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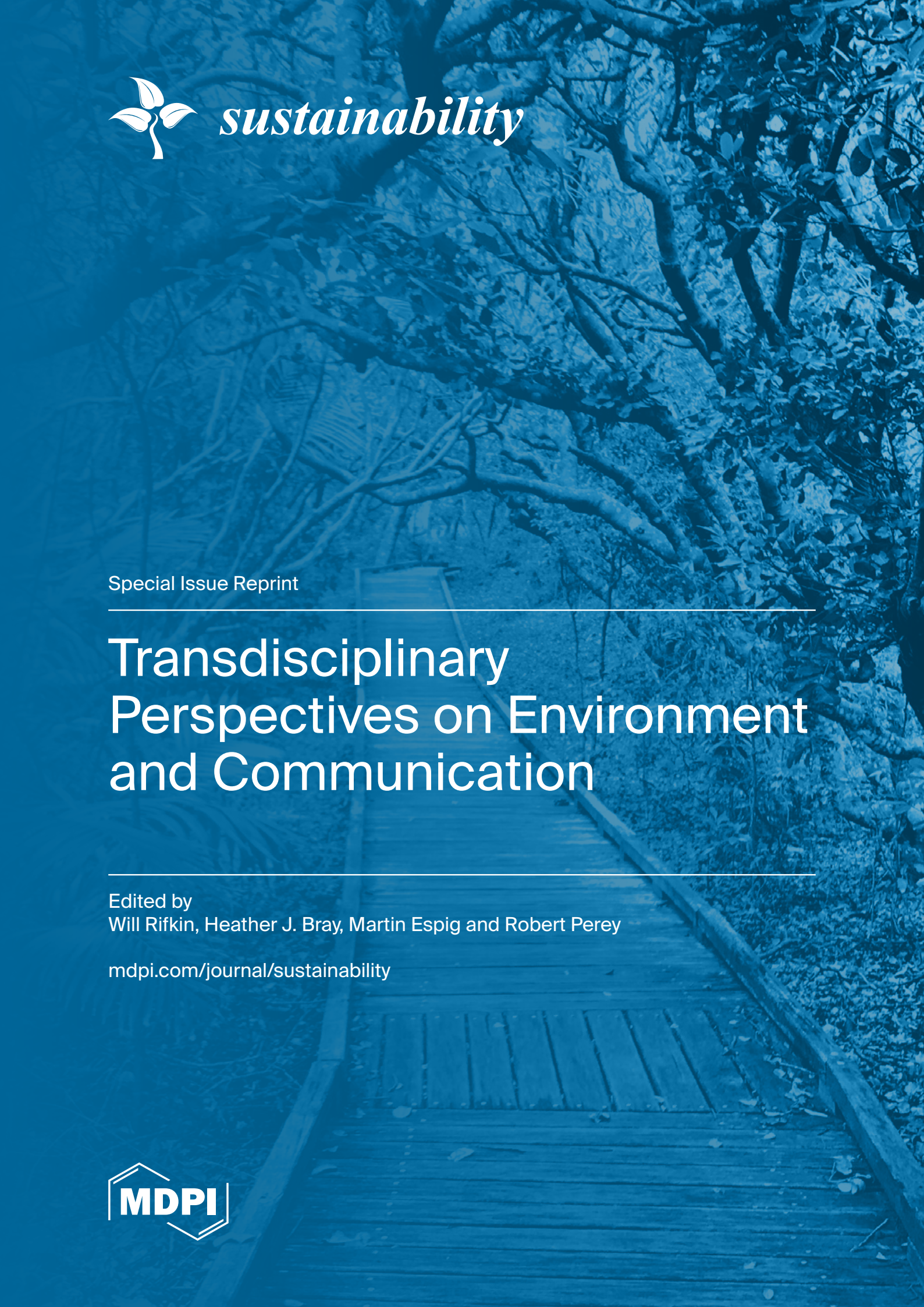

Special Issue Reprint

Transdisciplinary Perspectives on Environment and Communication

Edited by
Will Rifkin, Heather J. Bray, Martin Espig and Robert Perey

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Guest Editors

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Cover image courtesy of Kimberley Crofts

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About the Editors

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Preface

The concept of transdisciplinarity has captured the imagination and attention of scholars and practitioners since the 1980s. A distinct rise in use of the term in published works could be seen as a harbinger of the 1997 adoption of the Kyoto Protocol and a growth in global recognition of the existential and intrinsically multifaceted risks that are caused by humanity's social and ecological behaviours: global warming, loss of biodiversity, increasing species extinctions, and increasing resource scarcity. A devastating irony is that although the original protocol required transdisciplinary coordination, nations are now permitted to meet targets employing just their own lens rather than engaging in further messy negotiations. It has become increasingly accepted that a transdisciplinary perspective is required to address the "so-called wicked problems" associated with climate change and other contemporary environmental challenges. When there are cumulative, overlapping, intersecting effects across the globe that manifest in a multitude of ways across villages, towns, cities, and regions, conventional ways of analysing and resolving such issues often prove insufficient.

What is meant, though, by "transdisciplinarity", and what does such a definition imply for how we communicate about environmental issues? This edited volume explores this question by placing a transdisciplinary lens on how environment-related problems are being addressed in different settings. It is our view—and one shared by the authors in this volume—that disciplinary boundaries must be transcended to effectively address climate change and other environmental challenges in settings ranging from schools and local government to forests and oceans.

This book is a collection of stories and analyses about, and by, people trying to make sense of what transdisciplinarity means in a practical sense, both now and into the future. Each chapter can be seen as a stepping stone to wider understandings as the array of authors, reviewers, and we—this volume's editors—present a mix of familiar and fresh perspectives from a range of fields. These fields include social studies of natural resources and the environment, science communication, impact assessments, communication and media studies, social psychology, sociology, cultural anthropology, political economy, and organisational studies.

The contributions to this volume demonstrate how meaningful engagements across disciplines can help us frame and navigate the complexity of these problems. The range of perspectives provides much-needed practical insight for how to ease the burden of approaching environmental problems in a transdisciplinary way. The empirical and conceptual wealth of insights across the different studies presented in this volume are a major accomplishment, embodying what it means to be transdisciplinary.

In conceiving the Special Issue of *Sustainability* on which this volume is based, we were looking for transdisciplinary work that was applied as well as innovative in nature. We challenged authors to explore particular environmental problems where communication is not one-way but involves contestation, synergies, or entirely new ways of understanding among multiple stakeholders. We also invited challenges to conventional research methodologies and to how impacts are identified and characterised. Communication within these emerging and often ambiguous interactive spaces offers unique gateways to understanding transdisciplinary practice.

In line with this orientation, we asked authors to address challenges when different ways of knowing are exposed and begin to influence how problems are framed. The resulting case studies were intended to provide readers with examples of how to advance transdisciplinary theory and practices in communication. We stressed, therefore, that manuscripts should be drafted in order

to be accessible and sensible to people outside the field and discipline of the authors. We also explained a desire for co-authorship among partners in different disciplines and with the voices, if not co-authorship, of counterparts outside universities.

We hoped that authors would address a suite of interrelated challenges and opportunities, such as literacy and expertise, different ways of knowing (including non-human), different ways of framing and social imaginaries, historical marginalisation by gender, income, age or social class, and procedural fairness, as well as attachment to place. We also sought a range of cases, from climate change impacts to population growth, decline or migration, or a focus on evolving technologies for engagement. This volume's authors delivered in these areas and more.

The key themes that emerged from the authors can be summarised as embracing complexity; surfacing differences through reflexivity; communicating across epistemic differences; and engaging through solidarity. Most contributions to this volume address not just one but multiple themes simultaneously. For example, Abraham (2023), Spurr and Currasco (2024), and Whitley (2024), touched on all four themes, while Burakgazi and Reiss (2024), along with Mah and Song (2024), addressed just one. Our overview in this volume discusses these interconnected themes and acknowledges that "embracing this messiness" is a "crucial step toward 'being transdisciplinary' ".

As an early career scholar, it has been my great pleasure to be a contributor to this Special Issue, augmenting the efforts of the official Guest Editors. I especially note the generous mentorship of Professor Rifkin.

By Dr. Kimberley Crofts.

Acknowledgments

We thank all of the authors for their contributions to this Special Issue. The editing team would also like to acknowledge the valuable contributions of Dr Kimberley Crofts. While completing her doctoral work, she elicited submissions and, together with two Guest Editors, commented on initial drafts of half of the papers in this volume. Dr Crofts then led the authorship of the synthesis article after all manuscripts were accepted.

Will Rifkin, Heather J. Bray, Martin Espig, and Robert Perey

Guest Editors

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Editorial

Overview of the Special Issue: Embracing the Messiness of Transdisciplinarity

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This Special Issue utilizes a transdisciplinary lens to analyse how environment-related problems are being framed and communicated in different settings. A drive for net zero greenhouse gas emissions, preserving biodiversity, or reducing pollution can challenge deeply entrenched values and interests in the status quo. These values and interests can affect how different people understand or frame questions about the environment [1]. They underlie societal debates and negotiations, and they affect how communication about environmental issues occurs and what bodies of knowledge are drawn on and given authority. These dynamics indicate that addressing such complex problems entails the development of new ways of sharing knowledge, coordinating practices, thinking, and experimenting to progress toward a joint purpose or resolution when an array of stakeholders is engaged. Our overview identifies some of these approaches as they have surfaced across this collection of articles.

The cases in this Special Issue address aspects of environmental and societal sustainability in city planning, soil fertility, education, water governance, and other settings. Essentially, these cases involve complex socio-technical-environmental systems where biological life and political life are intertwined through the interaction of multiple physical elements, a variety of actors, and different bodies of information, knowledge systems, life experiences, and beliefs. While not placing a sole emphasis on transdisciplinary communication itself (as conducted by Misra and Lotrecchiano [2], for example), each case study raises several obstacles and opportunities that practitioners and researchers face in communicating effectively within their given setting.

Another layer of complexity is added to these settings by the fact that the concept of sustainability is subject to a diversity of interpretations across scientific disciplines and societal institutions, based on a variety of bodies of knowledge, worldviews, and belief systems. These underlying elements are often well entrenched and hard to recognise as they influence how groups—such as scientists, farmers, or activists—communicate and engage with others. This attachment can result in resistance to accepting alternative interpretations of sustainability or to accepting the actions of others who hold a different view on what is sustainable.

Such situations are illustrated with examples from the articles in this Special Issue, ranging from climate change and biodiversity to more localised environmental concerns like water governance, urban planning, and biosecurity. The authors investigate their cases through different theoretical perspectives and methodological approaches. In doing so, they reveal common challenges often referred to as "wicked problems", which evade simple definition and resist conventional modes of problem solving [3]. Unlike tame or

single-dimension problems, wicked problems are intertwined with other challenges, each problem being a symptom of another [4]. They feature a range of other characteristics that make wicked problems difficult or impossible to resolve, such as an inability to test solutions or to determine whether a remedy actually works. These factors are illuminated in the extensive literature on this topic.

Addressing wicked problems, such as those associated with sustainability, requires a range of strategies. For instance, complex systems theory provides tools that are well suited to navigating dynamic, messy structures [5]. Complex systems theorists consider wicked problems not through the individual components or systems of the problem but by addressing the collective properties that may have led to the creation of the problem as a whole. Transdisciplinarity is another approach that seeks to move beyond—or transcend—disciplinary boundaries to address inherently tricky and multilayered issues, such as climate change and other environmental or social challenges [6–8]. Both types of framing focus on the properties that emerge from patterns that result from interactions among multiple systems—for example, economic marginalisation in a community and the geographic distribution of air pollution—making them resistant to a reductionistic approach (i.e., simple technical solutions) and necessitating more sophisticated strategies.

To reveal insights emerging from this collection of articles, this overview synthesises their contributions by describing the concept of transdisciplinarity and providing a brief explanation of how it emerged in the editorial process. The analysis here places each of the articles within a thematic framework that expands from the three principles (or axioms) of transdisciplinarity proposed by Jantsch [6] and further developed by Nicolescu [7]. These principles are: (1) a recognition of different levels of—or lenses for viewing—reality; (2) the development of a middle ground; and (3) the acceptance of complexity. A fourth principle, which is supported by the cases in this Special Issue, is added to suggest a heuristic for practitioners who work in such arenas: (4) engaging through solidarity. The principles resonate with recent explorations into contemporary challenges in science communication that were identified by scholar-practitioners [9]. Their examples include combatting misinformation that prevents some people from seeking COVID-19 vaccinations or overcoming vested interests in carbon-based industries.

The synthesised overview presented here can thus help to identify common approaches to communicating and working within transdisciplinary settings. Here, we provide a background on these concepts to preface the individual contributions to this Special Issue.

Transdisciplinarity began to gain traction in the early 20th century as political movements, such as post-normal science and other critical fields, started to question the dominance of existing educational, knowledge, and democratic systems [10]. As a concept, transdisciplinarity was defined and gained prominence in the 1970s through the work of Piaget, Jantsch and Lichnerowicz [7]. For these scholars, transdisciplinarity refers to going "beyond" disciplines, capturing both academic forms of knowledge and other bodies of knowledge. This formulation aligns with a parallel body of work differentiating pure versus applied science, as promoted by Nowotny, Scott and Gibbons [11] and others. They differentiate between "mode 1", research aimed at contributing to academic knowledge, and "mode 2", applied research aimed at a multi-disciplinary policy or managerial audience.

In the cases here, descriptions of the need for transcending disciplinary boundaries and the centrality of communication in that process have facilitated the achievement of the goals of this Special Issue. These goals were framed in the original call for papers: (1) to explore communication that involves contestation or unexpected synergies among multiple stakeholders about environmental problems; (2) to address challenges when different ways of knowing (science-based and ways that are not science-based) are exposed and begin to influence how problems are framed; and (3) to use these examples to advance transdisciplinary theory and practices in communication.

Assembling this volume required the submitting authors, reviewers, and Guest Editors to "walk the talk" of transdisciplinarity. Authors were asked to ensure that their contri-

butions were rigorous within their disciplines but accessible to the journal's readers, who come from a range of disciplines often outside the authors' fields or sub-fields. Similarly, reviewers needed to be accepting of research methods that they might not use themselves, e.g., a biologist needing to recognise the value in an ethnographic case study. Incongruity in paradigms between each author and at least one of their reviewers was evident for most of the manuscripts submitted—creating an engaging tension that suggested that an interesting and worthwhile shared space was being formed. The shared space was cultivated by the Guest Editors, and occasionally the journal's regular Academic Editor, interpreting specific criticisms as, at least in part, representing such paradigm differences and suggesting or endorsing methods to address such differences. This accommodation could range from steps as simple as re-ordering or re-labelling sections to citing conceptual works in qualitative methodologies.

These paradigmatic disagreements provided real-world examples of the difficulties of communicating across disciplinary boundaries, albeit in the highly structured format of the peer-review process. In less well-defined settings, the complexity of interrelationships and interactions amongst actors in transdisciplinary arenas where boundaries between bodies of knowledge are rife makes the means, assumptions, successes, and failures of communication a critical factor in determining the success of these encounters [2]. The intriguing challenges presented by this complexity suggest why *Sustainability*'s Editorial Board asked to have communication as the focus of this Special Issue.

The key points from the various contributions to the Special Issue are summarised below, followed by a reflection on the insights that a transdisciplinary lens on communication and the environment offers across these settings. Understanding this set of articles as a collection emphasizes the importance of transdisciplinarity in the arena of environmental issues; the collection highlights the shared elements of successful approaches while also revealing the pitfalls encountered in other cases. Read together as a collection, the contributions in this issue highlight themes that can enable more effective applications of transdisciplinarity—in policy and practice—across a diverse range of settings.

In synthesising ideas across the articles in this issue, the focus is on how authors or their subjects of study have navigated challenges in communicating and engagement across and beyond disciplinary boundaries in conducting their work, whether it is empirical research, implementing policy, or responding to stakeholders, or in other contexts. An analysis of these varied cases suggests four principles for approaching wicked environmental problems:

(i) Embracing complexity;
(ii) Surfacing differences through reflexivity;
(iii) Communicating across epistemic difference;
(iv) Engaging through solidarity.

While not all four principles are evident in every article, there was sufficient commonality to suggest a trend indicating that these principles are arising implicitly, if not explicitly, in many of these settings. This outcome could be expected, as it aligns with the transdisciplinary axioms identified by Nicolescu [7] and the common themes arising in certain types of science communication—messiness, epistemic asymmetry, and reflexivity—as identified by Rifkin et al. [9]. These principles are defined in the sections below, where we demonstrate how each one, in turn, applies to certain contributions in this Special Issue.

As highlighted by many of the settings studied across the 12 articles, the complex interplays between these principles in practice mean that transdisciplinary inquiry is not a simple endeavour. Rather, it requires researchers and practitioners to step outside their familiar disciplines in pursuit of both developing holistic understandings of wicked problems [12] and taking effective steps to resolve them. As mentioned previously, a synthesis and explication of common approaches can enable more effective applications of transdisciplinarity. Each of these four principles may be considered as heuristics or systematically derived "rules of thumb" that can guide transdisciplinary ways of working.

(i). Embracing complexity—Wicked problems are characterised by complex interactions fuelled by different worldviews and differences in preference regarding different bodies of knowledge, e.g., different areas of science or lay experience [12]. Such complexity can often be considered a negative to be overcome instead of a dynamic that is always present in wicked problems. Attempts for simplification may thus occur because people seek ready and familiar solutions to novel challenges. These approaches can often include adhering to certain worldviews and methods for knowledge construction, prioritizing some over others [12]. For instance, one might prioritize gathering stakeholder input through surveys rather than through interviews.

Yet, as many of the articles in this issue conclude, the complexity introduced by the wicked characteristics of many contemporary environmental problems requires a corresponding complexity of methods and factors in analysis (such as examining belief systems). This intentional complexity is fostered through transdisciplinary approaches to communication processes and other shifts in education and institutional activities. The articles' authors recognise the potentially positive value of complexity, a complexity that welcomes contributions by different disciplines to enable a greater understanding of a system's elements. Fragmented thinking in disciplinary siloes should give way to "pertinent knowledge", as stated in a later work by early transdisciplinary theorist Morin [13], where subjects and problems are studied in context in all their complexity.

The principle of embracing complexity is reflected in several articles. For example, Contribution 1 notes that meaningful collaboration between local stakeholders and planning professionals in a brownfield redevelopment in Amsterdam is achieved through the acceptance of congruence rather than striving for consensus. The congruence for them described in Contribution 1 emerges through negotiation as "contextual agreement on collaborative action", where difference is maintained alongside areas of agreement to enable action and inquiry to move forward. Similarly, Contribution 6, which focuses on public engagement with climate issues through social media, promotes an embrace of congruence (for them, a form of consistency) over consensus (a degree of agreement). They cite disagreement as a potential resource to help address climate challenges because surfacing—rather than suppressing—multidimensional perspectives is crucial for addressing the wicked problems associated with climate change, such as economic drivers that may hinder energy transitions and the existential threats faced by island nations as sea levels rise.

The ability to view a problem in more than a single dimension is also addressed by Contribution 12, which analyses a region's need to transition away from coal mining through a speculative design lens, one that enquires into the potential, possible, and plausible futures. This speculative lens expands the complexity of the problem space to include avenues that may have otherwise remained obscured.

Contribution 10 notes that complexity increases when it comes to defining exactly who is recognised as having a "stake" and, therefore, who should be included in "stakeholder engagement". Ensuring that a sufficient number of perspectives is explored to identify potentially viable ways forward means broader inclusion to encompass an array of actors both human and, some would argue, non-human. For example, the articles in this Special Issue variously suggest including a wide range of stakeholders, including children, scientists, First Nations peoples, residents, government staff, advocates, and in some instances, non-human species such as whales, as highlighted in Contribution 9.

The integration of an apparent logic that is recognised as non-human, e.g., the responses of natural systems or animal species or plant species, is a potential direction for future investigation in transdisciplinary practice, particularly in relation to the connection of First Nations groups with land, water, and air. The involvement of a range of perspectives in such cases might be more effective in revealing a broader view of the complexities of the problem space, recognizing conflicts among worldviews and belief systems, and considering more potential options compared to a traditional or bureaucratically led approach. It is also an argument for procedural rights to enable input from a wider array of voices.

Assessing how contextual factors affect communication is raised in Contribution 11 to show that situations may be more complex than described through the perspective of a single knowledge source, whether from an expert or a relative non-expert. When policy-making experts were hosted informally on farmlands in Kazakhstan, the farmer hosts were able to express their resistance to officially prescribed methods in ways that were not possible before. The understanding of government experts, who had been influential in past policies, was expanded to include a more complex level of detail than they had seemed ready to accept. That shift was seen as potentially enabling the consideration of a greater range of solutions for addressing rising salinity in soils.

Thus, these articles embrace complexity in defining problems, identifying optional responses, and determining who, or what, is worth paying attention to, all of which can potentially influence practice.

(ii). Surfacing differences through reflexivity—Reflexivity is essential for conducting ethical, participatory research because it asks researchers to consider power and how positionality affects methodological choices, the subsequent interpretations of findings, and the resulting knowledge [14]. Reflexivity in practice enables recognising that the different value systems that people operate under may influence the way they understand and communicate about an environmental issue. Stirling [15] emphasises that reflexivity thus entails a more thorough consideration of issues by reflecting on a wide range of possible consequences that may affect others.

As a form of "self-awareness", in these settings, reflexivity is required to attend to the ways in which subjective views may shape interpretations of the object under consideration. This self-awareness could mean, for instance, coming to the critical realisation that identifying the consequences of using a new technology may depend on the point of view and expectations of a specific individual or group.

Such reflexivity can occur at a micro-level in transient moments when hierarchical relationships are suspended, according to Rifkin and Fulop [16]. At this micro-level, the command of a conversation can shift among participants, in that some are granted by others a more authoritative and secure participation status [17]. Higher participation status can lead to an ability for the voices of the less powerful to be heard, to focus the conversation on topics that they need addressed, and to increase the likelihood for their inputs to be heeded. These shifts can induce greater feelings of safety and a reduced sense of vulnerability among the less powerful and, importantly, among the more powerful, enabling the latter to be more circumspect [9]. Collins and Ison [18] argue that this form of dialogue can support the social learning needed to address complex socio-environmental challenges. Without reflexivity, differences will not be surfaced and contestation can continue to limit the types of strategies employed, hindering the achievement of desired outcomes.

Reflexivity is approached in several ways in the articles of this Special Issue, for example, through learning dialogue, making difference visible, enabling creative expression, establishing visceral experiences, representing of local knowledge, and conducting multi-party meetings. These cases illustrate instances where tactics, such as enabling creative forms of expression (such as drawing), or meeting in places that the powerful are less accustomed to meeting (such as on a farm), can enable reflexive dialogue to emerge, which is also highlighted by Steelman et al. [19]. Contribution 10 states that if power imbalances are not made visible, they remain easy to exploit, and the interests of powerful actors will remain a priority. Understanding differences in power is therefore crucial in adapting policy responses in ways that correspond to the needs and expectations of different audiences. The reflexivity of the researcher and author can foster greater reflexivity among the decision-makers they study and, one hopes, among those to whom they reportas well.

Another common theme is that the externalisation of different framings and meanings is crucial in multi-stakeholder arenas. Contribution 1 and Contribution 3 suggest, for example, that involving community members in framing environmental issues reduces the possibility of conflict arising because of differences in perspective. Contribution 2 shows how scientists, citizens, and artists in a citizen science project in Milan used a field notebook

as a boundary object to help negotiate their diverse approaches. In Contribution 7, the creation of a "design wall" in the classroom where children's sketches are displayed is an example of externalising knowledge, making it available for others to discuss, critique, and build upon. Visualisation was also crucial in Contribution 12 as the authors' architecture students used diagrams, maps, and other visual methods to create a "common language" for diverse groups to engage in discussions about what potential futures in a coal mining area might "look and feel like".

