □□ □□□□□?
If Yes, please proceed. If No, you are not eligible for participation in this study.

Brief Summary
You are being asked to participate in a research study. Researchers are required to provide a consent form to inform you about the research study, to convey that participation is voluntary, to explain the risks and benefits of participation, including why you might or might not want to participate and to empower you to make an informed decision. You should feel free to discuss and ask the researchers any questions you may have.

You are being asked to participate in a research study of Climate Innovation and Technology: Community Perspectives on Advancing Social Equity. Your participation in this study will take about 45-60 minutes in one setting over Zoom. You will be asked to answer a set of questions exploring the intersection of technology-based climate innovation and your thoughts on how to make it more equitable.

The most likely risks of participating in this study are discomfort from using technology and engaging in an interview in a virtual Zoom environment.

You will not directly benefit from your participation in this study. However, your participation in this study may contribute to the understanding of technology-based, equity-centered climate innovation.

Purpose of this research
You are being asked to participate in a research study of climate innovation and strategies to make technology-based climate innovation more equitable.

You have been selected as a possible participant in this study because of your expertise/work portfolio that is related to the study's central research questions.

From this study, the researchers hope to learn the guiding principles for centering social equity in climate innovation, especially when technology is involved.

What you will be asked to do
If you decide to participate, you will be asked to participate in an interview, asking you a set of questions on the study topic. These questions will focus on your opinions related to the topic of technology, climate innovation, and social equity. We will also ask your thoughts on how to create a more equitable ecosystem for climate innovation. This interview will be recorded and transcribed to be analyzed at a later time for accuracy. Your name or affiliation will not directly be disclosed or associated with a specific quote. Only de-identified quotes and data will be presented.

Potential Risks
In this study, you will not have any more risks than you would in a normal day. You can see further information in the confidentiality section below.

Potential Benefits
Participation in this study will not benefit you personally. Overall, we hope to gain information about the abovementioned topic of technology, climate innovation, and social equity.

Your Right To Participate, Say No, Or Withdraw
Participation in research is voluntary. You do not have to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. You may skip questions or stop participating at any time. Whatever you decide, you will not lose any benefits to which you are otherwise entitled.

Privacy and Confidentiality
Data will be kept confidential and only be accessible to the research team trained in research ethics. Although we will make every effort to keep your data confidential, there are certain times, such as a court order, when we may have to disclose your data. Additionally, the data will be de-identified after transcription, and only de-identified data will be shared with anyone other than Ans Irfan for analysis or dissemination purposes. We will keep the data confidential and under password protection. The data will be stored on secured servers only accessible through unique passwords, which are not shared by anyone other than the research team. Data will only be available to the following personnel or entities:

Ans Irfan, MD, EdD, DrPH, MPH
Alex Koohang, Ph.D., MSM, MS
Middle Georgia State University Institutional Review Board (IRB).

Costs And Compensation For Being In The Study
There are no costs to you for participating in this study. You will not receive money or any other form of compensation for participating in this study.

Alternative Options
The alternative to participating in this research study is not to participate and withdraw from the study.

Contact Persons
Contact Ans Irfan (202) 930-3189, ansirfan@gwu.edu, and Alex Koohang at 478.471.280, Alex.Koohang@mga.edu if you have questions, concerns, or complaints about this study. You can also call if you think you have been harmed by the study.

Call the chair of the Middle Georgia State University IRB, Dr. John Hall, at 334.391.4778 if you want to talk to someone who is not part of the study team. You can talk about questions, and concerns, offer input, and obtain information, or suggestions about the study. You can also call the IRB chair if you have questions or concerns about your rights in this study.

[Google Form Question After the Consent Statement]
Have you read the consent form, do you consent, and wish to participate in this demographic survey?
Yes — Consent will be obtained, and participants will proceed to the sociodemographic study

No — Participants will proceed to a page reflecting their lack of consent and ineligibility to participate in the study.

Appendix 3: Sociodemographic Survey Questions

Are you at least 18 years or older?
Yes — Proceed
No — Ineligible to participate

What is your age?
Under 21
21 - 25
26 - 30
31 - 35
36 - 40
41- 45
46 - 50
51 - 55
56 - 60
61 - 65
Older than 65

What is your gender?
Man
Woman
Transman
Transwoman
Nonbinary
Genderqueer
Other
Prefer not to say
Other…

What is your sex?
Male
Female
Intersex
Other
Prefer not to say

How do you identify racially?
White
Black
Asian or Pacific Islander
American Indian/Alaskan Native
Other
Prefer not to say

Do you identify as Hispanic?
Yes
No
Prefer not to say

What is the primary geographic focus of most of your work?
Midwest
Northeast
South
West
Outside the Continental U.S.
Non-U.S. (International)
Prefer not to say (*this option served as the global scope option, inclusive of the US/non-US work portfolio. Participants were verbally informed to select this option if the geographic focus of their work was global*).

What is your employment sector?
Academia
Federal Government
State Government
Local Government
Private Sector (Industry/Consulting, etc.)
Non-profit Sector
NGOs
Other

What are your primary areas of work/expertise? Please list at least the top 3. (For Example: climate justice; federal policy; information technology)

Do you believe your work/organization serves Black, Indigenous, and People of Color (BIPOC), poor, and other socially vulnerable and historically marginalized communities in the United States?
Yes
No

Could you specify what specific communities your organization/work portfolio represents the interests of? (For Example, rural West Virginia, Indigenous communities, etc.)

How long have you been working in this capacity? (This corresponds to your first response to the previous question)
1—3 years
4—5 years
6—10 years
Over 10 years

Participation Declined [Consent Decline/Under-18 Message**]**
You have chosen not to participate in this survey, or you are ineligible to participate in this study. Please contact Principal Investigator Ans Irfan at ansirfan@gwu.edu if you have any questions. Thank you for your time.