Attempting reflexivity in practice can be challenging. There are different experiences and lifeworlds that must be made known and respected, as underlined in the forest biosecurity issues addressed by the New Zealand school in the case study from Contribution 7. Multiple perspectives are considered in this article, including Western scientific and indigenous knowledge, adult perceptions, and those of the schoolchildren. In slowing down the engagement between the researchers and children, the authors suggest that engaging in a less frenetic and more natural (less structured) fashion allows for new perspectives to emerge through a less confrontational dialogic process. The importance of an accommodating posture emerged across other articles where scientific experts of various types were engaging with non-academic participants. A respectful cadence to knowledge making therefore appears to be an essential element in transdisciplinary practice.

Contribution 5 suggests that taking people out of their usual settings—or perhaps, more correctly, enabling them to encounter familiar settings in new ways—can assist in making different perspectives more visible and available for interrogation. To do so, the authors employ what they call "city walks" as a creative format for climate communication. Participants can encounter their surroundings in new ways and reflexively re-familiarise themselves with their city and local climate change-related issues.

This focus underlines the common thread across the articles about the importance of recognising how distinct stakeholder groups or demographic segments might differently frame what they see and experience as changes are made to their environment.

(iii). Communicating across epistemic difference—After embracing complexity and highlighting the differences in problem framings, values, and world views, the next challenge of transdisciplinary work is to coordinate practices, thinking, and experimentation to enable moving toward a purpose jointly defined by participating stakeholders.

The challenges inherent in this effort closely align with third-order thinking about science communication described by Irwin [20]. Irwin notes the deficiencies in one-way communication about science (first-order) and in narrowly defined engagement practices, labelled as "dialogue" (but is often observed as being implemented as cursory "consultation"), involving limited groups of stakeholders (second-order). Irwin argues for a greater acknowledgement of the complexity of the context in which one-way and two-way communication about science and the environment tend to occur [20]. This argument highlights how institutions, policy settings, discipline-based dynamics, and power differences among stakeholders shape both what can be said and the influence of those statements [21].

Using a transdisciplinary perspective to jointly define the problems and the purposes to be served in resolving them requires moving beyond one- or two-way exchanges; it requires communication that is not just to or from but amongst an array of actors with different bases of knowledge, experience, and values. For this type of third-order communication to be meaningful and effective, it should occur early on and continue throughout efforts to address environmental issues, starting from the first stages in collaborative problem framing [22].

To transcend disciplinary boundaries, the authors in this Special Issue created, implemented, and analysed a variety of approaches to bridge the deep chasms between disciplines and actors, including hybrid methodologies, arts-based practices, and the use of "boundary riders". In contrast, some authors explored how more narrow approaches appear to be trapped within boundaries defined by knowledge or access to other forms of power, such as government mandates.

Contribution 1 indicates that different settings (e.g., formal institutions or laboratories) have different consequences for how successfully actors are able to develop congruence. Contribution 1 also contends that methodological plurality is required to suit different epistemic preferences. Some prefer a more "fixed" boundary (e.g., to define an expert argument) and others prefer more "fuzzy" boundaries (e.g., to express values and be exposed to the values of others). In achieving a suitable and effective balance, as with Irwin's more general reference to third-order communication, there is no single correct approach. Returning to the idea of "pertinent" knowledge [13], progress comes from highlighting what needs to be known and recognising how the context might shape the development of someone's understanding and how it can influence their communication about that understanding.

Contribution 2 defines what they consider "fitness for purpose" regarding the tools they employed, creating "hybrid activities" from the approaches of different fields. In bringing artistic practice together with science and humanities, they aim to expose the reductionism inherent in conventional science and to nurture other ways of being and knowing that include more-than-human communities (i.e., from nature). Their careful approach to knowledge production is, however, not without its problems. Some scientists in their group expressed frustration with the qualitative and reflective methods of social scientists, viewing them as less rigorous than their own scientific methods.

Contribution 10 contends that more "hybrid" means of decision-making have emerged in managing natural resources as less top-down approaches have superseded previously bureaucratic, top-down methods. In these forms of hybrid governance, stakeholders collaborate to manage common-pool resources like water, land, and the atmosphere. What shapes the effectiveness of communication and people's ability to engage in these hybrid spaces is the person's access to different types of capital (e.g., social, cultural, financial). As with the previous principle that calls for reflexivity, Contribution 10 notes the importance of developing mechanisms to transparently surface and evaluate these differences in access. If imbalances are not known, what is communicated will not be reflective of the diversity of stakeholders' needs and interests.

Contribution 1 and Contribution 2 suggest that less formal communication spaces contribute to the successful co-development of problem framings and joint definitions of purpose. Arts-based practices are a common thread across other settings covered here to nurture informality. For example, the authors of Contribution 7 used graffiti-style murals on shipping containers and "design walls" (large pinboards for sketches and artworks) to re-engage primary school children in New Zealand with forest management. The externalisation of knowledge through arts-based practice is a key support for transdisciplinary work in that setting. As one of the children remarked about the design wall, "It was the first time I forgot what work was mine. . . All of it was our story". The arts-based practices used by the authors of Contribution 2 helped to bridge linguistic gaps and provided a "common ground" for members from different backgrounds and disciplines as part of a participatory process to assess soil fertility in the urban area of Milan, Italy.

The authors of Contribution 12 used visual methods, common in their field of architecture, to explicitly demonstrate the links between current situations and "yet-to-exist" possible, plausible, and probable futures, making these possibilities seem more concrete for community stakeholders. Through diagramming connections between multiple issues of a coal transition in a rural area in Australia's Hunter Valley, architecture students revealed potential alliances between unlikely industry and disciplinary partners. These diagrams offered previously unseen avenues for hybrid programmes to effectively address the complex and wicked problems associated with a fossil fuel transition.

Contribution 11 describes a culturally based apprenticeship model, which implies that knowledge is not merely explained but demonstrated in context. They characterise a situation where Kazakhstani farmers hosted workshops with policymakers in their villages, as noted earlier. In these familiar settings, farmers were more comfortable communicating to policymakers the challenges presented by official programmes and regulations

(e.g., problems with a subsidy scheme). This example suggests that the physical location of transdisciplinary work can effectively shape the communication of knowledge across disciplinary boundaries.

Contribution 1 raises the importance of facilitators in multi-stakeholder processes, particularly those who are able to balance the individual needs of participants with the common good of the community and society. Facilitators adapt methods to emerging project goals and create environments where diverse areas of knowledge can be gathered and considered to foster social learning. Contribution 1 uses the term "phronetic management" to describe this facilitation role. It involves reflexivity that leans toward "pragmatic action", drawing upon Loeber and Vermeulen [23], who have brought together the instrumental objectives of project management practice with the Aristotelian concept of "phronesis", or practical wisdom [24].

Intermediaries are also present in Contribution 10, the city walks article on water governance, where their use is less than successful, and Contribution 3, which discusses the climate resilience effort in Dayton, Ohio. Teachers in school settings can also be seen to play that facilitator role in the English eco-schools described by Contribution 4 and the New Zealand school described in Contribution 7. Whale scientists in Ecuador documented in Contribution 9 have positioned themselves at the junction between international conservation networks, national ministries, and local communities (including operators of whale watching cruises) to represent the perspective and interests of whales, leading to policies that benefit a wider array of stakeholders.

These cases suggest a need for—and the potential effectiveness of—carefully aimed and intentional approaches to facilitating transdisciplinary communication. These approaches include not just a shift in mindset but an openness to unusual methods and locations, and roles for intermediaries who can facilitate interaction and foster productive engagement.

Communicating across epistemic differences is also illustrated by Contribution 8 and Contribution 6, which contrast with the mainly qualitative and ethnographic work in the other ten articles. These two articles employ statistical methods to analyse large data sets of speeches on climate change by political elites (e.g., politicians in Contribution 8) and to assess responses to climate NGOs on social media (Contribution 6).

The authors in each case provide commentary on how their quantitative analysis can be informed by qualitative fieldwork, such as interviews, and how their conclusions can build on qualitative characterisations of specific settings to explore more general trends. This commentary provides a contrast with the framing of the qualitative articles, some of which illustrate a measure of "scientific-ness" in order to appeal to more technically minded reviewers and readers.

Both approaches underline the notion—evident across the set of articles—that in each setting, different bodies of knowledge vie for priority, suggesting that one is not just crossing a boundary but also subsequently finding a slot in a hierarchy. Transcending boundaries requires naming the paradigms that shape how different disciplines operate [13] so that their limitations might be made more explicit. In making them explicit, limitations can potentially be overcome by relying on other, complementary bodies of knowledge. That means, for example, recognising that while quantitative correlations between factors do not identify a cause–effect relationship, they can indicate a need for qualitative investigation. Conversely, qualitative investigations will provide deeper insight around causation, but they may lack the trend indicators that quantitative research uncovers.

The consideration of these quantitative analyses as "outliers" in this Special Issue underlines the potential value of this transdisciplinary principle of communicating across epistemic differences. Powerful insights can be gained through being open to the interplay between qualitative and quantitative work, as noted by Lee and Liebenau [25] in relation to their field of management information systems. A wilful transgression across these epistemic boundaries indicates the final principle for handling transdisciplinary wicked problems in the sustainability arena: engaging through solidarity.

(iv). Engaging through solidarity—It is almost a tautology to say that crossing disciplinary boundaries is common in multi- or inter-disciplinary approaches. In contrast, in transdisciplinary work, the aim is also to integrate the knowledge of people in non-academic roles and outside traditional professions through participatory engagement approaches [22,26]. The term "engagement" in sustainability arenas can be understood to imply boundary crossing, which can be achieved through various approaches.

When engagement between scientists and a range of sectors of public audiences is approached as a one-way delivery of knowledge from an expert to a non-expert audience, it is known as the deficit or public understanding of science model [27–29]. Subsequent theoretical developments have sought to engage stakeholders in two-way dialogue, or to cede almost full control from experts or corporate and government officers to the affected people [30,31]. However, this third-order trend in communication, which has been cited above, faces challenges.

Kankaria and Chakraborty [27], for example, explain that these "improvements" continue to locate engagement within hierarchies of power, where it is still an expert cohort making the judgement of what capabilities and methods would benefit the non-expert audience. Such positioning reduces the value of events that promote diverse inclusion to a mere instrumental "ticking of the box" approach to engagement [32]. That is, a broad, though constrained [33], range of types of stakeholders are included only to give the impression of engagement and not to make an authentic effort to comprehend or respond to their situations, understandings, needs, and perspectives.

In transdisciplinary work, engaging through solidarity means that diverse actors are valued for their different contributions, not just for their attendance. They add richness to the understanding of complex systems. Contribution 7, for example, states that children should be afforded the same respect as adults with the recognition that though they may have goals that differ from those of adults, they are nonetheless equal as eco-citizens. For working with children, Contribution 7 offers four key practices related to epistemic justice, the notion that all people should be respected as knowers [34]: (1) the development of equitable relationships; (2) giving opportunities for deep engagement; (3) giving spaces for both individual and collective thinking; and (4) granting adequate time for deliberation and reflection.

Respect for other forms of knowledge is also represented, according to Contribution 11, when scholars acknowledge that their understanding has developed from both expert and non-expert or local sources. Extending understanding, respect, and solidarity amongst individuals and among different disciplinary fields suggests procedural fairness and related ethical dimensions to transdisciplinary practice, as noted in Contribution 2. In seeking participants to volunteer, the authors of Contribution 2 created a large team whose members had a wide range of areas of expertise, bringing both "strong motivations and valuable knowledge". The integration of this value-based dimension led to the construction of knowledge that was more "socially robust", which they define as responsible, inclusive, and relevant. Contribution 1 notes that understanding the ethics and values of actors is crucial in working across difference in what she calls "in-between spaces". In these arenas, allowing for different values to coexist can be seen as part of the respect for different sources of knowledge and insight and the solidarity required for collaborative work on wicked problems. This notion can also be seen to underlie the focus in Contribution 1 on congruence rather than consensus.

In Contribution 3, solidarity is seen through the recognition of how systemic injustice—such as racial discrimination, poverty, unemployment, homelessness—affects a person's ability to respond to and recover from natural disasters. In their case study, although public officials recognise such chronic stressors as problematic, they do not attend to how stressors might affect public responses to long-term resilience planning. Residents, on the other hand, see that these stressors need to be addressed as part of community resilience building to avoid perpetuating inequity. This perception relates to the call from Contribution 10 to

make imbalances of power and access to social, political, and financial capital more evident so that they might be addressed.

Contribution 7, Contribution 2, Contribution 11, and Contribution 9 can be seen to promote the rights—or at least highlight the interconnection with social and political systems—of non-human species and ecosystems, such as whales, forests, and soil. Engaging in this work of solidarity introduces broader understandings of what communication and engagement may entail in addressing complex environmental issues. The whale populations described in the case study from Contribution 9 can be understood to break out of the enclosure of an economic paradigm (i.e., as a tourist attraction) to transform them into governable subjects worthy of ethical care, as is provided for humans.

In sum, the solidarity principle of transdisciplinarity that seems to emerge here suggests that, in addition to recognising complexity, reflecting on differences in sources of knowledge, and respecting those who rely on different sources, one needs to authentically engage across boundaries [35]. Engagement here implies not merely presenting to the "other" or ticking the box that they are in attendance but joining them in tackling the problems being faced.

One can conclude that the contributions in this Special Issue raise several challenges for practitioners and researchers who may want to be more transdisciplinary in practice, such as highlighting differences in values and beliefs, imbalances in capacities, and power differentials. To help in meeting these challenges, this synthesis article has distilled a conceptual understanding of transdisciplinarity based on the case analyses in the contributions.

The diversity of approaches presented in this Special Issue do not offer plug-and-play solutions. However, they provide several lessons for practitioners and researchers addressing sustainability that can help them to critically engage and possibly adjust how they undertake and explain their own work. These lessons can be summarised under the four principles described above.

i. Embracing complexity
   - Include a breadth of perspectives that match the complexity of the problem space.
   - Surface differences without forcing consensus. Move forward on those aspects on which you can agree.

ii. Surfacing differences through reflexivity
   - Involve a wide array of relevant actors (those with a stake) in framing the problem space.
   - Develop a respectful cadence to knowledge making. Slow down to allow for a less confrontational atmosphere.
   - Develop methods that support participants and allows them to feel safe to share their perspectives.
   - Make differences in framings and meanings visible so that they might be interrogated. Do so through tangible methods (e.g., posters, diagrams, design walls).
   - Offer a deliberate change in context. For example, go for a walk or create a mural.

iii. Communicating across difference
   - Meaningful (third-order) communication amongst stakeholders should occur early on and throughout.
   - Highlight what needs to be known and develop multiple strategies for use across different settings to communicate understanding (tools that are "fit for purpose").
   - To be inclusive, resist rigid formality in the setting as it can evoke historical differences in power.
   - Evaluate how differences in social, economic, and political capital can affect the potential of different stakeholders to engage effectively.

iv. Engaging through solidarity
   - Strive for epistemic justice, which includes respecting different bodies of knowledge.
   - Recognise how historic stressors might affect a person's capacity to participate.

While far from being comprehensive, this list reflects a diverse array of useful insights from the wicked problems and the approaches to address them that are described in this Special Issue. As with any list of heuristics, one can see a pragmatic flavour, such as in the "Celestial Emporium of Benevolent Knowledge" from Borges [36] that contains animal types such as mermaids, animals that belong to the emperor, and stray dogs. In this practical framing, the twelve articles have revealed the challenging messiness of engaging in transdisciplinary practices. Embracing this messiness and its potential to nourish the emergence of more meaningful environmental communication is a crucial step toward "being transdisciplinary".

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Your Sustainability Is Not My Sustainability: In-between Spaces for Meaningful Collaboration between Local Stakeholders and Planning Professionals to Construct Congruent Frames over Contested Meanings

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Abstract: Urban sustainability is a highly contested topic because the challenges of sustaining urban ecosystems are interlinked with environmental justice and equity concerns. In urban planning processes, this requires more collaboration between professionals and local stakeholders (citizens and entrepreneurs). Yet, participatory processes in urban planning are strained with various challenges. This article suggests that in order to consciously shape communication for meaningful collaboration, it should be studied as a function of communication spaces, termed "in-between spaces". These so-called in-between spaces are studied through the comparative analysis of two such spaces in the same brownfield redevelopment project in Amsterdam. The first space was created by an instrumental participatory process and the second through a co-creative approach. The spaces were studied through desk study and action research. The results indicated that fuzzier boundaries of in-between spaces and methodological plurality are needed for creating new congruent meanings, creating inter-dependencies between actors, and potentially fostering transformative learning, needed for sustainable urban development. Secondly, this article offers grounded insights into the contested interpretations of sustainable development between different sets of actors and identifies the potential of well-designed in-between spaces to make these tensions constructive. Lastly, this article highlights the diverse use of phronetic management (wisdom or 'mindfulness' in learning and leading attitudes for pragmatic action) by actors and the use of visual and creative methods for creating congruent meaning between actors, provided that local stakeholders feel ownership over the creative process and resulting output.

Keywords: participatory planning; meaningful collaboration; sustainability; communication; transformative learning; frames of meaning

1. Introduction

In the 1970s, Amsterdam was the site of contestation between planning professionals and residents because they imbued meaning differently to the notion of a "modern city" [1]. Fred Feddes, Dutch journalist and writer, reasoned that this was because the professionals envisioned a future of technical refinement, and the citizens envisioned one of social refinement [1]. Present-day Amsterdam, with its rich urban form and cycling culture, is the result of that contest. Half a century later, the city is again the site of a new but similar contest of meaning—what does it mean for Amsterdam to be a sustainable and liveable city in the future? Cities like Amsterdam are facing challenges like climate change adaptation, energy resilience, social injustice, procedural injustice, etc., which has resulted in the evolution of the field of planning: to become more reflexive by including integrated, adaptive, and participatory approaches [2–4]. This form of sustainable urban development, which includes multi-stakeholder perspectives, is highly dynamic and contested in nature [5–7].

Sustainable development is understood as a balancing act integrating social, environmental, and economic goals, but a common contentious question is "what is it that we want to sustain, and for whom?" [8]. Is it the current social order, or current production and consumption patterns that we want to sustain? Is it the integrity of (urban) ecosystems? And, if it is about the latter, what does a sustainable city look like? [6–8]. The ambiguity of urban "sustainable" development and its contested meaning is well-documented in the literature [6,9–11], with contradicting and competing definitions [12]. These contradictions reflect different interpretations, including environment–economy integration, impact on future generations, environmental protection, equitable growth to meet the needs of those lacking resources, quality of life beyond economic growth, and the participation of different stakeholders in recognising different needs [9]. These principles can result in fault lines between different actors; for example, the degree of environmental protection can vary while integrating the economy with the environment [9].

In the early decades, the focus of sustainable development research was mainly on ecological sustainability; but in more recent years, equity and environmental justice concerns have come to the fore to address the barriers created by the afore-mentioned fault lines [7,13]. Additionally, the challenges of urban sustainable development are interlinked and require an integrated and deliberative approach, between the governors and the governed [14] and between the natural sciences and social sciences [15]. Different knowledges (of municipal actors, of practitioners and professionals, and the tacit knowledge of citizens) are needed for locally attuned sustainable urban development [16]. Urban sustainability transitions—pathways to more sustainable urban futures—require fundamental changes in structures, in institutions, and in the daily practices of the various actors involved. Urban sustainability innovations need to be developed locally [7,8], and do require transformative learning [17]. Transformative learning in sustainable development is the ability for individuals and organisations to "recognise and reassess" their frames of meaning used to structure their expectations and assumptions about sustainability and the related policy areas (like mobility, sustainability, etc.), which inform how they feel, think, or act in various situations [18]. These frames of meaning determine their views on what needs to change and what needs to be sustained.

Due to the contested nature of sustainable urban development, this article studies how communication for collaboration takes place between different sets of actors within two distinct "communication spaces" [19]. Such spaces are dynamic and constructed by actors trying to "fix" space by asserting political, cultural, statutory, and physical boundaries [19]. The first communication space is "fixed" by an instrumental participatory process and the other by a co-creative process. To differentiate these communication spaces as a function of communication for collaborative practice between actors, as opposed to the exchange of information alone, this article identifies these spaces as "in-between spaces". Communication in these spaces is not for the purpose of conveying information but to create joint problem definitions and argumentation through interaction and translations between different actor groups [20], in this case, planning professionals and local stakeholders. These in-between spaces take form outside the immediate network of different actors, who leave their comfort zone to participate in collaborative processes. Establishing the boundaries of these "in-between spaces" allows the study of these contested processes and how they can be designed to allow for the exchange of perspectives, the joint creation of new meaning, and transformative learning.

Creating these collaborative in-between spaces is additionally challenging because the implementation of participatory planning processes do not necessarily lead to satisfactory outcomes [21–23]. Hence, this article additionally investigates the challenges and the paths to meaningful collaboration (i.e., collaboration which evokes a sense of purposeful and worthwhile interaction) in these in-between spaces that can lead to congruent frames between actors, which can lead to transformative learning. Congruence here refers to a pragmatic, contextual agreement on collaborative action between actors, each achieving a favoured value.

The article outlines the challenges of, the need for, and the paths to, well-designed in-between spaces for meaningful collaboration in sustainable urban development as follows. The first introduction section consists of (a) the background of citizen inclusion in urban planning projects, (b) meaningful [24] collaboration and the (re)construction of meaning through framing, and (c) phronetic management (actors using leading and learning attitudes for transformative change) [25]. Section 2 describes the research design and the methods used to gather empirical data. Section 3 outlines the results from the two different in-between spaces. Section 4 discusses the results in three sub-sections: (a) the challenges of creating well-designed meaningful collaboration within in-between spaces and the need for diverse methods to create them, (b) the potential impact of well-designed in-between spaces where contested interpretations of sustainability can be translated into the joint creation of new meaning, and (c) the role of actors involved and the potential use of creative methods. The last section concludes the article by emphasising the need for well-designed in-between spaces and avenues for future study.

In this article, the following research questions are addressed:

- How, and to what extent, do different in-between spaces allow for the communication of meaning and the creation of congruent frames of meaning between planning professionals and local stakeholders?
- How, and to what extent, do different frames of meaning lead to contested interpretations of the sustainability within these in-between spaces?
- Which qualities of in-between spaces allow for transformative learning, potentially leading to congruence between actors?
    a. What roles do different methods play in fostering transformative learning?
    b. How do actors use principles of phronetic management to foster good in-between spaces?

1.1. Background: Citizen Inclusion in Urban Planning Processes

The inclusion of local stakeholders in planning projects is challenging, and despite good intentions from professional actors, these processes are not always satisfactorily experienced by actors as genuine or meaningful. These processes are implemented in the form of citizen hearings, invitations for comments on zoning, citizen voting, and information evenings, amongst others [22]. The resulting dissatisfaction can result in anger and mistrust, or in people placed into polarised camps. Eventually, such experiences lead to alienation from the political planning system [22]. This article uses a classification from participatory literature that differentiates these processes as instrumental, deliberative, and empowering [26,27]. The latter two categories have transformative potential [26] which can be understood as transformative learning where actors can find congruence between formal knowledge and the lived spatial expertise of stakeholders. This can generate new ideas, congruent meanings, and stronger social networks [28].

The Netherlands has an established history of (instrumental) statutory participatory processes, partly encoded in law. For example, participation in the Municipality of Amsterdam has been prescribed in the "General Participation Ordinance" since 2016 [29]. Additionally, the new Dutch Environment and Planning Act 2024 ("Omgevingswet" in Dutch) gives more legal prescriptions for the inclusion of citizen perspectives in order to strengthen adaptive capacity through knowledge sharing and to create social capital [30]. There is also a local professional culture which gives space to (partly) foster deliberative democracy (as an example, [31]) and empower participants through (co-creative) processes in participation (as an example, [32]). Despite this rich history in participatory planning practice, a report on the development trajectory of a housing project in Amsterdam by the regional Ombudsman concluded that there was a "gap" between citizens and professionals. This was despite efforts by the Amsterdam municipality to facilitate citizen inclusion through various formats, such as "value walks, game-based processes, and 'living-room' sessions", etc. [33]. The report identified areas of miscommunication, particularly where citizens were unclear as to their role in these processes and felt that they were participating in

matters that had been decided on or had little say in. Yet, the report [33] also noted that the municipality had good intentions to facilitate participation through informing, commenting, and ensuring that citizens had a say in the redevelopment of their living environment.

This contradiction in how participation is envisioned by planning professionals and how participation is experienced by local stakeholders is a case in point of a more general phenomenon, documented in the planning and participation literature [23,34–36]. Citizen participation in planning processes is often seen in public discourse as a chance for citizens to "feel heard" or "feel involved" [33]. However, the notion of "feeling heard" assumes that citizens only want to be heard, as opposed to being understood, and their input valued by the recipients. Furthermore, this contradiction stems from a history of the planning profession imposing plans that did not match how citizens perceived their city, because it was assumed that their needs were understood by the professionals [37]. In Amsterdam, this is further fuelled by policies that have reduced the social housing stock in the city, leading to long waiting lists and creating more distrust [38]. Additionally, participatory processes have gained the negative image of a tokenistic exercise undertaken by policymakers to "tick the box" [23,39]. This results in an unbalanced space where citizens offer their time to validate, or add to, the knowledge of planning professionals, as opposed to a space where new transdisciplinary knowledge is jointly created by teasing the tension between professional and local knowledge. While there is more awareness amongst planners to include citizens in practice, centralised and rationalist modes of thinking are built into the field and require changes in the system. However, there is an example of flexibility from the municipality of Amsterdam, in response to a group of residents who underwent a participation strike, which has resulted in a co-creative relationship between the actors involved [40].

This contradiction has three noticeable consequences: firstly, an increased resistance to the implementation of sustainable urban development plans; secondly, a missed opportunity to incorporate local expertise into the development of such plans, which can lead to their success and increased value for stakeholders; and, thirdly, participation fatigue [21] within actors (both professionals and stakeholders).

1.2. Meaningful Collaboration for Congruent Frames of Meaning

The working definition of meaningful collaboration in participatory planning processes can be drawn from the work of Yeoman [24] as the ability for local stakeholders and planning practitioners to engage with each other over their living environment while maintaining a positive emotional connection to (a) the physical and imagined city, (b) other actors, and (c) the participatory process without feeling alienated. The need for collaboration, which evokes a sense of genuine and worthwhile interaction between actors, is well documented [21,26,33,41]. Yet, meaningful collaboration between different actor groups is challenging because they operate from different frames of meaning, with assumptions and expectations based on their experiential knowledge, their value systems, and their background theories (academic or professional) [42,43]. These different frames also result in the contested interpretation of sustainability by different actors.

Nonetheless, participatory processes allow the opportunity for local stakeholders and planning professionals to communicate their frames of meaning, engage with other frames of meaning, and create new congruent frames of meaning. For instance, these processes allow actors to engage with one another, with the potential to enrich their lived experience. This can potentially result in the creation of new joint frames of meaning, and empathy for other frames of meaning. These new congruent frames (not necessarily shared) are the needed groundwork for transformative learning that can lead to collaborative action between stakeholders [43]. Congruent frames, as opposed to shared frames or consensus between actors, means that different actors within the planning projects (both planning professionals and local stakeholders) can recognise their values and have their needs met by the city (or development process), resulting in common action [43]. Congruent frames are both a result and a catalyst for meaningful collaboration in participatory processes

because they allow actors to create interdependencies and interlinkages between different groups, while maintaining positive emotional connections to the real and imagined city, the actors, and the participatory processes themselves. These congruent frames of meaning can be potentially fostered within well-designed in-between spaces.

1.3. In-between Spaces for Collaboration and Phronetic Management

In-between spaces can be defined as abstract spaces of communication between distinct actor groups. These spaces can potentially foster transformative learning and the construction of congruent frames of meaning. These spaces are similarly described by Duiveman as spaces that foster problem structuring through interaction and translations between two distinct communities or disciplines [20]. In urban planning, these in-between spaces are created between the boundaries of different communities, namely, planning professionals and local stakeholders (typically laymen like citizens or entrepreneurs).

These spaces are also similar to solution-oriented transformative spaces [44], as "safe-enough" collaborative learning spaces for sustainability transformation. However, the goal of in-between spaces is not to find solutions but to create congruent meanings around contested topics. They also share similarities to "communities of practice" [45], but they remain different because, while actors share interests (the redevelopment of the city), their spheres of expertise are too dissimilar for "shared practice". These in-between spaces are also unique from other boundary-spanning (crossing) techniques in the boundary-spanning literature because their objective is to facilitate interaction between two domains while preserving the integrity of the boundaries. Crossing boundaries alludes to continuity across two domains by fulfilling a bridging function [46,47]. Planning professionals are bounded by their professional mandate, laws, experience, etc., while local stakeholders are bounded by the mandates of their daily lives, profession, or businesses. It is unreasonable and impractical to expect continuous exchange and knowledge production between these two groups, unlike interprofessional knowledge production, where the actors are bounded by more similarities than differences (for example, similar working hours and overlapping institutional cultures).

Now that they are defined, it is important to understand how they can be initiated and maintained by actors who take on this role. These individuals may originate from the different actor groups, with a capacity for self-critical reflection and an intrinsic affinity for communicating with the other, or an independent actor hired or volunteered for this role. These individuals are unique because they can use learning and leading attitudes with principles of reflexive phronetic management, as articulated by Loeber and Vermeulen [25], to create these spaces by (i) balancing individual needs against the common good (like sustainability), (ii) adapting project goals to emerging project needs, (iii) creating a neutral environment where diverse types of knowledge be balanced against the operation of power in institutional settings, and (iv) fostering transformative learning within the participants (and internally in the in-between actor). Phronetic management can potentially create the necessary conditions for making pragmatic agreements for fixing boundaries of in-between spaces.

2. Case Description and Methods

2.1. Case Description: Sustainable Redevelopment of an Amsterdam Brownfield Area

In 2021, the municipality of Amsterdam published a vision for a "humane metropolis" [48]. This vision was to be realised through five strategies: polycentric development, growth within limits, sustainable and healthy mobility, rigorous greening, and making the city together [48]. The brownfield area in question falls under the city's ambition to phase out polluting industrial activities within the city limits, which currently contribute to 18% of the city's carbon emissions [49]. One of the resulting projects was that a portion of the current industrial area would be transformed into a mixed live-work area in the next 15–20 years, also taking into consideration the housing needs of the city [50]. The brownfield area included very few residential buildings; however, its boundaries overlapped with the

ongoing civic functions of the city (like public green spaces and sports facilities). While the area of the brownfield redevelopment project would be limited to three neighbourhoods in Amsterdam, the pool of stakeholders included five adjacent neighbourhoods because of the anticipated impact. The impact is significant because the current population (using the city's place-based approach to demarcating boundaries) will increase from 42,000 households [51] by an additional average of 55,000 households [52]. It is also relevant to note that, in 2023, for the area (and its surroundings) in question, nearly 80% of the existing population had a mid-high education level, 43% of the population had a non-migration background, 21.9% of the households had children, and nearly 15% of the population were 65+ years old (retired) [51].

As a part of the city's vision, the municipality of Amsterdam published a policy document outlining its ambitions for the brownfield redevelopment plan. They envisioned a mixed-use development with more housing, more jobs, a new low-car mobility perspective, and a greener healthier district that was targeted at starters, retired persons, students, expats, single-households, and families.

As per the city's statutory framework for participatory planning [29], the policy document was opened to comments or perspectives from local stakeholders (including citizens, entrepreneurs, and social organisations). This article will use the term "local stakeholders" to refer to this set of actors and fall back on specific terms (like citizens or entrepreneurs) when specificity is needed. The local stakeholders responded with nearly 400 comments, which were predominantly pessimistic about the municipality's ambitions. As per the statutory process, the municipality responded to the comments within a period of six months, along with two pages of changes to the policy document. The policy document, the 400 responses from the citizens, and the response from the municipality summarising the comments along with answers (80-page document) formed the dataset to study the first in-between space. The citizens did not feel that the municipality offered a meaningful response to their questions and concerns. Some citizen representatives expressed their dissatisfaction by writing letters and organising field visits (bike safari and walking tours) with the municipal team. This dissatisfaction eventually led to new arrangements: a one-year experimental city-lab or citizen consultation group set up by the municipality, with a vision to "do better participation". The second in-between space is represented by these new arrangements. The core team maintaining the second in-between space included local stakeholders (a citizen collective and entrepreneurial representatives) and the project team from the municipality, and an independent facilitator was hired by the municipality. The citizen collective comprised eight different local citizen-led associations, for example, residential associations, allotment garden associations, sports associations, park management associations, etc. The goal of the core team, developed jointly under the guidance of the facilitator, was to identify relevant issues in order to develop a multi-value qualitative framework of the existing area. This framework was conceptualised to dynamically capture the "soul" of the area (at the request of the citizens), and it was to be updated periodically (by continuation of the city-lab) and to be referenced by planning professionals during the subsequent phases of the project. To identify themes and content for this multi-value framework, the core team organised public workshops targeting specific sub-groups within the local stakeholders (residents, entrepreneurs, teenagers).

The next section discusses the methods used to collect and analyse the data.

2.2. Methods

Action research has been identified as a relevant methodology for creating new actionable knowledge, enhancing collaborative governance arrangements, and facilitating systemic changes that are needed to address the inter-linked challenges of urban sustainability [53,54]. This research used a bifurcated approach to action research for urban collaborative governance: conducting action research and linking theory with practice [54]. The following stages [54] were used in the research design: pre-research, fieldwork, analysis, design and experimentation, and output. Due to the nature of action research, these

stages are blurred and overlapping in practice [54]. The activities in these stages included negotiating the starting point, enacting multiple roles and responsibilities, challenging the existing structure, and reflexivity [53].

The results were produced through a comparative study between the two in-between spaces: (1) based on typical instrumental participatory planning practice and (2) based on reflexive arrangements for a more co-creative approach.

The first in-between space was studied as a part of the pre-research stage of the research project, through observations, desk-analysis of the policy document, a thematic analysis of the 400 comments by the local stakeholders, and the response by the municipality.

The second in-between space was the one-year city lab with a core team (local stakeholders, municipal project team, and facilitator). The activities of the core team over a period of ten months were studied as part of the fieldwork stage of the research design. This required the author to become a contributing member of the core team, by being sincerely interested in their collaborative goals, by being a committed ally (not just collecting data), and by having a "hands-on" approach [54]. The author had a variety of roles in the project: supporting the core team to make visual objects to capture contested meanings, brainstorming ideas for the workshops, supporting implementation, and offering reflection moments to different actors during one-on-one discussions.

The fieldwork stage included the author's participation in seven meetings by the core team, two public workshops organised by the core team (approximately 120 participants), individual meetings with stakeholders, and three codesign meetings with the citizen stakeholders. This fieldwork stage also combined the "design and experimentation" stage [54] undertaken in collaboration with the facilitator and others in the core team.

The second in-between space was studied using fieldnotes by the author, the communication within the core team, and the output from the activities of the core team, such as documents, maps, and drawings.

In both spaces, the observations noted are through the perspective of the author's professional background as an architect, urban planner, and a social scientist. This unique position allowed the author, as an action researcher, to approach different actors with an empathetic lens.

An abductive approach was used in the analysis of the data collected from both in-between spaces. Three (overlapping) themes emerged from a preliminary overview of the data, which indicated contested meanings around sustainability: urban and architectural elements (towers, industrial heritage, landmarks, land parcels, etc.), green and water (recreation and ecological values), and mobility. The resulting themes were used to filter the data, which were manually coded using the seven building blocks or elements, as suggested by Sullivan to study communication spaces (ideas, objects, ethics, practices, rules, emotions, and expertise) during collaborative work [19]. The analysis of the data was parallelly fed back into the work of the action research while reflecting on the case with actors in the core team.

The work of an action researcher is challenging, in that it requires maintaining a neutral position as a researcher. At the same time, action researchers have the unique position of empowering the less powerful through knowledge and capacity [55]. These dilemmas made reflection with colleagues and other co-inquirers a necessary part of the research.

3. Results

3.1. First In-between Space

The boundary of the first in-between space was fixed by the *rules* and the *process* of the municipality's statutory framework for participation and a policy document which outlined future plans for the district. Commenting in the process was open to stakeholders and those interested in the project. The participatory process was limited by the statutory framework as the ability to put forward opinions to the proposal and offered no space for formal objection.

The *object* at the heart of the first in-between space was the future city imagined by a policy document, which also sought to spatially consolidate policies for the region. This core object was formed by *ideas* that actors had about the city, based on their frames of meaning or perception of what was acceptable or not acceptable. The municipality formed these ideas based on institutional knowledge and professional expertise. The ambitions outlined in the policy document were based on a set of principles for sustainable urban development, which included a dense work–living environment, a car-less environment, improved public transportation, preserving the cultural characteristics of the city, etc. The citizens formed their ideas of the city based on their lived expertise of the built environment; for instance, the 2020 global pandemic had resulted in an increased appreciation for a healthy active lifestyle and accessibility to open spaces. Additionally, citizens may form ideas for the city based on historical events or actions by the municipality [56]. For example, some citizens believed that high-rise buildings did not fit the urban morphology of the city; this view comes from the local historic failure of high-rise housing [57].

The instrumental nature of the first in-between space allowed the municipal actors to demonstrate their *expertise* through the policy document. It was roughly 150 pages, with photographs of existing and imagined spaces (through examples from other cities), explanatory text, structural plans of the area, and illustrations with architectural typologies that reflected the policies for the area. The use of dense professional language, both written and visual, was criticised by citizens for being inaccessible to laymen. The use of international reference images was not appreciated by the citizen stakeholders because they felt it was a technique used by planning professionals that sometimes ignored local contextual factors.

Though the written format of the statutory process imposed limitations on sharing their lived experience, the citizens still demonstrated their expertise by sharing their perception of future problems and the valued parts of the city that would be lost as a result. They also demonstrated expertise through the mobilisation of voices. Nearly 25% of the comments were recognisable variations of "manifestos" by local community organisations or small alliances (groups of two or three people writing together) to increase their impact. Some citizens also shared their own professional expertise, and a few used emotions through the written word (like short poems) or evoked visual local references from the Netherlands or past examples of urban development that did not have successful outcomes. The local stakeholders also had singular diverse opinions to share, ranging from mild dissatisfaction with the high-rise buildings and low household-to-parking ratio to wind turbines destroying houseboat communities, amongst others.

In the responses from the municipality, comments from the citizen stakeholders were anonymously filed under different themes (like housing, mobility etc.). The comments of approximately a dozen companies or associations were also responded to (not anonymised). Table 1 illustrates the imagined future of the brownfield area, focusing on three themes: architectural (such as buildings) and urban elements (such as land parcels), blue and green networks (for their recreational and ecological value), and mobility.

Multiple citizen respondents also echoed a joint plea to, "do real participation". However, the municipality emphasized that appropriate participatory meetings, both online and in-person, would take place at different phases of the project. The changes to the policy document by the municipality were under two pages long. These included updates to the legends of maps and the rewording of some sentences for improved clarity. Specific topics were set aside for further study. There were no significant concrete changes with spatial impact apart from the exclusion of the city-level park (as a consequence of an earlier adopted motion in the local council) in the green calculation and the removal of a speed limit for bike lanes in neighbourhood streets. It is also clear that there was a lot of uncertainty, and the municipality did not have clear answers at this phase of the project. The uncertainty was also compounded by the challenges of integrated sustainable urban development, which is dependent on other governmental and private stakeholders and not just the municipality.

Table 1. Table illustrating communication of meaning in the first in-between space.

Municipal Policy Document	Local Stakeholder Comments	Response from the Municipality
	Architectural or urban elements	
Highly dense work-living environment to accommodate more than 100,000 new residents and an additional 50,0000 jobs.	Went against the idea of having a village-like or garden-city-like experience in the city. Some citizens were concerned that many high-rise buildings in the city are not successful for various reasons (wind tunnels, shadows cast on surroundings). The citizens wondered if the municipality had truly considered these technicalities.	The municipality reiterated the underlying principle, the redevelopment was to be a highly dense urban district. They suggested that further studies and exploration with urban forms were needed to answer questions.
Many old industrial buildings were set for demolition, and parcels of land allotted temporarily for cultural activities were to be phased out to create space for new buildings.	A few citizen stakeholders emphasised the existing culture in the city, where buildings were creatively appropriated by entrepreneurs and cultural organisations.	Many of the buildings in question or plots were not owned by the municipality, and plans for that were largely dependent on their ability to acquire property. The municipality did not have free space to allocate for creative appropriation by local stakeholders at this stage of the project.
Land currently allotted for a sports association had been demarcated for other uses. The policy document proposed compact sports parks.	The citizens felt that a much-loved sports institution and community association that was integral to health, well-being, and strong community ties had not been given recognition in the policy document. The citizens felt strongly that such locally developed institutions were extremely important. They also believed that the current location was paramount because of its accessibility (biking distance for children).	The municipality agreed that the sporting facilities were important. The sports and community centre could stay until the end of the lease (less than a decade away). The sports facility would be relocated eventually, but the current position after lease expiry would remain uncertain until there was more clarity about the extension of the metro line to improve public transport connectivity.
	Blue-green networks (ecological and recreational value)	
An existing city-level park was extended to be included in the new project.	The citizen stakeholders valued and intensively used the existing city-level park and were unable to comprehend why it was included in such a dense urban development. Broadly, the citizens were concerned about the green space standards being followed in the project.	The municipality responded that a motion was passed in the local council to consciously not include the city-level park in the green space calculation. However, there were privately owned green spaces adjacent to the city-level park that the municipality wished to acquire. The relevant green standards were not elaborated further.
The policy document proposed that some of the much-needed green space would be achieved through green roofs.	Some citizens felt that green public spaces on roofs did not have the same accessibility as the existing "grounded" green spaces.	Not mentioned.
	Mobility	
The municipality aimed to only allow a car–household ratio of 1:5.	A few citizens were concerned about the impact this would have on car ownership. They felt that it was not always feasible for everyone (differently abled, parents of small children) to use public transport (currently expensive). It is important to note that, despite car parking being a contentious topic in participatory planning projects in the Netherlands, it was not a large theme in the responses.	The municipality reiterated that the underlying principle was to have sustainable mobility (with only 20 per cent car usage). The municipality assured the citizens that shared mobility, a high-quality public transport network, and cycle infrastructure would compensate for personal car ownership. However, the affordability of public transport was not addressed in the response.

Table 1. *Cont.*

Municipal Policy Document	Local Stakeholder Comments	Response from the Municipality
The policy document had an ambitious plan to have a high-speed cycling infrastructure that connected this new development to the rest of the city.	The citizens appeared to be outraged that the proposed cycling infrastructure cut through allotment gardens that were carefully maintained by residents and was uniquely home to special urban flora and fauna. They believed that it was paramount to protect the unique flora and fauna in such a dense city like Amsterdam. They also pointed out that efficiency alone was an outdated parameter for designing cycling infrastructure; elderly people, children, and leisurely cyclists needed to be equally accommodated.	The municipality reiterated the importance of the cycling infrastructure as a part of the policy document's new mobility paradigm. However, they acknowledged more studies needed to be conducted to explore alternative routes.
The policy document illustrated a plan to improve public transport connectivity (metro line) of the brownfield area to the centre of the city.	Some citizens were concerned that the route indicated on the structural map would disrupt spaces in the city-level park.	The exact route of the metro line had not been decided at that moment; hence, the municipality could not offer any certainty but acknowledged that more participatory processes with stakeholders were needed with the affected parties.

It is also important to consider the *ethics* and underlying value framework of the actors. The municipality's values are echoed in its vision for the sustainable development of the city. However, the citizens have different value frameworks that illustrate the physical characteristics of social sustainability [13]. For example, when citizens brought up concerns of wind turbines in proximity to their homes and businesses, or about the predominance of public transport in the project, it was important to understand the values and ethical identities of the citizens at play. The objection to the wind turbines was a concern that houseboats (affordable housing) in proximity would be lost, and the objection to public transport was not in principle, but rather to the high price of public transport in the Netherlands.

Ultimately, the municipal responses were deemed unsatisfactory by the citizens. A select group of representatives of citizen groups continued to discuss the policy document and the municipal response. They adopted different methods to convey their dissatisfaction to the municipal project team, by instrumental means, such as writing letters to the Alderman and the project manager, and by creative means such as field visits (bike tour and walking tour), where the citizen stakeholders invited professionals from the municipal project in order to offer their lived-experience perspective of the policy document's spatial implications. The project manager was unable to make promises regarding concrete spatial changes in the policy document but agreed to set up a city lab to deliberate the concerns of various stakeholders.

3.2. Second In-between Space

The second in-between space was significantly different from the first space, in that it was developed as a dynamic experimental studio *process* as opposed to being determined by a statutory framework. The boundaries of the space were "fixed" by the active citizen stakeholders and the project manager, who collectively exhibited partial characteristics of phronetic management (leading attitudes) by exerting influence on the existing system [25]. The citizens advocated for a more collaborative approach to jointly create new meanings around the core *object* (the sustainable redevelopment of the brownfield area), and the project manager was able to set up the new process outside of the municipality's statutory framework. While this was a joint outcome, signifying new congruent frames, there were no *rules* highlighting obligations and expectations from the actors involved. This is similar to what some academics have described as fuzzy governance [58], which can have the potential for collaborative learning [59].

The project manager appointed an independent facilitator from a conflict resolution agency with academic ties to maintain the second in-between space. He also accepted the role of an action researcher (the author of this paper) on request from the citizen stakeholders. The facilitator was to organise a city-lab in the form of a collaborative studio process between the local stakeholders and the project team (jointly called the core team). The studio was defined as a transparent process where citizen stakeholders could jointly work with the project team towards the next phase of the brownfield redevelopment project. It is important to acknowledge that, at this point, the citizen stakeholders were fatigued from engaging in this process for nearly two years (since the publication of the policy document) and were suspicious of the project manager and the project team behind him. They did not want to just "feel heard" but have a genuine impact on the outcomes. The municipal project team were simultaneously concerned because some of the citizen stakeholders' worries were dependent on decision-making within the political sphere, where their role as civil servants was ambiguous. It was agreed within the core team that there needed to be a clear understanding of the "negotiables and non-negotiables". The municipal team also emphasised that it was important that the process would extend beyond the demographic reach of the citizen representatives in the core team, for the perceived legitimacy of the results.

The facilitator took into consideration the concerns of the different actors before setting the ground rules for the process and putting forward a year-long proposal. The proposal included three public workshops with a broader reach of stakeholders from different target groups. The citizen stakeholders also emphasised that, while there were power differences at play, they did not feel they were inferior in strength and capacity as contributors to the development of the city. They were to be jointly planned and the results analysed by the core team. An agreement was made that the output of the studio process would not be design proposals but rather a multi-value framework of the stakeholders of how they perceived (and valued) their living environment. For the citizen stakeholders, this was important because their criticism of the policy document was that it failed to capture the "soul" of the existing lived environment and their lived experience. The project manager later instrumentalised this by proposing that the output of this studio would be an appendix to the original policy document and brought to the municipal council (local political sphere).

The public workshops were designed by the core team to elicit diverse opinions through diverse means. The participants were invited to share their contributions to the value framework through pitches, mapping, and the opportunity for one-to-one conversations with the core team. The first workshop was targeted at citizen stakeholders, the second at the entrepreneurial stakeholders, and the third was planned to target future residents (namely teenagers). The composition of the core team evolved to take into consideration the themes, the urgency, and the desired target groups.

The content of the core *object*, the imagined future city, was comparable to that of the first in-between space, and, hence, is not discussed in detail in this sub-section. However, how the content was communicated differed in important ways. The nature of the second in-between space was conducive for local stakeholders to communicate their concerns with both creativity and emotion, during both the public workshops and the core team meetings. Visual and creative methods of communication had an important role in the second in-between space. The fuzziness of the space allowed stakeholders to explain their concerns on maps, using reference images, pitches, storytelling, and poems. Written arguments were also made, when the visual or creative methods failed to capture the accuracy of some perspectives. The fuzziness of the space also allowed the facilitator and the action researcher to experiment with new visual methods to capture the multi-value framework of the stakeholders.

A significant result was that entrepreneurial stakeholders and citizen stakeholders were able to build empathy for one another. During the initial stages of planning the second public workshop, entrepreneurial stakeholders wished to keep their relationship with the

municipality project team separate from that of the citizens. This was because they had felt that their concerns were different, and that the interaction was not beneficial. Though the role of the citizen stakeholders were relatively minimised in the second public workshop, some entrepreneurs reflected on their position and appreciated the opportunity to find common ground (uncertainty), exchange perspectives, and expand their local network.

The second in-between space was more conducive for local stakeholders to offer their professional *expertise*. This expertise included both lived experience and professional knowledge or skills from other related domains (land development, engineering, architecture). However, this also meant that some skilled actors were able to advocate for specific themes. This means that the proportion of how much attention a theme received varied in both in-between spaces. For example, public transport infrastructure routes received more space for discussion in the second than in the first in-between space, because its impact was understood from citizen stakeholders with more experienced lenses.

Despite the above examples illustrating potential for transformative learning, various issues made collaboration a challenging exercise.

Firstly, the project manager had set up the studio process outside the institutional framework. This had consequences for project management due to the budget made available and the capacity of the facilitator and project team. This often led to miscommunication between the actors.

Secondly, the time it took (nine months since the municipal response) to set up the second in-between space also led to unrest and deepened distrust for the municipality amongst the citizens. The first in-between space additionally spanned roughly over a year. In the field of planning, such a timeline is relatively speedy for projects of this scale. However, it is notable that time duration is relative to different actors within the in-between spaces. The citizen stakeholders are particularly impacted by the prolonged uncertainty without the opportunity for professional detachment.

Thirdly, the fuzziness of the second in-between space that promoted inter-personal relationships across actor groups, paradoxically created situations where discussions became contentious, which made planning professionals uncomfortable. Such situations fall outside their expertise, and required actors like the facilitator and the project manager to use phronetic management skills to diffuse tense situations.

Fourth, in contrast with the first in-between space, where the citizen stakeholders collaborated internally within their associations to communicate their perspective, the second space played out differently. The core interests of the citizen stakeholders participating in the core team varied depending on their representative organisation or their own interests. In the interlude between the two in-between spaces, they had a common goal—the need for the second space. However, once that goal was achieved, their ability, capacity, and desire to maintain a coordinated front reduced.

Lastly, the municipal project team remained dissatisfied with the limited reach of the public workshops. The institutional framework that they operated under emphasised a link between legitimacy and demographic reach. They felt that a third workshop with young participants (teenagers) was critical before further analytical workshops were designed. Some citizens felt that this was a tactic to delegitimise their frames of meaning, however this was not the general opinion.

Despite the above-mentioned problems of the second in-between space, its inherent fuzzy nature also allowed the actors freedom to discuss them, re-establish trust, and adapt the programme of the process when needed. After the second public workshop took place, citizen stakeholders who were concerned about the legitimacy of the project could approach the facilitator, the project manager, and the action researcher with their concerns. It allowed the project manager to show evidence of legitimacy by describing how their comments were being used to make decisions for the public transportation routes in other spheres of municipal decision-making. It also allowed the facilitator and action researcher to reflect on methods, to reflect on how decisions were being communicated, and to re-evaluate the intended end output of the multi-value framework that was to be appended to the policy

document. The facilitator played a key role in diffusing tensions. It was also apparent from the feedback of the citizen stakeholders that the use of visual and creative objects was not always successful because stakeholders needed to feel ownership over them.

The citizen stakeholders also recognised a need to meet independently of the core team meetings or individual conversations. A significant learning outcome in the meetings with the citizen stakeholders (outside of the core team) was that drawing together was a way to learn together (social learning) [60], and subsequently create joint meaning together. The city-lab studio programme was adapted to include additional on-street workshops organised by the citizen stakeholders and the project team, with the ambition to draw and learn together on-site. These were proposed to take place parallel to the last remaining public workshop of the city-lab programme. Considering the negative impact of the existing budgetary and capacity constraints, the outcome of this addition to the programme remains to be seen.

4. Discussion

There are three significant insights that can be drawn from the results. Firstly, that there are favourable and unfavourable elements of both in-between spaces for communication of meaning. The way the boundaries of in-between spaces are "fixed" can have consequences for meaningful collaboration and the potential for congruent frames. A fuzzier boundary has more meaningful outcomes than an instrumental boundary, though methodological plurality is key. Secondly, the frames of meaning that the planning professionals and the local stakeholders used to discuss topics like liveability, green spaces, and sustainability are contested. However, there is potential to turn this contested meaning into positive outcomes. Thirdly, the analysis of both spaces offers insights into the methods and the role of actors needed to facilitate or maintain meaningful collaboration.

4.1. Collaboration within In-between Spaces Created in Participatory Planning Projects

Despite the limitations of the statutory procedure, the first in-between space allowed the citizens to reflect and renew their positive association with (their existing) surrounding environment and articulate what they wanted for their future and for generations to come. It also led to collaboration between individuals to collectively make joint statements (visions and manifestos). The procedure had a wider reach than those who may have physical or time constraints to contribute in-person. The written format was partially suited to those who had the intellectual capacity to process a long document and make clear counter arguments. Others could appropriate it by using poetic expression or linguistic means to share emotion. However, there were limitations for the format to fully capture the emotional links to the city, which were more visible in the second space. Ultimately, the written format had both positive and negative characteristics, which indicates a need for methodological plurality.

The statutory framework also reinforced the boundaries of the planning professionals' expertise, by allowing the municipal project team time to reflect on the comments and give deliberate answers. While this was perceived unfavourably by the local stakeholders because they did not have the opportunity to exchange arguments, the space shielded the professionals from contentious discussions by helping maintain the boundaries of their expertise. However, it did not offer space for them to exercise or develop expertise in fostering collaboration or in creating congruent meaning with other actors outside their immediate network.

The first in-between space fostered the partial creation of congruent frames across different sets of actors by highlighting contested meanings around sustainability. It also partially fostered meaningful collaboration by allowing stakeholders to articulate their values and develop new appreciation for their current living environment.

In contrast, the boundaries of the second in-between space were fuzzier [59]. This meant that citizen stakeholders were able to interact and develop a relationship with the municipal project team. Both the core team meetings and the public workshops allowed for actors to develop these relationships outside of their immediate network.

This allowed actors to recognise the values and needs of other actors, and communicate meaning through these specific frames. The municipal project team saw that citizen stakeholders were unable to recognise the "soul" of their current living environment in the policy document, and they were open to an appendix to the policy document that captured the multi-value framework of the local stakeholders, in order to address this problem. Similarly, the citizen stakeholders were able to understand the concerns of the project team regarding the prolonged timeline. This space also allowed planning professionals to experience the emotional connections that local citizens have with the city that could be severed during urban redevelopment. However, the fuzziness also made the second in-between space laden with uncertainty regarding roles and responsibilities. The facilitator played a key role in using phronetic management, repeatedly reinforcing and reiterating the ground rules set at the start of the project.

In addition, the fuzziness of the second in-between space disrupted the expertise of the planning professionals. This disruptive nature meant that planning professionals had the opportunity to learn from the discomfort and embrace a new collaborative persona.

The space also gave more room for the use of visual and creative methods to make contested meanings of sustainability by highlighting contradictions between policy and their spatial implications (elaborated in Section 4.3).

To conclude (See Table 2), the manner in which the in-between space is created has consequences for the development of interdependencies between actors, which is an important aspect to address the inter-linkages of urban sustainability challenges.

Table 2. Comparison between the two in-between spaces.

	First In-between Space	**Second In-between Space**
Boundaries of in-between space	Created by the publication of the policy document and facilitated by the statutory framework for participation.	Created by the citizens and the project manager's capacity for phronetic management (leading attitudes), and fostered by the facilitator (learning attitudes)
Type of participatory process	Instrumental.	Deliberative, co-creative.
Methods	Written (policy document, comments) and visual references. Appropriate for some to share emotions using creative or linguistic means.	Use of written, and visual methods both in the workshops and the core team to share emotional links with the living–working environment.
Phronetic management	Citizen stakeholders and the project manager exert pressure on the existing statutory framework by balancing leadership attitudes.	Exhibited by the project manager and the facilitator, exhibiting a learning attitude to maintain the integrity of the space.
Transformative (learning)	Contested meanings over sustainability were made visible, but learning was limited to the boundaries of the actor groups. The need to disrupt the process set up by the statutory framework was a significant learning outcome.	Contested meanings over sustainable development were visibly discussed outside the boundaries of the actor groups, and was more apparent through visuals, mapping, and storytelling (pitches).
Construction of congruent frames	Partially. Citizen stakeholders were able coordinate their efforts to articulate their values and their vision for their future city.	Partially. Stakeholders and the municipal project team were able to empathise with each other's frames.
Meaningful collaboration (positive associations with the city, processes, and actors)	Partially. Space to articulate values and make positive associations with the existing city and the desired future redevelopment, and to strengthen the connection with other stakeholders within their network.	Partially. Space to articulate values and make positive associations with the existing city and the desired future redevelopment, and to strengthen connection with other stakeholders outside their immediate network.

4.2. Contested Frames of Meaning and Implications on the In-between Space

The contradictions and dilemmas of urban sustainability played out empirically in the brownfield redevelopment project in two ways. This is illustrated through the concerns about the green space in the city.

Firstly, this was observed through the competing values of the different actors. The data illustrates the citizens' frames of meaning while imagining the sustainable redevelopment of the brownfield area, which was linked to their personal or cultural values, their lived experience, and their own professional backgrounds. In contrast, the frames of the planning professionals were linked to their institutional frames. Due to these differences, citizens who valued urban ecology could not recognise its importance in the policy document because the municipality's priority (for sustainable development) emphasized a new mobility paradigm (less dependency on cars) leading to new mobility routes disrupting existing green spaces.

Secondly, there are inherent contradictions in the municipality's own vision for a "humane metropolis" [48]. Despite the strategic goal for rigorous greening, a dense living–work environment inherently puts pressure on the existing ecological and recreational green spaces. Balikçi et al. [61] have calculated that urban development in Amsterdam has led to a 4.7% loss of green space, to a 15.7% per capita decrease over a period of 10 years, and to more fragmented green spaces. While Amsterdam has favourable conditions (governance structure, high percentage of municipal owned land) for the protection of green space, this paradox is partly because densification is calculated using population and area metrics, which do not accurately depict the pressure on green spaces from densification [61]. However, this is more visible from the citizen stakeholders' frames of meaning. These contradictions can be made visible by the interaction of policy at various levels of government and their representation on geographical space. While there are different solutions that can be drawn from such an example (more dimensions to calculate and define green space or stronger green policies) [61], the more significant takeaway is that in-between spaces can reveal the negative spatial impacts of such contradictions when professional expertise and expertise from the lived street-view are given space to create congruent meanings. This is not only relevant to finding solutions for sustainable development, but also relevant to defining the problem.

This illustrates a need for well-designed in-between spaces that can potentially scrutinize these contradictions and lead to, as an example, the protection of green spaces from reduction and fragmentation. The long drawn-out time frame of urban planning projects mean that planning professionals may be hyperopic to the contradictions that play out on the ground, and local stakeholders may be myopic to the long-term consequences of the status quo [62]. This also illustrates the added complexity of the role of actors using phronetic management to set up and maintain disruptive in-between spaces. The underlying principles of phronetic management require a learning and leading attitude while balancing particular needs with those of the common good [11]. The contested nature of sustainable meanings makes the "common good" difficult to grasp. When these contested meanings are not made visible, they can lead to tension and distrust, which can be a barrier for transformative learning [63].

There is, however, a brighter side to these contested meanings. The multiple interpretations of sustainable development, when appropriated by actors using phronetic management, can lead to congruent frames between actors. This ambiguity has been described as a necessary shift from misleading concrete categorisations [64] and offers the opportunity to draw out meaning depending on references to space and time [65]. The ambiguity is similar to what Pinch and Bijker describe as interpretive flexibility [66]. The next subsection looks at how methods and practices can embrace the ambiguity created by sustainable development and their potential in leading to congruent frames.

4.3. Methods and Practices for Fostering Ambiguity within In-between Spaces

This sub-section discusses the methods and practices used by actors to communicate meaning in the two in-between spaces.

The first in-between space allowed for the communication of meaning in the form of a policy document and textual responses from stakeholders. This mode of communication has a different impact on the different actors. As suggested in Section 4.1, this mode allowed the municipality to assert their professional expertise through complex legal explanations and technical maps, but, in doing so, they also framed the role of the stakeholders, especially the citizens, as the non-experts. This also limited the municipality's own intention for how the original policy document was to be used. The project manager had perceived that it would contain the ambitions of the municipality but with the flexibility to be filled with perspectives from stakeholders.

The instrumental nature of the first in-between space made this desire for flexibility challenging. However, the citizen stakeholders had three avenues to adapting to this medium, by—(a) coordinating themselves to present a joint and stronger voice, (b) mirroring the municipality's professional expertise with their own professional expertise from other or similar domains, and (c) using creative expression or visual imagery from local contexts to share their frames. The entrepreneurial stakeholders also adapted to this form by mirroring the municipality's professional expertise and countering the policy document with questions and alternative proposals. Additionally, the municipality had shared their ambitions through examples of international cities and renderings, but the citizen stakeholders could not relate to these examples because they did not fit in with their own perception of their living environment. They preferred to share relatable examples of local narratives or designs from the Netherlands.

The second in-between space was comparatively fuzzier and less rigid. This allowed different actors to adapt personas and use communication methods beyond what was expected of them. The municipal project team could shed their role as experts and share their concerns about the uncertainties prevalent at the early stages of urban planning projects. This also created more space for the flexibility to fill in the policy document's ambitions with local perspectives. The second in-between space allowed local stakeholders to better articulate their perspectives in the core team meetings and the public workshops by creatively using poems, stories, pitches, photographs, and mental maps. It simultaneously offered flexibility for the citizen stakeholders to offer written arguments when they found oral or visual methods did not sufficiently address their needs. For the entrepreneurial stakeholders, the space gave them the opportunity to use storytelling (in the form of pitches) to add nuance to their role as innovators and proponents of the economy, by sharing their concerns about the changes from the redevelopment plans. While both in-between spaces similarly allowed stakeholders to share ideas about concerns and preferred futures, the second in-between space allowed actors to additionally broaden their network and be inspired by one another.

The second in-between space was, in theory, well-suited to developing more experimental approaches to visual expression, but, in practice, the distrust and capacity constraints within the project made this difficult to explore. A clear conclusion that could be drawn from the empirical data of both spaces was that stakeholders need to have ownership over the output of the creative process. This leads to drawing two significant conclusions for in-between spaces, (a) the need for methodological plurality to accommodate different modes of expression (both technical and human), and (b) that visual (maps, images) or textual narratives (policies) need to be adaptable by or relatable to the audience.

This bridges the next question: what is the role of actors using phronetic principles to maintain these spaces? As described earlier, phronetic management is used by actors with a leading and learning attitude to change institutional structures. Actors from the municipality, the stakeholders, and the facilitators all exhibit (partial) skills of phronetic management. The diverse use of phronetic principles by different actors (not just one person) is needed to foster such in-between spaces. Some citizen stakeholders and

the project manager used phronetic management by exhibiting leading attitudes to disrupt existing structures, while others like the facilitator used a learning attitude to understand different needs and to adapt the space to strengthen the conditions for meaningful collaboration.

In order to create spaces where ambiguity (as suggested in Section 4.2) can be embraced and operationalised for the creation of congruent frames, actors tasked with phronetic management need to be able to effectively use storytelling while fixing the boundaries and maintaining these in-between spaces. According to Polletta, ambiguity in stories can be a more powerful resource than other media, like reports, arguments, or descriptions, because they offer room for multiple interpretations [67]. This form of communication can lead to more solidarity, diffuse opposition, offer legitimacy, and create room for more stories. This can also allow for diverse meanings to coexist as opposed to being contested. The use of visuals can contribute an additional dimension as a tool for co-creation of congruent meaning, as suggested by Metze [68]. Visual storytelling not only has a wider reach, but it also puts forward a concrete idea that can be either adapted by actors or supplanted with an alternative. However, both authors suggest a need to balance accuracy and details with the necessary ambiguity, which requires further scrutiny.

5. Conclusions

This article illustrates, from a grounded perspective, the inherent difficulties of meaningful collaboration between local stakeholders and planning professionals to find congruent meaning as to "what needs to be sustained?" for urban sustainability. There are three main conclusions: (a) well-designed in-between spaces, with fuzzy boundaries (though disruptive and uncomfortable) and methodological plurality, can create mutual interdependencies between actors and foster transformative learning through the creation of new learning networks; (b) such in-between spaces can be used to foster congruent meanings for the problem definition, "what needs to be sustained?", and contested meaning can be potentially translated into a constructive tool to sustain urban ecosystems for future generations; and (c) visual and creative methods are a powerful tool that can be used by action researchers to support multiple actors using phronetic management, as long as the participants feel ownership over the creative process and the resulting output. This article offers additional questions for further enquiry:

- How can actors use creative and visual methods to set up and manage these in-between spaces in urban sustainability-driven projects?
- How can creative and visual methods be developed to support meaningful collaboration within in-between spaces while ensuring the actors involved feel ownership over the resulting object(s) or output(s)?
- What are the limitations of creative and visual methods for collaborative communication?
- How can action researchers offer support for the innovation of new methods for sustainability-driven projects that have underlying uncertainties and mistrust?

To conclude, well-designed in-between spaces can be used for collaborative communication and to translate contested meanings into congruent frames by offering conditions for learning through interaction. While the fuzziness of such a space may lead to discomfort for the actors, it gives room for this discomfort to be transcended. However, the legitimacy of such a space should not be determined by the demographic reach, but rather by its capacity to create congruent meanings by highlighting contradictions from contested topics in sustainable urban development. Democratic legitimacy in participatory processes can be achieved through other means, like deliberative citizen councils. Hence, a plurality of processes is needed to communicate for meaningful collaboration in urban sustainable development projects.

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Informed Consent Statement: (a) For the research participants whose personal data were not processed, oral informed consent was obtained. The participants were informed about the objectives of the action researcher and her academic affiliation. This group includes the citizens, entrepreneurs, planning professionals, and the facilitating team. The research data were collected with verbal informed consent concerning participant observation data. No personal data were collected for the purpose of this article, and actors were only identified by the broad group that they represented, without any identifiable characteristics beyond their contributing role (professional or citizen/layman) in the project. Lastly, the role of the action researcher, and her academic affiliation, was additionally announced at every meeting and noted in the meeting minutes. Moreover, a collaboration agreement was written with the representatives of the different stakeholder groups to document the oral agreements, and oral informed consent was obtained at the beginning of the project when the participation of the action researcher was accepted by all parties. It is also important to note the action researcher has been invited to join this project through the agency of the participants, as opposed to research subjects participating in a research study. (b) For research participants who, due to their unique role and position, run the risk of identification, additional written consent was sought. This group includes just two actors. The description of their unique professional roles in the article is essential to interpret the research results but can lead to a very small chance that they would be identifiable by other professionals or colleagues with internal knowledge about the project and the specifics of the departments involved. It is important to note that these two actors are academically affiliated co-inquirers interested in the research outcomes of the action researcher and have consented in writing to the small risk of being identifiable in publications by others with background knowledge despite the author's efforts of pseudonymisation.

Data Availability Statement: The raw data will be archived internally at the AISSR Secure Closed Archive, accessible only by the Data Steward with permission from the Dean of the Social and Behavioural Sciences Faculty, University of Amsterdam. Aggregated and deidentified data will be available on request by the author.

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Developing a Participatory Process for Soil Fertility: A Case Study in an Urban Area of Italy

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Abstract: Approaches that are transdisciplinary and participatory can help to address complex socio-ecological issues by integrating multiple disciplinary perspectives while taking into account the different needs and experiences of community members and other stakeholders. Despite this promise, such approaches are rarely applied within the scientific community, as researchers and public actors often lack the training, practice and reference cases required to handle the working relationships and translations of terminology, ideas and values across multiple bodies of knowledge. A case study described in this manuscript depicts a group of researchers, artists and citizens consciously engaged in the construction of a transdisciplinary process as part of a 40-day 'citizen science' experiment focussed on assessing soil fertility in the urban area of Milan, Italy. The group drew from recognised scientific approaches, applied agronomic methodologies, artistic practices and technological tools, integrating them into a hybrid process of collective and participatory inquiry. As a quantitative outcome of the experiment, a dataset of bio-chemical parameters was generated, which was enriched by agronomic interpretations but also by artistic and reflective materials. Importantly, the process developed transdisciplinary and participatory skills, as it created a potentially replicable procedure of engagement, analysis and presentation for use in other citizen science settings. This

article presents the context, the multiple objectives of the research and the applied approach and its timeline. Described in detail are the process of designing and conducting the experiment by involving an extended research community—including both junior and senior researchers—in progressive steps. Quantitative and qualitative results are provided. The findings are meant to contribute case material and methods to inform the advancement of transdisciplinary research approaches within the scientific community as well as examples of ways to transcend the boundaries of science to include artists and community stakeholders. The aspiration is to inform and inspire concrete application of transdisciplinary and participatory methods in concert to address complex socio-environmental challenges.

Keywords: transdisciplinary research; citizen science; urban soil; citizen involvement; local knowledge

1. Introduction

All major challenges facing the current century, whether they are ecological and environmental or socio-cultural and geo-political, are too complex to be adequately tackled by individual disciplines alone [1]. The degradation of ecosystems, the depletion of natural resources, food insecurity, rising energy demands and the increased frequency of severe weather events caused by climate change point to social, economic and ecological issues that are intertwined, often conflicting and contributing to the worsening of social conditions and political tensions. They all require complementary knowledge and diverse perspectives, spanning ecological systems, society and governance, in order to inform and impact decision-making [2,3]. Therefore, a transdisciplinary approach can play a vital role in addressing the phenomena under study [4,5].

Transdisciplinarity can be viewed as both an epistemological and an operational approach that transcends boundaries among disciplines, and fosters connections among different types of knowledge, across scientific and non-scientific communities [6,7]. Transdisciplinarity involves thinking laterally and imaginatively, reassessing the factors that need consideration from various and different perspectives [8]. To this end, the contributions from the arts and humanities are in some circumstances welcomed and integrated to foster deeper awareness of ways of thinking beyond the linear and reductionist approaches that are characteristic of Western modern science and to bring forth modalities of being and knowing that are situated, contextualised, embodied and directed towards the needs of human and more-than-human communities [9].

Furthermore, this emphasis on including different disciplinary perspectives can be extended to encompass practices such as Participatory Research and Citizen Science (CS), which also have high potential for building a deeper integration of knowledge and skills. Albert et al. (2023) [10] suggest that both CS and transdisciplinary research can address not just the analytical and social dimensions but also the ethical dimension by recognising the complex intertwining of disciplines and by developing solidarity among people. Consequently, they help to overcome disciplinary protocols and move goals 'beyond' customary scientific standards. In fact, they claim a constructive encounter among individuals, local communities, policymakers, educators, scientists and experts from different disciplinary fields, possibly with different roles [11,12]. Depending on the level of involvement of different stakeholders, CS may foster communities of both interest and action in which the research questions and the methodologies stem from multifaceted expertise and interests incorporating local knowledge and perspectives [13]. Power dynamics in CS have long been studied; scepticism about policymakers' willingness to consider citizens' perspectives is expressed, and the often-asymmetric relationship between scientists and citizens is emphasised. While scientists decide aims and activities at the outset, citizens are seen as mere executors. More recently, there has been greater recognition of the need for equal engagement and increased citizen participation in decision-making about the methods and

objectives of the research [14]. Moreover, CS, increasingly applied by the scientific community and policymakers in the context of environmental and land issues, holds significant epistemological value within the framework of Post-Normal Science (PNS) [15,16]. PNS promotes the creation of 'extended peer-research communities', which include a wider range of stakeholders, each bringing a partial yet legitimate perspective. Both the aim and the challenge of PNS approaches is the idea of open dialogue fostering mutual learning despite different disciplinary backgrounds and the ability to address conflicting interests and value disputes. In this sense, both the PNS and participatory approaches can contribute to generating relevant and responsible knowledge practices [17] and well complement the transdisciplinary approach because of their common ability to tackle complex and 'wicked' problems [8].

This article reports the experience carried out in Milan, northern Italy, within the research project BRIDGES—Building reflexivity and response-ability involving different narratives of knowledge [18]—the goal of which is to develop tools that support responsible and participatory scientific research in the Italian context. This aims to tackle complex socio-ecological problems that hold personal and collective relevance.

Specifically, the BRIDGES project developed transdisciplinary and participatory research, informed by CS and PNS, by involving academic and nonacademic expertise, local knowledge and artistic research practices to face the fundamental concern of urban soil fertility.

Soil fertility represents a complex and contentious matter entwined within the current global socio-ecological health crisis. Soil fertility is a topic of local and global interest; its management and protection imply a series of new relationships and visions between science, society, ecosystems and human and non-human actors. The main causes that are currently leading to the loss of soil fertility are of anthropogenic nature, such as deforestation and the overexploitation of vegetation, the practice of monoculture cultivation, overgrazing and the indiscriminate use of agrochemicals and heavy machinery. Soil fertility impacts various aspects of sustainability including economic, social and environmental dimensions, as reflected in the Sustainable Development Goals. Fertile soil is also important for food production, aligning with the Food and Agriculture Organization (FAO) goal of zero hunger. It provides plants with all the nutrients they need for human health. Furthermore, soil fertility significantly impacts many economic activities, economic growth and efforts towards poverty alleviation. Moreover, good soil fertility management can help reduce pollution in soil, water and air; regulate water availability; support a diverse and active biotic community; increase plant cover; and enable a carbon-neutral footprint [19]. Finally, the fertility of soil has important implications for landscape management, social activities, public health and well-being. Among the many initiatives undertaken to protect soil at the national and supranational level, it is worth mentioning the public consultation on soil fertility launched in 2022 by the European Community [20]. The EU focus has been on maintaining soil health while minimising environmental damage caused by excessive fertilisers. This includes reducing land degradation, conserving and increasing soil organic carbon stocks, reducing soil pollution and preventing soil sealing. To this end, it aimed at involving diverse fields of knowledge and actors from national, regional and local authorities; European, international and multilateral organisations; relevant economic operators such as landowners and users; civil society; research; think tanks; and academic institutions [20,21].

These considerations make soil fertility a paradigmatic and complex problem to be addressed within a transdisciplinary approach and thus motivate the choice of this topic as a case study of the project.

It must be highlighted that the participative experiment—which is the focus of this paper—had both specific goals and broader aims. A first specific objective was to start collating a set base of data and knowledge useful for communities and administrations tasked with taking care of urban soil. As detailed in the following sections, this objective was mostly addressed through participatory CS activities [22]. A second objective was to offer

a training opportunity for young researchers and public actors to practise participatory and transdisciplinary research in the context of a concrete case. Thirdly, the study overall was a social experiment aimed at developing a methodological process, supporting transdisciplinary and participative practices. From a broader perspective, the project sought to investigate the possibilities for building a collective and care-oriented understanding of soil fertility, conceived as an encompassing concept incorporating not only its biophysical components but also its socio-economic, ecological and relational dimensions: from its historical evolution to the different economic and administrative purposes it served and the ecological relations that characterise a landscape, including both human and non-human communities. All these aspects are interdependent and inevitably contribute to determining the state of the health and sustainability of urban soils. Enabling local social actors and scientists to act as an extended research community can potentially make for more effective ways to preserve the fertility of urban soils through mutual accountability and shared responsibilities. So, two main research questions guided this study:

To what extent can a transdisciplinary and participative approach be enacted to support a rich set of practices and narrations addressing the complex socio-ecological issue of urban soil fertility?

What procedures and tools are effective in fostering collaboration between scientific disciplines and society on these issues?

The following section illustrates the context of the experiment and the methods applied in its performance. Subsequently, this article describes the original methodological implementation, that is, the process purposely developed for building the research community and the participatory activities, from the iterative design to the field operations. Then, it describes the performance of the experiment by delving into its main activities and synthesising its main achievements. Finally, it provides a critical examination of the process that occurred, the tipping points encountered and reflections on the lessons learned. In response to the described objectives and research questions, the experiment produced both elements of quantitative knowledge on the fertility parameters of the local soils analysed and qualitative insights into the ongoing dynamics between soils and the subjects involved. More than anything else, however, the experience enabled outlining a path for the practical application of a transdisciplinary and participatory approach in a specific local case. This process represents one of the main results of this study. The methods applied here can be revised and adapted for different research topics and in different local contexts, offering both educational and training opportunities as well as operational suggestions to communities and interested experts.

2. Materials and Methods

In this section, the physical and spatial setting of this research (Section 2.1) and the methodological principles adopted in the design of the participatory experiment (Section 2.2) are presented while keeping separate the strategies adopted for building the research community from the scientific and technological components used in the execution of the data collection activities. Next, the methodological steps involved in the implementation of the social experiment (Section 2.3) are detailed, and its evolution and specific component activities are highlighted.

2.1. Study Area

Milan is the largest and most densely populated urban settlement in northern Italy (more than 1.3 M inhabitants in the city area and more than 3.2 M inhabitants in the metropolitan area) and the country's main post-industrial city.

In 2020, the metropolitan area of Milan exceeded 10,500 hectares of artificially covered land, corresponding to 32% of the total area. Of these, 217 hectares fall in protected areas and 695 hectares fall in areas with high hydraulic danger [23]. The intensity of the urban sprawl has brought up environmental and health problems (for example, poor air quality and the consequent high rate of respiratory diseases) but also rising economic

inequalities and the loss of historic social ties as a consequence of the displacement of the middle classes towards the peripheral neighbourhoods. Despite the expansion of the urban agglomeration and its myriad socio-environmental challenges, large areas of cultivated land or lawns persist in the city outskirts, some safeguarded by public administrations while others are protected and recovered from industrial settlements, thanks to the efforts of city associations [24]. In fact, Milan has a rich tradition of environmental and voluntary associations, and, in the last decade, numerous small participatory projects have originated from the initiative of active citizens who got together to create social bonds and increase their mutual support networks but also to take care of the neighbourhood.

Starting from the early 2000s, local institutions have promoted policies and initiatives in support of urban agriculture, urban farming and urban food gardening. These practices contribute to restoration and recovery actions, to foster the maintenance of both the agricultural heritage and the historical landscape system, to support the creation of networks among citizens and farmers and to encourage their involvement in the preservation of traditional agricultural techniques [25]. 'Carta of Milan', the city's strategic environmental plan, recognises 'green infrastructure' as the best way to achieve environmental targets, promote social development and improve social welfare. The city of Milan implements different nature-based solutions as part of its architectural and urban renewal strategies [26]. Urban Gardening, for example, plays an important role in the city by involving people in the management of urban green spaces. Green urban areas, in particular public parks, gardens and urban forests, are created for multiple purposes. Green urban areas provide Milan with important ecosystem services, while Green Rays and Green Belts are meant to connect the green areas using pedestrian/cycling green roads. The city of Milan currently includes more than 10.4 km^2 of parks, 909 play areas, 391 areas equipped for recreational use and 354 areas suitable for dogs (data updated to 2021) [27].

Over the past decade, the evolution of these practices in Milan has been analysed from environmental, social and cultural perspectives, and relevant areas have been mapped and investigated [28–30]. The convergence of many socioeconomic and environmental challenges, along with organised citizen groups interested in the potential of these areas, makes Milan an ideal case study for the experiment.

2.2. Methods Used for Building the Research Community and the Participatory Activities

Opting for a transdisciplinary and participative approach to address soil fertility entailed the consideration of specific design features that needed to be incorporated right from the beginning of the study and the selection of a set of methodologies and tools to support participatory research, as described below.

2.2.1. Involvement and Training of Participants

Since its official start in April 2021, BRIDGES could count on the endorsement of diverse active citizenry groups, willing to play their part for a better quality of life and showing interest in the project's research and outcomes. Local associations with environmental, agricultural and social interests had in fact been contacted from the outset since early 2021, in the initial stages of proposal writing. Through a snowball sampling approach, numerous volunteer networks and private citizens approached the project and expressed an interest in joining participatory activities planned for the following months.

In January 2022, the project envisaged the launch of an extended survey—the description of which is beyond the scope of this article—addressed to Italian researchers in the early stages of their careers. The survey reached about 2000 people and was answered by 810. Of these, 78 reported an interest in taking part as volunteers in the next phases of the project. These were then invited to participate in subsequent training events for the purpose of selecting a core group of young researchers to join the original research team to participate in a social experiment of transdisciplinary research (more detail in Section 2.3.1).

The selection of participants for extending the research community aimed to be representative of diverse interests, educational backgrounds, scientific disciplines and personal

characteristics (including age, gender and geographical origin). In practice, this objective was balanced by the opportunity to welcome subjects who voluntarily proposed themselves, such as networks of local citizens and associations interested in soil fertility, bringing strong motivations and valuable knowledge.

Motivation to participate was particularly important. While it was necessary that the motivations to participate were strong and rooted, it was equally right and healthy that the motivations were different among the community of participants. Motivations could be linked to personal interests or to the needs of a local community or to study and work reasons. This diversity was beneficial for the project because it shed light on the many facets of soil fertility.

A summary of this information about the participants in the experiment is provided in Figure 1.

	participants	working area	main interest	place of living	gender	age (estimation)
ORIGINAL RESEARCH TEAM	21	14 scientific res. 2 artistic res. 1 transdisciplinary res. 4 business	4 science communication 3 agronomy 2 artistic research 2 statistics 2 biology 1 transdisciplinary res. 1 science education 1 sociology 1 animal science 1 forest ecology 1 geographical information 1 Citizen Science 1 RRI	5 case study area (Milan) 10 north Italy (not Milan) 4 central Italy 1 south Italy 1 out of Italy	14 f 9 m	12 over 50 8 over 30 1 over 20
EARLY RESEARCH CAREER VOLUNTEERS	16	16 scientific research	1 landscape architecture 1 philosophy of ecology 1 environmental ecology 1 RRI 1 plastics 1 sewage purification 1 anthropology 1 digital ontologies 1 food philosophy 1 agronomy 1 computational ecolinguistics 1 marine biology 1 spatial data infrastructures 1 urban geography 1 territorial governance 1 marine ecology	4 case study area (Milan) 8 north Italy (not Milan) 2 central Italy 2 south Italy	9 f 6m 1 not binary	7 over 30 9 over 20
LOCAL VOLUNTEERS	85 (estimation)	6 associations 3 public bodies groups of citizens	2 education (higher, childhood) 2 recovery, renaturalization 2 social promotion and farming 2 sustainable cultivation techniques 1 cultural promotion 1 territorial protection 1 urban horticulture 1 scientific research	case study area (Milan)	balanced (estimation)	16 over 50 17 over 30 11 over 20 41 under 20

EXTENDED RESEARCH TEAM

EXTENDED RESEARCH COMMUNITY

Figure 1. Summary of the characteristics of study participants: spread and number; biographical information; personal interests; and areas of work. Some information is estimated.

The research community's varied backgrounds were also considered during both the design of the procedures and the selection of the tools to ensure satisfactory data quality. The very concept of 'satisfactory quality', which is related to the concepts of 'fitness for use' and of 'fitness for purpose' [31,32], was defined together with the community to respond to the different needs expressed by the group.

The project team established suitable data collection procedures to address the qualitative and quantitative objectives, ensuring their robustness and concurrently fostering a transdisciplinary, knowledge-sharing process.

Specific training was designed to accommodate different community backgrounds and legitimate interests. This was achieved by offering multiple interaction channels

(e.g., webinars and face-to-face meetings, theoretical and practical activities, the sharing of relevant literature, digital edutainment proposals, etc.) and diversifying the topics of discussion, according to the requests of the group.

Finally, it was also important to give recognition to the value of voluntary contribution. Very often, when designing CS activities and contributory collections, the project team envisages reward mechanisms for volunteers to foster their motivation [33,34]. This is typical of top–down approaches. In a participatory project instead, when a research community plays an active part in defining research questions and tools, recognition is deserved for both the commitment and time dedicated, as well as the intellectual contribution [35]. Both the analysis of the results and the scientific merit of the work were thus shared with the research community. For the same reasons, the experiment's participants were also the protagonists of co-hosted webinars; they received certificates and had the opportunity to discuss the project topics at conferences and public meetings. Their profiles can be found alongside those of the original research team on the project website. Also, community members have been invited to participate as co-authors in writing research products.

2.2.2. Collection and Management of Quantitative Data

Due to the transdisciplinary nature of the project, the connections between the activities are of great importance. Researchers from different backgrounds purposely designed hybrid activities, combining different approaches, coming from natural sciences, social sciences, geo-information sciences and artistic and educational practice, with multiple objectives. Specifically, in the operational phase of the experiment, two main methodologies were used to gather quantitative information on the presence and viability of the microbial communities in the soils, which are strongly correlated with their fertility: NIR-litterbag analysis and metagenomic analysis.

- The NIR-litterbags analysis consists of the burial, monitoring, extraction and description of litterbags (small net bags with standardised straw content), functioning as biological proxies, which were then subjected to the following laboratory analysis with a near-infrared (NIR) technique. The analysis of litterbags makes it possible to determine the soil microbial fingerprinting and, from this, to extrapolate numerous parameters related to its chemical and microbiological characteristics. From the NIR-litterbags analysis, it is also possible to obtain predictive information on the state of health of a soil and on the estimated rate of productive yield. The participative monitoring of similar biological probes, aimed to measure the decay rate of plant materials, has been carried out in international CS projects such as in the TeaBag project [36], in which volunteers worldwide were called to bury tea bags and report qualitative observations after three months. In BRIDGES, agronomists from the research team proposed to perform the NIR-litterbag analysis with a CS approach, aimed at collecting evidence of microbial activity in different urban and peri-urban soils, as a proxy for their biological activity and diversity.
- A metagenomic analysis is a mass sequencing technique on the total DNA that can be extracted from an environmental soil sample [37]. The statistical analysis of the DNA sequences allows for identifying the presence of taxonomic groups and finally to elaborate biodiversity indices, relating them to soil management methods, environmental conditions and cultivation systems [38]. The activity was proposed by the biologist members of the research team, and the experimental design was completed in conjunction with the agronomists.

Generally, in CS projects, participants are called upon to contribute observations of various natures by the aid of ICT tools, which have the dual function of both providing a user-friendly interface to guide the creation of 'high-quality' observations and uploading the data in a database managed at the server side. This way, data analysts can query the database in real time to monitor the status of the observations and, in the data analysis phase, can perform quality-based filtering and analysis on the collected data.

In the scientific and technical literature, there are several meta-tools that aid technicians to develop web applications, both proprietary and open source. In BRIDGES, it was chosen to use the open-source KoBo Toolbox software toolkit [39] (version 2.022.16) to develop a web application, named Soil_mAPP, dedicated to the collection of field observations relative to the NIR-litterbag experiment and enabling their easy management and sharing.

2.3. Implementation of the Urban Experiment

The following subsections describe how the methodological approaches illustrated above have been implemented in BRIDGES.

2.3.1. The Process

Since its inception, the transdisciplinary research experiment was designed as an iterative process of reflexive adaptation and re-elaboration. It was initially drafted in the proposal by the project research team—mainly composed of scientific researchers, professional agronomists, educationalists, science communicators and artists—and then proceeded hand-in-hand with the expansion of the research community. Part of the research process therefore also included the progressive definition of the research community and an assessment of the strength of its participatory activities. The iteratively designed elements also included training and knowledge exchange activities, defined as a response to the increased awareness of the group's social dynamics and needs. The main steps and iterations are shown in Figure 2.

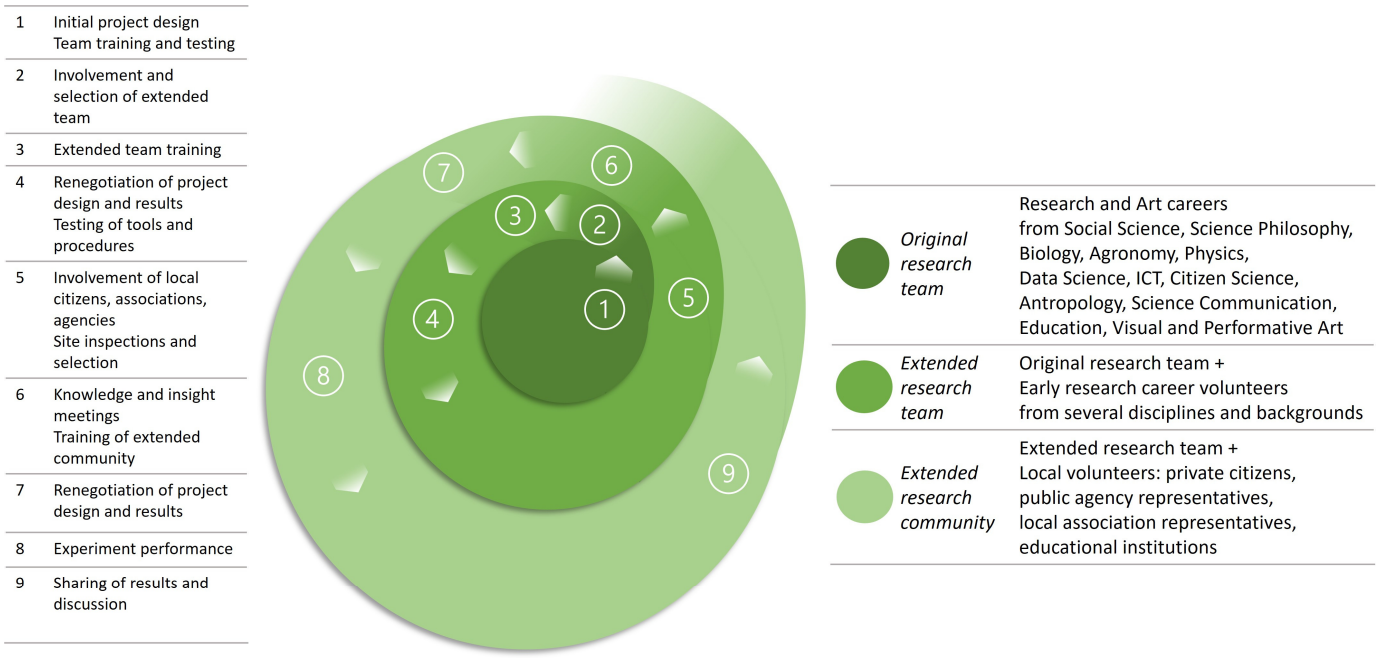

Figure 2. A synthetic diagram of the steps implemented for the building of the community and participatory activities in the BRIDGES project. On the right is the colour legend describing the participant groups.

The diagram shows the progressive enlargement of the research group in different shades of green. In the first turn of the spiral, the original nucleus of researchers and artists, named hereafter the original research team, is joined by a group of volunteer early career researchers from diverse academic backgrounds. As anticipated in Section 2.2.1, a number of early career researchers came into contact with the project for the first time in January 2022 during a large national survey, at the end of which they reported their interest in following and/or being directly involved in the subsequent phases of the project. A selection of them, from May to July 2022, participated in thematic workshops and in a week

of training and operational field activities held in the artist residence Pianpicollo Selvatico, together with the original research team. Throughout that week, the project objectives and methods were collectively tested and re-assessed. Subsequently, the extended research team, as it is named hereafter, collaborated in carrying out the following activities, albeit with different roles and based on individual propensity/availability, guided by the project's objective to build a transdisciplinary community.

In the second turn of the spiral, the activities planned as an integral part of the urban CS experiment were presented and proposed to local associations, groups and individual citizens who had shown interest during the previous phases of the project. Some of these include three public bodies, two educational institutions, six associations/communities of citizens and three private groups of citizens. This group, combined with the extended research team, forms what will henceforth be called the extended research community. Most of these subjects had an interest in the recovery of the urban and peri-urban areas of Milan; in urban agriculture, gardening and horticulture; in agricultural production for commercial and self-sustaining purposes; in landscape enhancement; in ecosystem protection; and in environmental monitoring as well as socio-cultural development, education and training in the ecological and agronomic fields (see also Figure 1 for a synthesis).

Figure 2 also summarises, using progressive numbers, the main steps that characterised the planning and development of the urban experiment. They are briefly described below.

1. The original research team discussed methodologies, contents and objectives and sketched the project proposal. From the winter to spring 2022, it carried out self-training courses to enhance the understanding and integration of the different methodologies and approaches of the group members.
2. In the winter 2022, a group of Italian researchers in the early stages of their careers, recruited through a survey, joined—as volunteers—the project and were invited to participate in training events.
3. In the spring and summer 2022, the extended research team took part in two training events: a workshop, focussed on the contribution of transdisciplinarity to knowledge production vis a' vis complex, socio-environmental problems and a one-week research residency focused on exploring artistic research methodologies. The residency included theoretical and practical activities focused on soil fertility issues, addressed in its socio-ecological, artistic and cultural complexity, borrowed from a performative arts approach, and integrating the contributions of the various disciplines and experiences represented, with special guidance by the artists members of the original research team.
4. During this research residency, the project objectives and the methods proposed to achieve them were actively experienced, discussed and re-negotiated by the group. The participatory tools and activities designed by the original research team leading the urban experiment were field-tested and reviewed by the extended team.
5. The organisations and citizens of Milan who had previously expressed interest in the project were contacted in the summer 2022, and the first site inspections and follow-up meetings were held. During the meetings, the mutual interests and objectives gradually became clearer, as well as the capacity of the sites to welcome the scheduled analyses. A dozen urban and peri-urban areas were identified for the field CS activities. They included public parks, association-owned terrains, scholastic institutions' and private citizens' green areas, targeted by preservation or recovering programs, leisure, cultural, gardening, social horticulture and agriculture activities.
6. Numerous individual exchanges and a collective meeting were held in Milan, in which the whole extended research community discussed the theoretical and scientific bases of the urban experiment, as well as their own individual motivations and expectations.
7. The extended community planned the urban experiment: the exact sites of investigation, the working groups, the activity calendar and the operating procedures were

agreed to on a participatory basis. Adjustments were made to the activities schedule to better match the needs and interests of the participants.

8. The urban experiment took place according to the agreed timetable in mid-September 2022. It entailed the integrated execution of a set of activities by the extended research community over approximately 40 days.
9. At the end of the 40-day time range, the original project team executed the laboratory elaboration of the parameters from the biological probes and the soil samples collected, interpreting them thanks to the detailed observations reported by the community during the 40-day period. All the results were finally shared in June 2023, discussed and enriched with the extended research community.

2.3.2. The Activities

As anticipated in the previous section, the strictly operational part of the urban experiment took place in a 40-day time range during which the extended community was involved in participative activities. The activities here below are grouped into three main categories, depending on their main objective: (1) data collection, (2) reflection on soil fertility and (3) interaction and communication (Figure 3). Nonetheless, as mentioned earlier, the activities were specially planned to hybridise different methods and approaches from multiple disciplines.

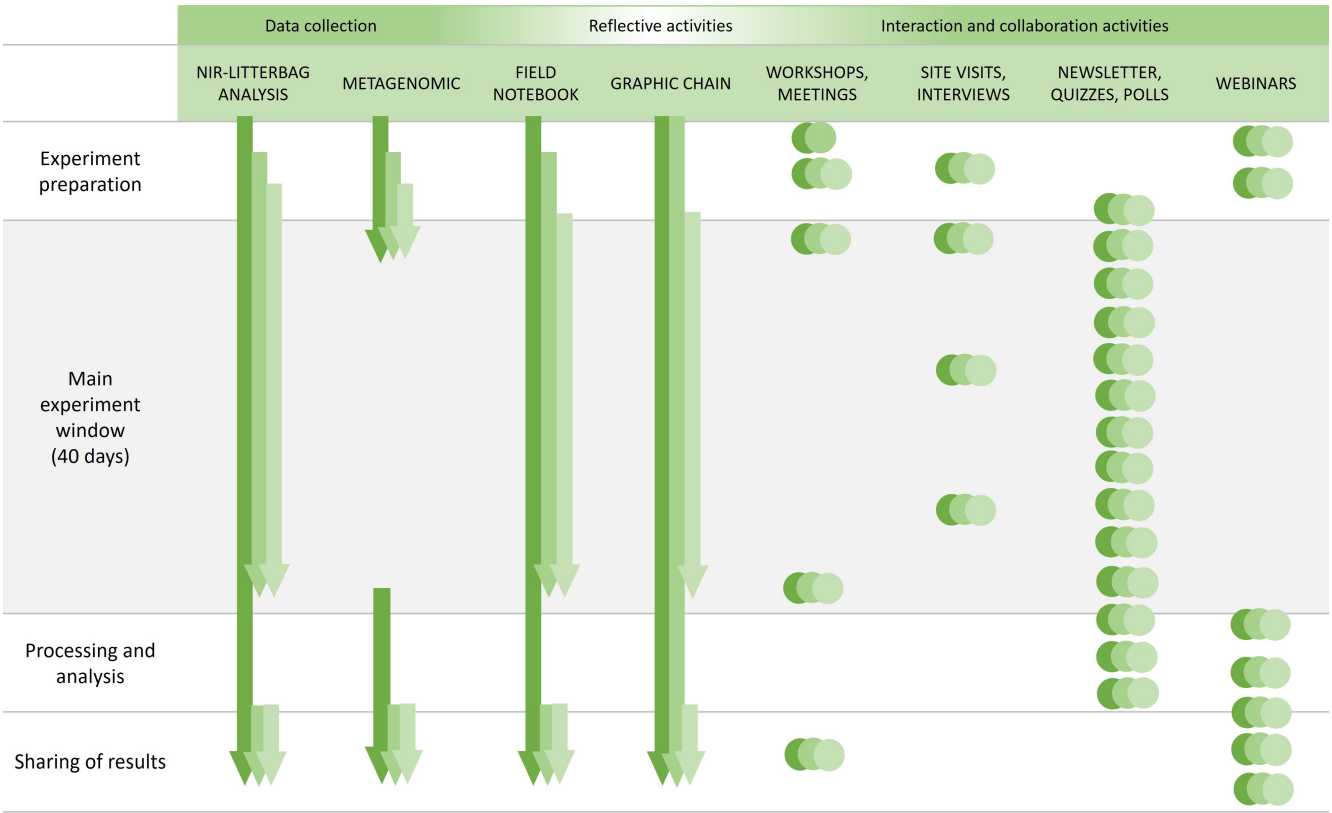

Figure 3. A summary representation of the activities carried out during the urban experiment and their implementation steps. The shades of green (refer to Figure 2 for the legend) indicate which groups in the transdisciplinary team took part in the activities.

The collection of the data from the soils and the observational and reflective activities, for example, were designed to be concurrent by following the same calendar and the same flow of investigation, albeit with different tools. They both involved the community in the production of measurements, those being in the more extended form of textual observations as well as through photographs or with the inclusion of graphical elements. Likewise, the interaction and communication activities were concurrent, aiding the data

collection process through periodic updates, both in-person and via online meetings as well as through edutainment formative activities.

Data Collection Activities for Soil Fertility Assessment

- NIR-litterbags analysis: The methodology (Section 2.2.2) was developed as a CS activity and adapted to the study context by the original research team. The web application called Soil_mAPP (Section 2.2.2) was implemented to support the participatory recording of local observations during the burial, incubation and unearthing phases of the litterbags while maintaining the consistency of the dataset. The extended research team, during the research residency in Pianpicollo Selvatico, tested and reviewed both the activity and the web application. The group also provided tutoring to local volunteers in the preparatory and operational phases of the experiment. At the start of the 40-day time range, local volunteers buried a total of 207 litterbags at 69 different sites in the urban and peri-urban areas of Milan, marking them with landmarks. A triplet of litterbags was buried at each single landmark so as to cope with possible losses. The community performed the litterbag monitoring, reporting, digging and drying according to the given schedule (Figure 4). Agronomists from the original research team then executed the NIR laboratory analysis. The results of the analyses were finally presented and discussed with the whole community.

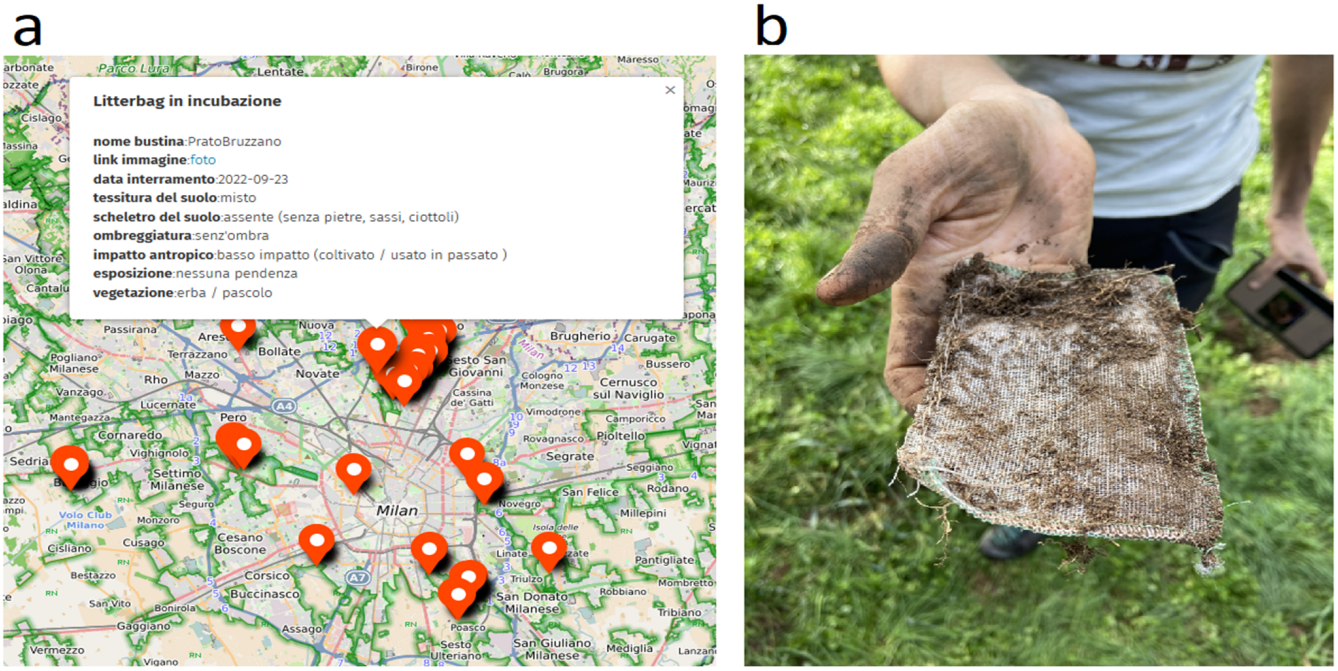

Figure 4. A map of the litterbag burial sites in Milan, as surveyed by the Soil_mAPP, showing an example of the scheduled observations entered by the participants at the time of burial (in Italian language) (**a**), and a litterbag at the time of unearthing (**b**).

- Metagenomic analysis: The extended research team, during the research residency in Pianpicollo Selvatico, performed soil sampling (in a rural area) to learn the methodology and to create a dataset for comparison. The researchers reviewed the experimental design together with the local communities to identify the most suitable sites and to schedule the soil sampling (Figure 5). The specialists from the original research team, together with the local participants, performed the soil sampling on the sites in Milan. The researchers then conducted the laboratory analyses and compared the results with those of the NIR analyses obtained at the same urban sites. The results were finally shared and discussed with the entire extended research community.

Figure 5. Images from the sampling and sample preparation steps for the metagenomic analysis.

Reflective Activities on Soil Fertility

- Field notebook: The visual artists of the original research team proposed to create a personalised field notebook to accompany the 40-day experiment with suggestions for practical activities that stimulated reflection and exchange within the extended community (Figure 6). Members of the extended research team voluntarily contributed to the notebook by proposing textual and visual material and evocative activities. The notebooks were distributed to and used by members of the extended community during the 40 days. A simplified digital copy was made available on the project website for more people to print and use. The activities of artistic research in-action led by the artists further involved the community during dedicated workshops and meetings and deepened the suggestions of the notebook.

Figure 6. Images from the field notebook.

- Graphic chain: An interactive activity was proposed by a member of the extended research team to involve the whole community in the processing and exchange of photographic, graphic and textual material. The activity focussed on the interconnections between the soil fertility, natural aspects and artefacts they observed while recording their observations on the study sites. The contributions exchanged between the participants were tracked and presented to the whole community at the end of the experiment.

Interaction and Communication Activities

- Workshops and meetings: Two main workshops were organised in the preparatory phase by the original project team, dedicated to consolidating the extended research team and the extended community, respectively. During these workshops, the training and redefinition activities of the experiment were carried out. A third meeting was proposed by a member organisation of the extended community at the urban park they manage. The event was designed together by members of the research team and the local community. During the workshop, which officially kicked off the 40-day experiment, the litterbags to be buried were crafted by the participants and some of the activities of the urban experiment were conducted on the host site. This event was attended by the whole extended community together with citizens who were at the site for the local biodiversity festival. The participants were also involved in hands-on activities, designed by artists to stimulate the ability to observe both the materials and the relationship between a living being and soil. At the end of the 40 days, when the litterbag incubation period was over, a meeting was organised to bring together the entire extended research community, to collect and share the contributions produced and to continue to share reflections on soil fertility indices.
- Site visits and interviews: Members of the original research team, together with members of the extended team, made site visits during the experiment and conducted interviews and video-recordings with the local associations and citizens' communities.
- Newsletters, maps, quizzes and polls: During the 40 days of the experiment, periodical emails updated the extended community on the activity progress at the various sites; drew attention to the schedule; shared images and drawings from the participants; and offered short games, polls and interactive material created specifically on the topic of soil fertility. These edutainment contents were designed to provide thematic insights and to strengthen the motivation and cohesion of the community. An interactive map, linked to the Soil_mAPP data collection geospatial web application, was regularly updated during the 40 days to report the observations shared by the community regarding the location and status of the litterbags in a timely manner.
- Webinars: By taking inspiration from the interests and specific expertise on soil management and care of the members of the extended community that emerged during the meetings and interviews, seven public webinars were organised. Here, local associations, representatives of public agencies and experts from several fields of knowledge (including anthropology, microbiology, science and media communication, urban planning, biophysics and ecotoxicology) were invited to discuss soil as a matter of concern and of care in their own experiences. The topics varied from agroecology to global and local food policy; climate change and sustainability in urban areas; citizens' engagement; and collaboration between different areas of expertise within and beyond Academia. All the webinars were moderated by members of the extended research team, with preference towards the younger members, who reinforced their transversal cultural competences (communication, dialogue, transdisciplinarity, etc.), which are considered more and more important in their curricula.

All the data and materials on the soil collected by the extended community were processed in the months following the experiment. The content of the litterbags and the soil samples to be subjected to the metagenomic analysis were analysed and processed by the researchers of the original research team who consulted with the local volunteers for

verification and further investigation. During this phase, the extended community was kept up to date with emails, videos and photos from the labs.

The results from the NIR-litterbag analysis and the microbial metagenomic analysis, once achieved, were compared by the specialists to obtain an in-depth bio description of the investigated soils. In a final meeting, open to the entire extended research community, the results were shared and discussed, and the themes for reflection that emerged during the experiment were further explored.

3. Results

As stated at the outset of this article, the broader aims of the social experiment were to create a context in which to (1) train and practise transdisciplinary research in the socio-ecological context; (2) approach the complex issue of soil fertility in a participatory CS perspective, where both the production of quantitative results on local soils' fertility and qualitative insights into the personal and social connections with urban soils were deemed fundamental; and (3) design and test a methodological process that can support transdisciplinary and participatory practice.

With regard to the collection of information on the fertility of city soils, at the conclusion of the incubation phase of the urban experiment, 71.4% of the buried litterbags were successfully found, exhumed and returned to the agronomists for the NIR analysis. The most common reason why some litterbags were lost is that the markers used to identify their location had been removed by animals, people passing by or during agricultural and maintenance operations. The results were statistically processed using the Random Forest algorithm and compared with the observations collected at the burial sites using the Soil_mAPP during the incubation. From the NIR spectra, 23 parameters were extracted. Among these, four parameters were selected as the most significative ones to characterise the microbial activity recorded in the soils:

- The amount of ammonium (NH_4), because microbes decompose organic matter in the soil, releasing nitrogen in the form of ammonium;
- The amount of nitrate (NO_3), because nitrate is the end product of nitrification, a key microbial process in the nitrogen cycle;
- The substrate-induced respiration (SIR), because it specifically assesses the response of the active microbial community to a readily available food source (substrate);
- The microbial R-strategy and K-strategy populations (R_K), which are significant for indicating different aspects of soil microbial activity. R-strategists point towards the opportunistic exploitation of fresh resources, while K-strategists suggest efficient resource utilisation in a stable system.

Analysing all these four parameters together offers a more complete picture of the dynamic microbial community and its functioning in the soil ecosystem. Two interactive charts were created to facilitate a consultation and an aggregated data comparison. They are available on the project website [40], and one of them is shown in Figure 7.

An example of the output of the metagenomic analysis is reported in Figure 8. It shows how the four different agronomic management practices of soil result in different varieties of microorganisms.

The results of the NIR-litterbag and metagenomic analyses were processed, compared for each site, integrated with traditional chemical and physical analyses and with the knowledge provided by local subjects and interpreted together with them.

Each group of volunteers participating in the experiment received a summary sheet showing the numerical results of the analysis on their respective sites. They were particularly eager to know the results of the NIR analysis relative to their site: generally, they asked the agronomists many questions for interpreting the parameter combinations and to know whether their site was characterised by normal or exceptional conditions or whether it would require specific recovery interventions. The community's positive reaction was a clear indication that the delivery of the results served as an excellent reward for them.

As far as the technological support for data collection and visualisation is concerned, the applications used have proved to be adequate, both from the user side and the administrative one. The Soil_mAPP provided users with a custom web form and enabled them to report complex observations on phones, tablets and computers. It automatically detected the user geolocation (corresponding, in the experiment, to the litterbag's burial site) by the GPS receiver, even without internet access, which was perfect for remote locations. A paper questionnaire reporting the same fields was provided to the participants who indicated that they preferred it to the digital version.

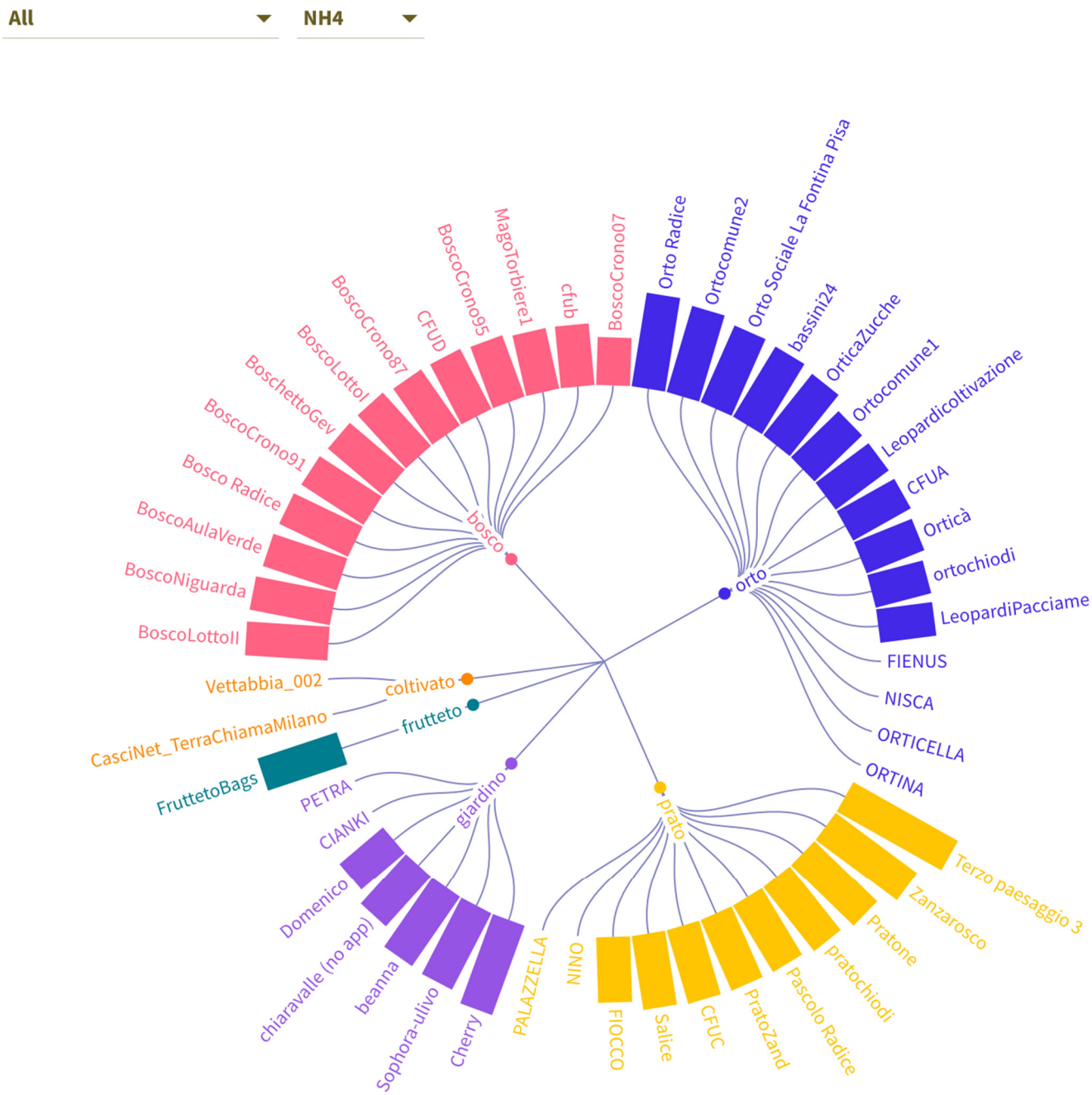

Figure 7. An example of the display of the parameter NH_4 for each litterbag on an interactive graph. From the drop-down menu on the left, users can select the parameter and litterbag group to be displayed. Clicking on the individual litterbag provides context information. The dimension of the bar is proportional to the selected parameter value (in the figure to the quantity of NH_4).

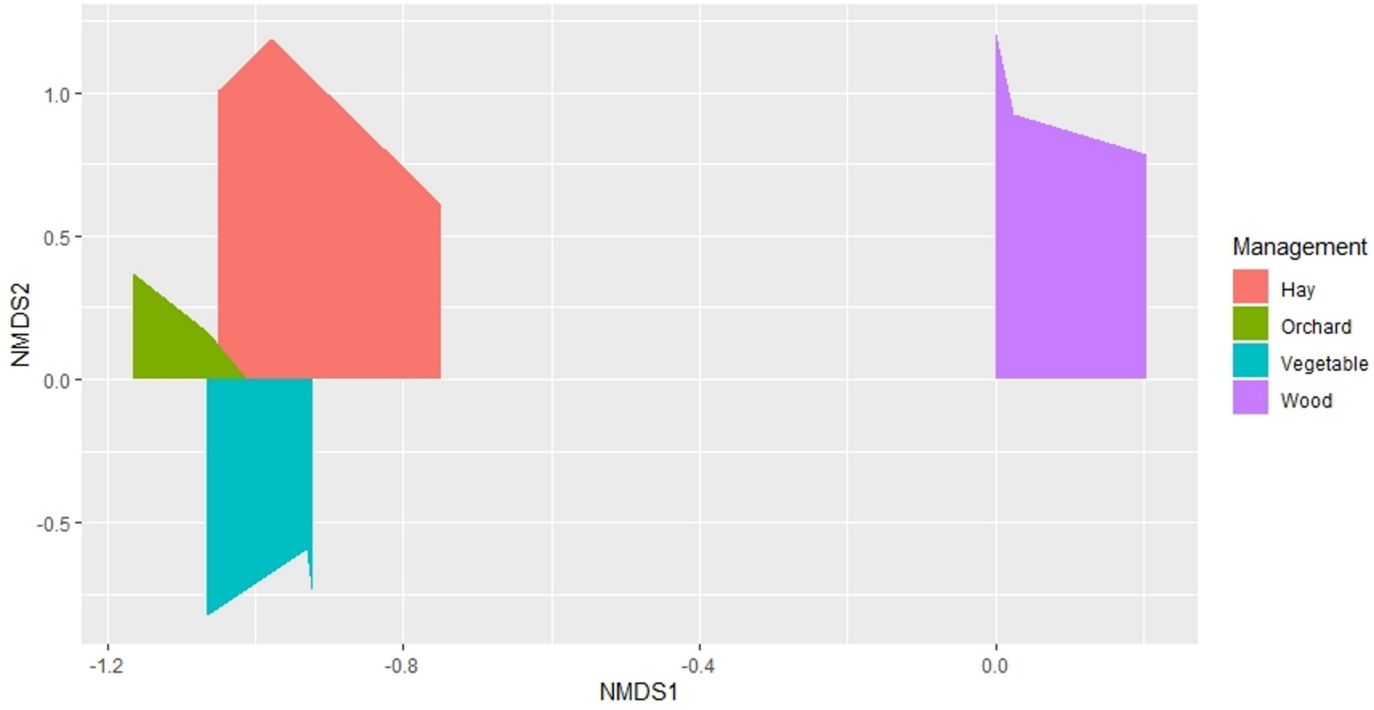

Figure 8. The graph illustrates the variation in the fungal communities' composition (β-diversity) among the soil samples, as resulted from the metagenomic experiment. The sample data are displayed in the nonmetric multidimensional scaling (NMDS) of the Bray–Curtis dissimilarity matrix. Polygons enclose the soil samples from the sites having the same agronomic management. The placement of the polygons shows how the management practices influence the microbial community: the communities characterising wood sites are strongly dissimilar (right side) to the communities characterising the other management types (left side), which are, as well, clearly separated from each other.

The dense observations—345 reports collected by the volunteer participants over the 40 days—documented by means of the Soil_mAPP (or of the equivalent paper version), accompanied by their photographs and descriptions of the experimental sites, provided effective information and created a robust dataset for the laboratory analysis and interpretation.

It is not easy to determine how many people actively participated in the field operations. In fact, some citizens' groups participated with only one or two representatives, while others involved a greater number of people who divided up the operations and took turns over time. It was estimated that the extended research community that actively conducted field and management operations was composed of 21 researchers from the original team, plus 16 researchers in the early stages of their career, plus about 45 adult volunteer citizens and about 40 students from three classes, aged between 5 and 19 (as reported in Figure 1). However, the frequency with which the different local participants contributed to the production of information is not uniform. The top 5 contributors of observations on the Soil_mAPP produced more than half of the total reports. This uneven commitment is in line with the heuristic rule called the Pareto principle, in which effort in CS projects tends to be greatly partitioned with, for example, 20% of participants contributing to yield 80% of observations [41]. Nevertheless, the unevenness is also partly due to the fact that in some cases—as in the case of student classes—the reports were always entered in the Soil_mAPP by the same contributors, although many volunteers were involved together in the field.

The participation of the local communities, both in the preparation period and in the 40 days of field activities, was active and knowledgeable. If the availability of various communication channels (email, newsletter, mobile chat, website and Soil_mAPP with related web pages for data visualisation) created some initial procedural uncertainties, it subsequently turned out to be very useful to allow all the participants to make regular direct comparisons and receive quick answers. All the participants shared effective observations

related to the litterbag monitoring, while only a portion of them wanted to share their own personal observations made in the field notebook.

Given the rich skills and areas of interest of the local participants, some of the topics they introduced were developed in dedicated webinars: the citizens' contribution in the regeneration of urban areas, associationism, the conception of the landscape as an active subject and the ecological and social implications of urban green protection. The main impacts recorded in these subjects concern (1) the acquisition of new technical skills and fertility data relating to the soils under their jurisdiction and (2) the strengthening of relationships between associations.

As evidence of the interest aroused locally by the experiment, during the 40-day range, two new city associations contacted the research team and, although they were no longer able to follow the scheduling of activities together with the community, proceeded independently with the burial and monitoring of other litterbags provided and followed the latest project activities.

After completing the field operations and while awaiting the presentation of the analysis results to participants, it should be noted that community interactions tended to become more relaxed, and communication was maintained through webinars and newsletter updates. The extended duration of the project, in contrast with the relatively brief operational 40-day time range, probably contributed to a decrease in participation, as expected. This was also partly motivated by the participants' pre-existing commitments, sometimes related specifically to agricultural activities. It is possible to find some analogies of this behaviour with Tuckman's Stages of Group Development [42]. The initial phases of team structuring (forming stage) and collaborative design (norming stage) saw the initial enthusiasm/concern transform into confidence, constructive criticism and mutual trust. The particular participative nature of the project somehow minimised power conflicts and resistance (storming stage). The most creative and productive phase (performing stage) occurred for the early career researchers ahead of expectations, almost coinciding with the planning phase, culminating in moments of meeting in the presence of the group. The physical distance from the experiment sites (only four early career researchers live in Milan) probably favoured a progressive relaxation of participation in some team members (adjourning stage). Local members of the extended community, on the other hand, had a peak in participation over the 40 days of the experiment (performing stage). Their disengagement (adjourning stage) instead began in the following months, in which the laboratory analyses were carried out and in which they were not asked to perform specific tasks.

As regards the broader aims of the experiment, i.e., building transdisciplinary and participatory capabilities and setting up a devoted process, it turned out that it was beneficial for the entire research community to have specific training and concrete case studies acting as reference points. In particular, the decision to involve early career researchers aimed at filling the gaps in academic training related to transdisciplinarity: the BRIDGES experiment provided them with the opportunity to directly experience it, fostering a lasting impact on their approach to complex socio-ecological problems. Their youth and diverse interests proved valuable for injecting critical thinking into the workings of the group.

Of the early career researchers who volunteered for the project, only a few were familiar with the concepts of transdisciplinary research and CS. The main motivation for participating was related to the possibility of learning less traditional approaches to scientific research. Their initial reaction, after the project presentation and the first training meetings, was sometimes perplexity, sometimes curiosity. Moreover, the level of commitment required to join the extended research team was high, and as a consequence, an initial selection of the group took place spontaneously at this stage. During the project, in the various phases of interaction and re-elaboration, some researchers—especially those with a background in technologies and natural sciences—expressed a certain frustration and shared it with the group. Such a feeling was often due to the lack of familiarity with qualitative or reflective research approaches and with the introduction of the artistic and experiential research component. That said, these approaches also led at times to a light,

almost playful atmosphere. This light-heartedness generated positive influences by creating a climate of friendly collaboration between researchers, but there were also moments where such methods were not taken seriously or their validity as research methods was underestimated. Similarly, the need to iteratively rework procedural steps and concepts during the project contributed to a much-appreciated mutual learning environment and, but it also destabilised more pragmatic expectations (i.e., caused delays). Relations within the extended research team also continued informally after the end of the project through online group conversations, in which the sharing of material of interest, experiences and events is still ongoing.

The main outcome of the experience reported in this manuscript, however, is the very construction of a process that facilitates the practical application of the transdisciplinary approach to a complex socio-ecological problem and to include, through successive steps, participants from civil society, bearers of complementary interests and expertise. This process, although defined in the specific case of the study of soil fertility, can easily be adapted to different thematic, geographical and social contexts. Within the process, there is still ample room for training, further quantitative investigation as well as reflection and action-research activities, potentially meeting multiple needs and project purposes.

4. Discussion

Two important objectives of the project, previously stated, were (1) to practise transdisciplinary research within the socio-ecological context and (2) to approach the complex issue of soil fertility in a participative CS perspective. The latter would need to be aware of the overlap among both interests and constraints between the scientific world and the encompassing society. As the findings above, certain difficulties emerged but also impacts of the approach on the researchers involved, as well as emergence of elements that most supported the success of the experiment and controversial reactions of certain public actors.

The transdisciplinary experiment highlighted both strengths and weaknesses that need to be further investigated. Some considerations can be made on how the process was shaped by the transdisciplinary approach and how this impacted on the research team. Involving different backgrounds, interests, languages and research methods towards a common objective inevitably involves accepting initial difficulties and, in order to solve them, many compromises. The compromises concerned both the development times—which may require delays for in-depth discussions, iterations and backtracking—and the research methodologies—which must be agreed upon by several actors and therefore can produce results that are only partially satisfactory for some individual stakeholders. In our context, agronomists and biologists had to adapt their ideal experimental design, converging on the most convenient sites and time range for the local community. Research questions too were not the same for social scientists, natural scientists and land managers. Additionally, project times slowed down, as a longer training period for the researchers themselves became necessary, departing from what had been initially planned. The technological tools initially proposed by the data scientists for monitoring all the activities of the urban experiment have been repeatedly reviewed by the extended community. Specifically, their feedback was very helpful to the ICT members of the community who had to face and cope with both the linguistic gap of a transdisciplinary community (i.e., lack of knowledge of scientific terms and concepts) and the digital-divide problem when designing the web application. With the cooperation of the extended community, more effective solutions were identified by providing explanations of the technical questions asked by the Soil_mAPP with the help of the agronomists. Also used were images and tutorials. There was integration of the Soil_mAPP with paper tools designed in collaboration with artists and young researchers, which proved to be better suited to stimulate reflections and artistic contributions, as well as to facilitate data collection for some citizen groups. This experience confirmed the finding that 'doing-it-together', exploiting transdisciplinary contributions combining frameworks across disciplines, supports out-of-the-box thinking and experimentation [43,44]. Furthermore, the sociological and anthropological inves-

tigations, as well as the training activities, have contributed to refinement of the tools designed previously for other objectives: walking conversations during site inspections, open discussions during webinars and workshops, multidisciplinary training cues within the field book and through quizzes and games incorporated in the periodic newsletter and so on. These 'boundary objects', both physical and digital, acted as a bridge between different social groups, helping and facilitating communication, learning and collaboration despite differing backgrounds, knowledge sets and priorities [45].

The strategic planning of hybrid activities not only facilitated introductions and relationship building but also created a platform for knowledge exchange and offered participants opportunities to familiarise themselves with the transdisciplinary approach. As documented in recent studies [46–48], the establishment of 'communication spaces' having fuzzy boundaries, albeit structured interactions, supports the sharing of valuable insights and experiences, leading to collective learning and growth. Investing in well-designed interactions can be seen to have strengthened the community's foundation, unlocking more of its potential.

The linguistic gaps, due to the different semantics of the terms for the distinct scientific disciplines and transdisciplines, may have led to some initial misunderstandings. They were resolved as the experiment progressed, through moments of dedicated discussion and time spent together conducting practical activities. One key feature that was particularly helpful to make people with different disciplinary backgrounds come together and adopt a trusting and collaborative attitude was the implementation of arts-based activities. These activities were proposed to the research community both during the training sessions and during the 40-day experimental window, and they were integrated with hands-on or reflective activities. These arts-based activities provided a common ground for the various disciplines, creating spaces for openness and dialogue among community members, indeed serving as 'boundary objects' that enhanced the capacity to translate across culturally defined boundaries [49–52]. The experience highlighted how sensory and creative activities can create a favourable ground for knowledge exchange across disciplines, backgrounds and generations. They can be a powerful support for the implementation of transdisciplinary approaches. It was also noted how the transdisciplinarity of the approach, besides being a founding value of the experiment, turned out to be a driving force for attracting interest in the project and maintaining engagement.

As the approach to soil fertility from a participatory perspective included both scientific and societal interests, difficulties were encountered in attempts to match the sometimes-conflicting constraints and interests of the community. During the design of urban CS activities, the team experienced different reactions from public administrations, which deserve to be highlighted. An environmental public agency asked to be involved in the project since its first phases. However, the agency did not take action during the course of the project, stopped interacting and did not participate in the field activities. A municipality belonging to the metropolitan area of Milan was the protagonist of an emblematic refusal, when a local environmental association proposed for the experiment a peri-urban green area on which previous surveys were available. The local administration did not give the authorisation to bury the litterbags, nor to take the soil samples. They did not give an official reason but only informally communicated that they did not wish to discover something that could prevent their future plans for the area. If the reasons behind the first cited example can be related to bureaucratic difficulties and an overload of commitments, in the second case the reason for the behaviour of the municipality is to be attributed to an attitude of avoiding scrutiny. In this case, the opportunity for interaction with scientists and citizens in a public area of common interest was perceived by the public administration as dangerous rather than favourable because of potential conflicts with other socio-economic interests. Some would argue that this behaviour is not surprising for managers of private companies, particularly those who choose profitability (e.g., accountability to shareholders) over sustainability whenever they are in conflict are concerned as outlined in Epstein et al.

(2015) [53]. However, this risk aversion also seems to affect public administrators, who can be seen to be driven by concerns about their own forms of accountability.

It has been argued that a conscious participation of public administrations in 'communication spaces' can foster transformative learning and the construction of shared visions for the allocation of local community resources [48]. In contrast to this instance, very constructive collaborations were experienced with other public authorities. A park authority manager of a huge urban public park (about 790 hectares) in the metropolitan area of Milan not only joined the extended research community but also provided maximum support in all phases of the experiment. They provided hospitality for events, proposed activities, and facilitated the participation of several volunteers, school classes and civic groups operating within it. Even the municipality of Milan, which hosted most of the field activities, showed interest and support, taking part in webinars and workshops and facilitating the execution of the activities.

The process described and the approach followed were developed experimentally specifically for this case study and applied for the first time in the Milan area. The experience constitutes a fertile case study to add to the rich literature on transdisciplinarity and societal participation in ecological research.

Benessia et al. [3], in 2017, wondered whether CS could take part in the rescue of the quality and trust in science and argued that this restoration cannot be achieved by 'scientific' means alone. Rather, one needs to complement established science with new forms of practice and exploit avenues external to science's own institutions. The BRIDGES experience offers a contribution to the exploration of these complementary practices to traditional scientific approaches in the field of socio-ecology. It also enriches recent reflections on CS as a transformative ethical practice, enabling researchers to move beyond scientific standards [10,13]. The integration of methods appropriate for artistic and aesthetic research into the participatory experience is an additional step, which builds on didactic and holistic models [9] to foster broader understanding about human–environment relationships. These practices have proven effective in creating 'communication spaces' [47] in which the growth of trust and exchange of knowledge are fostered. They can be seen to contribute to preparing informed citizens capable of facing sustainability challenges [9]. It would be desirable in the future to further investigate the impacts of similar processes–on different research topics–on researchers, administrators and citizens in terms of learning and building mutual trust.

The application of a transdisciplinary and participatory process implies a longer preparation phase for the research team and a greater commitment of time and good will than that required by traditional investigations. However, it was precisely the extension of the preparation times that allowed the extended research team to carry out the (mutual) training process, which was one of the objectives of the project. In this role, it can be argued that patience and flexibility constitute key characteristics to allow for the application of these non-standard practices in the research environment. The inclusion of training courses dedicated to transdisciplinarity and to the participation of civil society in scientific research within academic curricula would be desirable. Such training would enable young researchers to approach scientific activity with greater openness, get off the beaten track and open up new avenues for future research. At the same time, it would be worth further analysing which changes to the system of the production and dissemination of scientific knowledge would favour the application of transdisciplinary processes in scientific research.

The experiment also outlined some limitations and future directions for this research. The possibility of developing the process in a participatory way, and sustaining interaction during the main experimental phases with a co-creation approach, was certainly favoured by the local scale of the activity. Replicating a similar experience on a larger scale—for example, regional or national—would lead to the loss of some of the interactions experienced within the project and it would present difficulty in managing face-to-face activities. On the other hand, a more extensive and denser mapping of the soils would be desirable,

both to create a broader dataset that reveals how the history and physiognomy of the territories influences its biological activity and to arrive at a plausible geographical interpolation between sufficient density of data points. In summary, if the local scale facilitated interaction, it probably limited the generalisability of the approach. A future spatial and temporal extension of the methodology and process implemented is desirable but will involve addressing these critical points and the establishment of multi-level and cross-local policies for governing the project.

5. Conclusions

This paper recounted the process followed to build an extended community of research in a transdisciplinary project dealing with the socio-ecological issue of the fertility of soil. This issue is complex and controversial, with its management and preservation requiring a new set of relationships between science and governance, society and ecosystems, including human and non-human actors.

Several reasons motivated the selection of the case study on soil fertility:

- Soil is fundamental for life and biodiversity, but its importance is often underestimated in respect to other planetary emergencies;
- Soil fertility is strongly correlated with the health and prosperity of all living things, human and non-human;
- Diverse knowledge systems (scientific, local, artistic and experiential) and a plurality of methods and multiplicity of scales are crucial for its understanding.

The traditional scientific research can be characterised as featuring a hegemony of theoretical and experimental science guided by disciplinary norms with relative autonomy for scientists and their institutions. This type of scientific research can lack connection with societal needs/interests. Counteracting that calls for diverse modes for knowledge production to be experimented with, subject to multiple accountabilities and reflexivity from a variety of societal actors and interests. For this study, a research community was built that bridges science, governance, society and the environment to perform soil fertility investigations. The proposed approach involved scientists, social scientists, artists and local communities. It combined theoretical, practical and artistic methods across various scales. The experiment aimed at building bridges between different disciplinary approaches—with social sciences and humanities dialoguing with the natural sciences, and academic knowledge interacting with local knowledge. It also sought to build bridges between theory and action, to co-create the conditions for greater participation of citizens in decision-making processes about complex issues related to sustainability arising at the interface between science, society and the environment.

Experimentation allowed the research team to identify and describe key insights: the process of community building and co-designing research was valuable; and combining different knowledge systems fostered a deeper understanding of soil fertility. Another key lesson was relative to the role of arts and emotions. Considering that traditional research often ignores the aesthetic and emotional aspects of environmental issues, the project incorporated artistic experiences to cultivate an 'ecological awareness' and to treat soil as a 'matter of care', in addition to one of interest and concern. Integrating emotional and sensorial connections with soil turned out to be a crucial aspect for responsible actions by participants in this instance, underlining the importance of placing value on the perspectives of a wide array of stakeholders. This shift can be seen as a necessary condition both for the democratisation of science—obviously true for the shared definition of desirable directions of scientific research—but also for the construction of 'socially robust' knowledge, which is responsible, inclusive and relevant.

Collaboration with local bodies and public administration proved to be an important element in the success of the experiment. Local policies can do much to support community involvement in sustainability initiatives and to foster collaboration with researchers, whether in the natural sciences, the humanities and social sciences or even in the arts. A particular challenge for local governments is translating the outcome of participative activi-

ties into applied policies that are respectful of the interests of different local stakeholders and forward-looking in their management of collective resources.

The experience described constitutes what can be considered a significant (and potentially the first) application of a participatory and transdisciplinary approach to ecological issues in northern Italy and in the Milan area in particular. It is hoped that it will become a starting point for new and broader joint actions between citizenships, local administrations and the scientific community.

Author Contributions: A.L. coordinates the project from which this case study is extracted. All the authors, who are members of the extended research team, contributed to the design, the performance and the analysis of the experiment described in this paper. L.C. and G.B. guided and moderated the writing of this paper. All authors contributed to the definition of the structure, the writing and the revision. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: The research conducted does not require acceptance of the human ethics committee in Italy. All the research participants have provided explicit consent to participate in the activities and for their data to be used for the research objectives.

Data Availability Statement: The use of the data collected through the Soil_mAPP application is in accordance with the GDPR protocol (https://www.garanteprivacy.it/il-testo-del-regolamento (accessed on 11 March 2024)). The data presented in this study are available on request from the corresponding author.

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Conflicts of Interest: Authors Stefano Crosetto and Enrico Ercole were employed by the company SEAcoop STP. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Perceptions of Urban Community Resilience: Beyond Disaster Recovery in the Face of Climate Change

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Abstract: Resilience of human systems has increasingly become a popular topic of research. The aim of this article is to present a juxtaposition of public officials' and residents' perceptions of community resilience along the three-class typology of resilience (basic, adaptive, and transformative) using Dayton, OH as a case study. A two-pronged data collection approach was designed to recruit public officials and residents. This approach was structured using the Community Capitals Framework. A multi-chain referral sampling process (and subsequent snowball sampling) was initiated subsequently. The data were gathered through semi-structured interviews with 75 participants. The interviews were analyzed using a three-tiered deductive structural coding approach. The findings highlight the similarities and differences in resilience perceptions between public officials and community members along the three-class typology of resilience that could inform creative policy initiatives. The factors that might undergird residents' and public officials' perceptions of resilience are discussed. Based on these perceptions, the importance of social capital, communication infrastructure, and addressing chronic stressors are discussed as important strategies to build community resilience, in addition to focusing on essential community infrastructure systems (such as roads, energy, water, sewer, and gas systems).

Keywords: community resilience; basic resilience; adaptive resilience; transformative resilience; disaster recovery; climate change

1. Introduction

Resilience of human systems has increasingly gained ground as both a targeted process of societal development and as a research topic in its own right [1]. As resilience often transcends both the natural and social sciences, it has become a basis for decision-making in studies examining the complex interactions between society, land use management, and policy [1]. While a large body of literature exists on community resilience, there are still significant gaps in knowledge and an imminent need for further research, especially social sciences research [2].

Most studies exploring community resilience focus on a single hazard event (such as a wildfire, flood, or earthquake), or focus on the dynamics pertaining to one system (such as energy systems or infrastructure), or explore post disaster recovery dynamics of a community [2]. Wise et al. [3] describe these focuses as addressing specific resilience as opposed to general resilience where the focus is on broader community capacities and ability to cope, acclimate, and adapt. By focusing on general resilience, this article addresses a gap in the literature that has not received much empirical research attention. Resilience could be subjective and context specific to different groups [4]. The main aim of this article is to present a juxtaposition of public officials' and residents' perceptions of community resilience, using Dayton, OH as a case study. Specifically, this article explores the similarities and differences in community resilience perceptions held by residents and

public officials and what factors might undergird such perceptions. Social scientists should pay attention to capacities that help communities adapt and the processes and relationships through which community resilience emerges over time, to assist public officials with developing policies to build community resilience [4]. Within that context, this article also discusses the resources and assets perceived as important for community resilience and the opportunities for building community resilience.

Community resilience is described in the literature using a variety of methods. Numerous articles, such as [2,5–8], have explored community resilience using a more theoretical literature review approach. Several studies [9–13] have explored community resilience using a survey approach. However, few studies, such as [4,14,15], have examined community resilience using a qualitative interview-based approach. Out of these, Adekola, Fischbacher-Smith, and Fischbacher-Smith [15] is one of few studies to explore community resilience perceptions held by different stakeholder groups. Adekola, Fischbacher-Smith, and Fischbacher-Smith [15] contend that it is important to explore perceptions held by different stakeholder groups to achieve desired policy outcomes and identify implementation gaps. In addition, Chondol et al. [12] contend that limited research has explored community resilience perceptions of government officials and recommend further studies. Therefore, by adopting a qualitative approach and by examining stakeholder perceptions held by different stakeholder groups, this study addresses an important methodological and knowledge gap in the body of literature.

Exploration of community resilience perceptions held by different stakeholder groups could add several important contributions to the community resilience body of knowledge. First, it could demonstrate where similarities and differences in perceptions are, and such insights could inform public officials. Second, differences in perceptions could point out the gaps in resilience strategies that need to be addressed through policy and new initiatives. Third, the perceptions of public officials could point out the limitations and challenges they face within the functions they are responsible for and the official lines of authority/responsibility, and such insights could inform community members on what areas require constructive community-inspired solutions. Fourth, the perceptions could elucidate how communication and other vital collaborative processes could help public officials and community members to work together to build community resilience.

Community resilience has been defined and described in a multitude of ways [2]. This article largely follows the three-class typology of resilience: basic (bouncing back to a similar state), adaptive (adapt to new or dynamic conditions by changing fundamental characteristics of the system), and transformative (substantial and explicit changes to social–ecological systems) [16–19]. While most pertinent literature consider disaster events as disruptions, this article adopts a broader view of disruptive events. This article recognizes two types of interconnected disruptive events: acute shocks and chronic stressors. Acute shocks are sudden events such as natural disasters, disease outbreaks, mass shootings, or terrorist attacks etc. Chronic stressors are continuing community dynamics that weaken the fabric of a neighborhood such as poverty, racism, food insecurity, and high unemployment. Chronic stressors could weaken the resilience of a community by themselves or could make a community more susceptible to harm from acute shocks. The next section reviews the pertinent literature on community resilience.

2. Review of the Literature

The body of literature on resilience in general and specific to disturbance recovery is broad and can be found in a wide variety of disciplines from psychology to engineering and from behavioral sciences to environmental sciences [2]. Resilience literature also examines a range of scales from an individual to planetary systems (and systems in between such as public infrastructure and regional economies) [2]. Recently, there has been a proliferation of community resilience research focusing on natural hazards and disasters such as flooding, hurricanes, wildfires, or earthquakes [7,20]. Such research examines how specific social systems, built environments, or ecological systems individually or

collectively contribute to resilience [20]. The synthesis of the literature discussed below focuses on the conceptualizations, manifestations, and operationalization of community resilience. The review abridges literature relating to disaster recovery, community change adaptation, and factors that enable disaster recovery and adaptation. For this purpose, a community is identified as a collective dynamic entity of constituents living within certain geographic boundaries (or space), sharing common interests and a shared fate [4–7].

2.1. What Is Community Resilience?

Holling [21] (p. 14) is credited as one of the first researchers to coin resilience as the "measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables". Subsequent research describes the ability as the ability to absorb, resist, or deflect the impacts of a shock [2]. Folke [22] contends that "Resilience is about cultivating the capacity to sustain development in the face of expected and surprising change and diverse pathways of development and potential thresholds between them". Vulnerability, described generally as susceptibility to harm, might be considered as inversely related to resilience: the more resilient, the less vulnerable [16].

While no broadly accepted single definition of community resilience exists, the varied definitions commonly focus on a communities' ability to plan/prepare for (and identify vulnerabilities), withstand, absorb, and rapidly recover from disasters to successful long-term adaptation towards changing social–economic–environmental conditions, as central to resilience [4,5,23,24]. Within this view, community resilience could be perceived as a strategy for promoting effective disaster readiness and response; or as a model consisting of a set of capacities; or as a process that links a set of adaptive capacities to a positive trajectory of functioning [6]. It can be imbued that as a strategy, or as a model, or as a process, the three dynamics represent critical and interconnected facets of community resilience.

Compared to other definitions, Wilbanks [25] (p. 10) provides a broader definition of community resilience as "one that anticipates problems, opportunities, and potentials for surprises; reduces vulnerabilities related to development paths, socioeconomic conditions, and sensitivities to possible threats; responds effectively, fairly, and legitimately in the event of an emergency; and recovers rapidly, better, safer, and fairer". This broad encompassing definition highlights how resilience could be viewed as an umbrella concept consisting of different precautionary, reactive, and recovery measures to be undertaken in reference to a disturbance event or changing conditions. In an attempt to better structure these different measures, some of the literature adopts a three-class typology of resilience: basic (bouncing back to a similar state), adaptive (adapt to new or dynamic conditions by changing fundamental characteristics of the system), or transformative (substantial and explicit changes to social–ecological systems) [16–19].

2.2. Basic Resilience

Basic resilience refers to bouncing back or recovering to a similar state that existed before the disturbance event. Within a disaster recovery context, the pertinent literature describes resilience as the qualities (or characteristics or the ability) of a specific entity (such as a community and its constituents or an individual) that enables it to recover from a shock [4,20,26]. To that end, the IPCC [27] (p. 37) defined resilience as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt naturally to stress and change". As evidenced by the literature, maintaining functions, relationships between actors, and capacity for recovery following a shock is critical for basic resilience. Similarly, Kirmayer et al. [7] (p. 72) define community resilience as the "ability or the capacity of a community to withstand, recover from, and respond positively to a collective crisis or adversity". Resilience of essential community infrastructure systems (such as transportation, water, energy, sewer, and natural gas systems) is largely focused

on minimizing the magnitude of impacts and restoration/recovery to pre-existing fully functioning conditions [2,5].

The idea of "bouncing back" to pre-status-quo of broader complex systems (such as a community) has been criticized as being too narrow and recreating the original vulnerabilities [2]. Comparatively, learning, re-organizing, adjusting to change to minimize the effects, and coping are considered as critical components of proactive or forward-looking resilience [2,5].

2.3. Adaptive Resilience

Folke et al. [17] (p. 1) describe resilience as "the capacity of a social-ecological system to continually change and adapt yet remain within critical thresholds". Sometimes referred to as "change at the margins" or "incremental reform", this approach entails an acknowledgement of risk and adaptation undertaken, but limited to those that do not threaten the core attributes of the system [28]. Adaptive resilience concentrates on learning processes and medium-term/moderate adjustments to pertinent systems in response to drivers of change through policy changes [29]. According to Folke et al. [17] (p. 7), "while adaptability is part of resilience, it represents the capacity to adjust responses to changing external drivers and internal processes and thereby allow for development along the current trajectory". Fazey et al. [30] notes that adaptability and flexibility, such as having a range of response options is going to be crucial in such a context. Preference for near-term stability over sweeping reform provides a strong incentive for adaptive resilience [28]. However, trying to adapt a community and its systems in a fast-changing complex environment could be challenging as the critical thresholds of the existing systems might not be able to withstand the pressures of new conditions. In addition, incremental adaptations might not be adequate in some communities if vulnerabilities and risks are significant, which may require transformational changes [31].

2.4. Transformative Resilience

As described by Folke et al. [17] (p. 7), "transformability is the capacity to cross thresholds into new development trajectories". Transformative resilience represents the capacity of communities to change/reshape its systems, forms, functions, processes, structures in a deliberate and conscious way [29,32]. Transformative resilience involves a status change in which the structures, institutions, processes, and identity of a community evolves into a more-desired configuration that carries the communities' values and functioning forward [7,33,34]. Transformative resilience requires a community intentionally altering social–ecological systems and material resources, which could be desirable when it is congenial with societal goals, but requires tremendous social agreement and political will [28].

Transformative resilience approach is sometimes referred to as bouncing forward and conducive when conditions are changing rapidly, such as due to climate change [18]. As the frequency and magnitude of climate disasters increase with devastating effects on communities, built infrastructure, and natural environments, communities would need to increasingly focus on transformations to become more resilient [30]. Transformative resilience as a response to climate change is at the forefront of many policy initiatives on climate adaptation and disaster risk mitigation, and opens a range of novel policy options that require further research attention [29,35]. Meeting the challenges of climate change in some communities will require unprecedented transformative solutions with careful consideration for implementation [36]. Catastrophic events could act as catalysts for community transformation or formation of novel communities especially in high vulnerability contexts (such as repeated storms or repeated wildfires) where collective action spurs the reconstruction process [4]. However, community-level actors cannot be left alone to guide their own resilience pathways, and in most cases, the public officials and the political leadership have to at least play some guiding and influencing role in the transition processes [1].

2.5. Systems, Resources, Assets, and Processes Considered as Important for Community Resilience

This subsection outlines key resources from pertinent literature that are considered critical for community resilience, in addition to community infrastructure systems. Numerous research recognize the impact of chronic stressors (such as unemployment, food access, lack of affordable housing, poverty, water shortages, disinvested communities, and lack of transportation, etc.) as pre-existing or underlying community conditions that weaken a community and make it more vulnerable to acute shock events such as earthquakes, fires, and floods, etc. [2,26,37]. Sometimes coined "social vulnerability", the potential for harm from a disaster event could be unequally distributed among the impacted population, based on larger social and cultural conditions [38]. Bergstrand et al. [39] measured community resilience and social vulnerability in counties across the United States and found that the most vulnerable counties also tend to be the least resilient.

It is important to note that social vulnerability factors often overlap or intersect [38]. For example, some ethnic minorities are more likely to be poor, less educated, and lack access to resources. The case of Hurricane Katrina and New Orleans provided vivid evidence of how intersecting chronic stressors made certain neighborhoods more vulnerable, led to greater harms, and recovery more difficult [38]. Systemic discrimination of different forms can contribute to greater social vulnerability in neighborhoods over time [38].

Numerous research attribute the ability to withstand and recover with minimum impacts and damage as emanating from a set of community capacities or resources (such as social capital, economic infrastructure, and communication) that can support the maintenance of certain critical functioning after a disturbance [4,5,40]. Some related research identify these community resources as different forms of capital or a network of adaptive capacities that could be collectively leveraged for resilience [5,6]. Different forms of capital include natural capital (ecosystems or natural environmental stocks that provide valuable services), social capital, as well as other economically defined forms of capital [33].

Multiple research exemplify the importance of social capital to community resilience. The role of social capital in community resilience could be complex and could be considered a key component of community resilience [4]. Rapaport et al. [41] examined the interconnections between social capital and residents' perceived resilience and found that the nature and type of social relationships and interactions embedded in a community are stronger predictors of community resilience. Other studies, such as [42], arrived at similar conclusions. Sherrieb, Norris, and Galea [43] (p. 233) define social capital as the "set of adaptive capacities that can support the process of community resilience". But this definition discounts the role of other important systems or factors such as communication infrastructure, assertive community leadership, and natural systems [4,6]. Social capital embodies the idea that social relations, social networks, voluntary associations, sense of community, place attachment, sense of inclusion, sense of belonging, citizen participation, and the structure/diversity of social relations can have synergistic constructive benefits to a community [5,6,30]. To this end, Aldrich [44] conceptualizes social capital as consisting of bonding, bridging, and linking interconnections that can help community members to self-support and self-organize during and after disaster events. The concept of social capital manifests the idea that resilience is a clustered phenomenon that occurs in groups of people embedded in a web of meaningful relationships that is crucial to facilitate the flow of resources and ideas [7,33]. Community activities, such as creating community gardens or green spaces, foster resilience through the establishing social networks [33]. In addition, citizen participation (involvement and engagement) in formal and informal community organizations is widely believed to be a fundamental element for building social capital [6].

Good strategic communication is essential for community resilience [6]. Communication within the context of resilience could accomplish the transfer of information to residents during emergencies, the coordination of recovery personnel, or the provision of opportunities for members to articulate needs, views, and attitudes on long-term community challenges [6]. Top–down (e.g., government agencies providing emergency information to citizens) and bottom–up (e.g., neighbors connecting with each other to recover following

a disaster) communication is important for building resilience [45]. Access to timely and accurate information on the threat implications of a disaster, what residents could do to minimize impacts, support resources available, and recovery efforts in place is critical for responding to and recovering from disasters and for building trust [26,33,45].

Synthesizing the above literature, several points can be highlighted that are pertinent and important within the context of this research study. It is evident from the literature that planning for and preparing prior to a disaster and maintaining community functioning, relationships between actors, and capacity for recovery following a disaster are critical for basic resilience. Staying within the bounds of current systems while proactively adapting for changing conditions provides strong motivation for adaptive resilience. However, incrementally adapting a community and its systems in a fast-changing complex environment could be challenging. While transformative resilience, especially within the context of climate change, opens up a range of novel policy options, transformational initiatives require tremendous social agreement and political will. Frequent climate disasters could act as a catalyst for transformation, but the process needs to be carefully guided by public officials and political leadership. The presence of certain community assets or qualities (such as strong social capital, or effective communication) seems to enhance a community's ability to withstand, maintain critical functioning, and recover after a disturbance. Conversely, the extent of (and overlapping) chronic stressors impacting a community makes its residents more vulnerable to harm from a disturbance event. Within this context, the main aim of this research was to explore the similarities and differences in community resilience perceptions held by the residents and the public officials along the three-class typology of resilience and what factors might undergird such perceptions. The next section outlines the methods adopted and describes the research site.

3. Methods

This study's broad purpose was to explore community resilience perceptions held by public officials and residents of Dayton, OH. The data were gathered through in-depth semi-structured interviews with 75 participants. Similar studies, such as [14,15], adopted a similar data collection approach. A research review was conducted to understand the dynamics that needed to be explored and to frame the interview guide for the semi-structured interviews. Resources from 100 Resilience Cities and Second Nature were also used to frame and draft the interview guides. Institutional Review Board (IRB) approval governing human subjects research was obtained concurrently. When needed to ensure adequate information gathering, the original questionnaire was adjusted and fine-tuned as the interviews progressed. Probes were used as necessary. The interviews were conducted between April and August 2020, during the height of the COVID-19 pandemic under unprecedented circumstances.

A two-pronged approach was adopted for sampling and participant recruitment. First, the Community Capitals Framework (CCF) was used to structure participant recruitment and initial purposive sampling process. This approach has previously been successfully employed in the literature [13]. Flora and Flora [46] present the CCF as a systems approach to examining and understanding community dynamics. The CCF analyzes 7 capitals (natural, financial, political, social, human, cultural, and built) to understand the strengths and weaknesses within each community and how the capitals could be leveraged to recover from a disaster or negativity [46]. The CCF has been used to study community recovery after a tornado [47] and wildfires [48]. The descriptions of different types of capitals outlined by Flora and Flora [46] and an asset mapping effort were undertaken to identify the key community stakeholders that would fall into the 7 types of capitals of the CCF. Biernacki and Waldorf [49] note that initiating multiple referral or sampling chains represent greater sensitivity and attentiveness to information, where the sample initiation and progress is deliberately developed and controlled.

A referral sampling chain was initiated for each of the seven capitals. Once the initial participants that aligned with the 7 capitals were identified, snowball sampling was used to

identify additional participants within each capital until data saturation. A total of 42 key stakeholders were interviewed under this effort. Public officials were asked to respond to the questions in their official capacity. If the participants represented a community organization (such as within social or cultural capital), they were asked to respond to the questions within their organizational context.

A second effort was undertaken to reach the residents through the neighborhood associations. Due to the COVID-19 pandemic, several neighborhoods did not have monthly meetings. Therefore, it must be noted that the voice of some neighborhoods (especially vulnerable) that did not have access to pertinent technology are not represented in the findings. A total of 80% of the active neighborhood associations were reached for participation. A total of 33 residents representing 18 different neighborhoods were interviewed. Snowball sampling was used after the initial set of interviews to identify additional participants and the interviews continued until data saturation. Resident participants were requested to answer the questions within the context of the neighborhoods they lived in.

Considering the challenges presented by the COVID-19 pandemic, all semi-structured interviews were conducted and recorded using Zoom. Each interview lasted around 45–60 min. Verbal informed consent was obtained from the participants at the beginning of each interview. Participants were encouraged to express their ideas and thoughts freely with guaranteed anonymity. Extensive notes were taken during the interviews for context and additional data. Some questions such as "what does the word resilience mean for your work/community?" were presented to both key stakeholders and residents. Both sampling processes (key stakeholders and residents) ended at the point of data saturation, at which point no new insights from the data emerged from additional interviews.

The interviews were then transcribed verbatim and analyzed using deductive structural coding and analysis methodologies. The key stakeholder interviews and resident interviews were coded and analyzed separately until the comparative analysis stage. A three-tiered coding approach was adopted. A codebook consisting of an initial set of descriptive codes was developed using pertinent research on community resilience and the interview questions. Answers to questions such as "what does the word resilience mean for your work/community?" were coded using structural coding. New descriptive codes were recognized and the codebook updated as the coding progressed (most new codes pertained to importance of certain resources or challenges). The codes were then organized into groups under a pattern coding effort using the three-class typology of resilience: basic, adaptive, and transformative. Thirdly, a comparative analysis was undertaken between the pattern coded key stakeholder data and the resident data to identify similarities, differences, and major themes along the three-class typology of resilience. No causality was implied in the comparative analysis. Findings were shared, presented to, and discussed with participants to obtain feedback and to ensure accuracy and validity.

Description of the Research Site

Dayton, Ohio has a rich historical legacy filled with innovative entrepreneurial spirit. The city is known as the birthplace of aviation. Dayton claimed more patents per capita than any other U.S. city in 1900 [50]. As depicted in Figure 1, Dayton is located at the intersection of highways I-70 and I-75, making it an ideal location for manufacturing industry. Its entrepreneurial climate nurtured innovators such as Charles Kettering, inventor of the automobile self-starter, and air travel pioneers Wilbur and Orville Wright. The city also nurtured companies that would become stalwarts on the Fortune 500 list, including National Cash Register (NCR), Mead Paper Company, Standard Register, Reynolds and Reynolds, and Dayco and Phillips Industries [50]. However, with globalization and automation, the city lost many of its renowned manufacturing giants.

The city and its residents have struggled to overcome adversities following the loss of NCR, General Motors, and consequently thousands of manufacturing jobs. The effects of industrial and manufacturing decline are still visible in some neighborhoods with abandoned industrial buildings. Many neighborhoods in Dayton are identified as food

deserts (areas that lack availability and access to fresh and nutritious food), as depicted in Figure 2 (neighborhoods colored in orange) and Dayton has one of the highest poverty rates in the United States of America, among mid- to large-sized urban areas [51]. But Dayton has pride, grit, and a knack for problem solving. Daytonians also value art. Dayton is one of the smallest cities in the country to have an orchestra, ballet company, dance company, and an opera company.

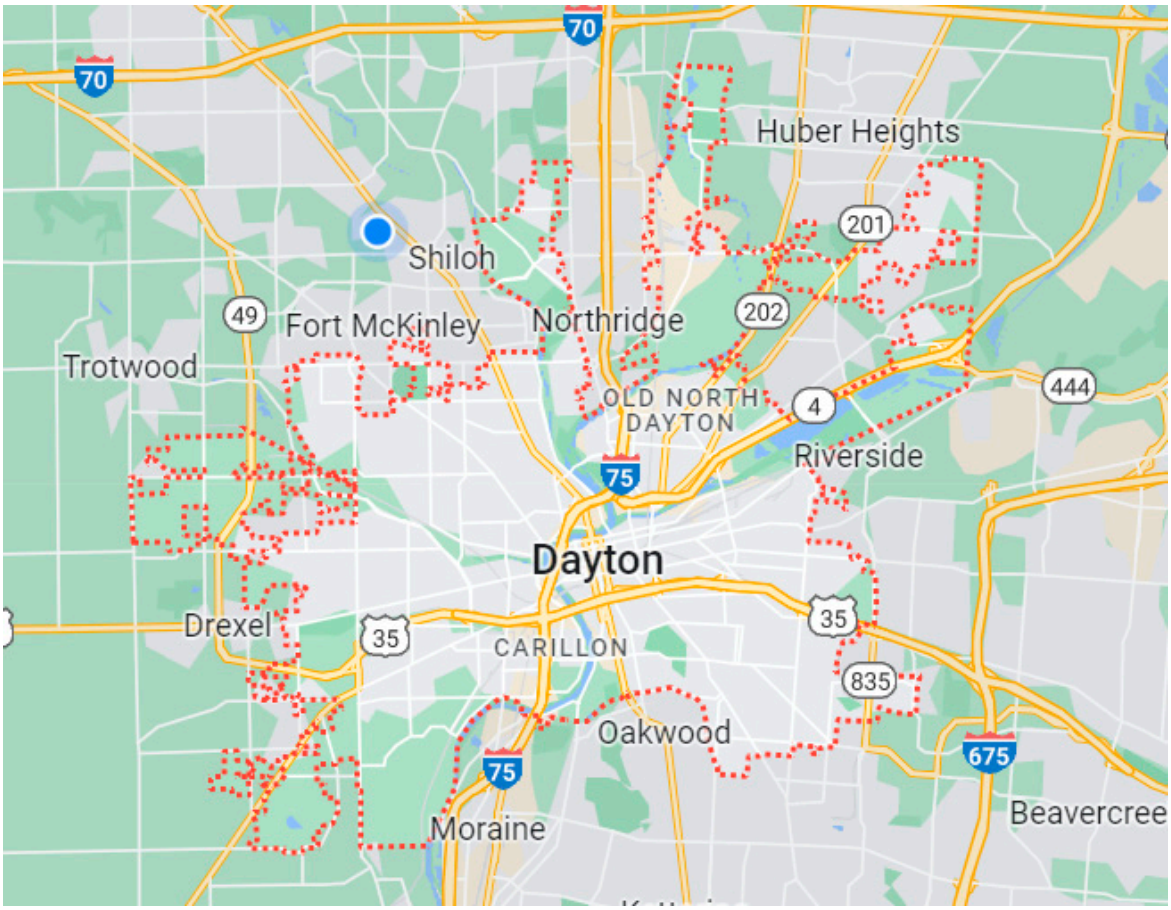

Figure 1. Map of Dayton, OH. Source: Google.

Recently, Dayton has experienced a resurgence. In the last decade, the city has seen a significant shift in the economic growth of the downtown area with new apartments; an increase in local restaurants and bars; and other small businesses that keep money in the community. One of the most notable ventures is the development of the Gem City Market. The Gem City Market is a community owned local grocery store developed and led by residents and located in a food desert.

According to National Weather Service, on Memorial Day in 2019, the Dayton area was struck by 19 tornadoes, and 15 of those happened within the Montgomery County, where Dayton is located. Many properties and neighborhoods suffered damages as a result. There was a mass shooting in 2019 in one of the historical restaurant districts of the downtown. There was also a white supremacist rally in downtown Dayton in 2019. The city also experienced a significant water main break in 2019. It is not an underestimation to state that Daytonians have experienced several disturbance events recently

Dayton's climate is also changing. The city has experienced an overall increase in temperature, warmer winters, record breaking heat in the summer, and periods of flooding followed by seasonal droughts. The change in weather within the region has led to crop damages for farmers, increased energy demand in the summer, and failures in infrastructure. According to the Great Lakes Adaptation Assessment [52], the average

temperature in Dayton is expected to increase by about 3–4 degrees Fahrenheit by the mid-century. Based on climate models, precipitation will continue to increase in Dayton with wetter winters, springs, and falls, but with drier summers, when agricultural crops are growing in the region [52]. These weather conditions might yield more hot days, frequently occurring heat waves, flooding during spring and fall, more single heavy rainfall events, and delayed spring planting [52]. However, warmer winter might also mean a longer growing season. With these expected conditions, it is clear that the city, its infrastructure, its systems, and Daytonians can expect to experience changing future climate conditions.

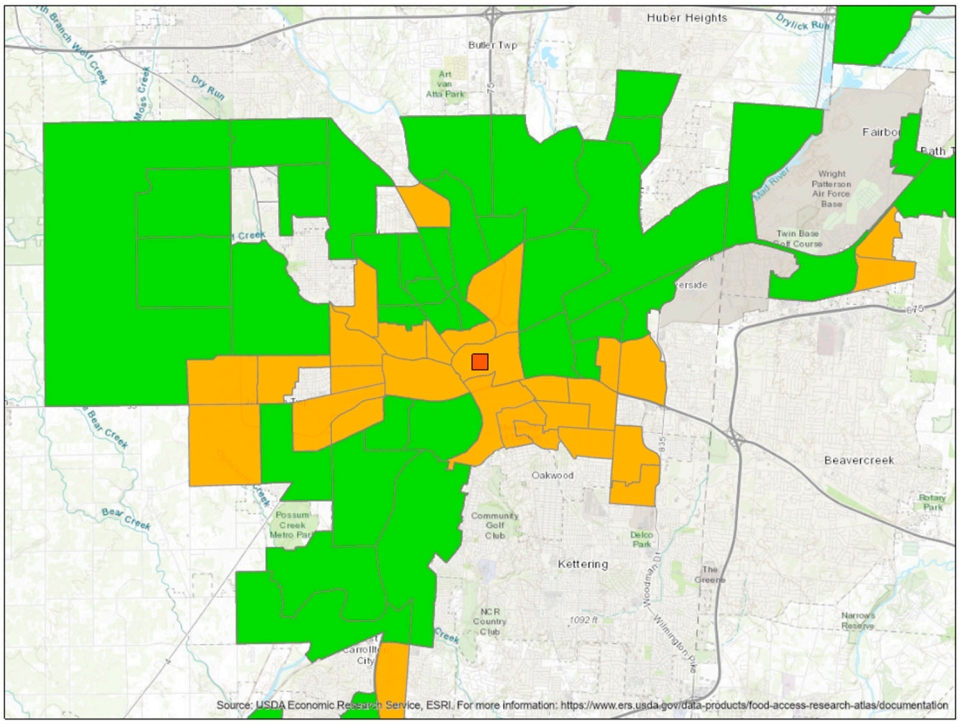

Figure 2. Low income and low food access neighborhoods in Dayton identified as food deserts, colored in orange. Source: USDA n.d.

Given the above background and community context, Dayton is a fitting place to explore community resilience perceptions. The city grapples with many economic hardships experienced by other rust belt cities. But it also has success stories to share. Dayton is already impacted by climate change with projected changes to come. But Dayton and its residents take pride in their innovative and problem-solving mindset, and in the art that brings them together.

4. Findings

The findings presented in this section describe the major themes that were frequently and consistently mentioned by the participants. Selected participant quotes are provided to support the findings and these quotes are representative of the ideas that were frequently mentioned by the participants and exemplify the findings. The findings are organized into four sections. The first three sections describe the public officials' and residents' perceptions of resilience along the three-class typology of resilience (basic, adaptive, and transformative). This section also highlights the similarities and differences between the perceptions of public officials and residents. The fourth section lays out the major community resources and assets that participants perceived as important for community resilience.

4.1. Perceptions of Basic Resilience

Public officials in general, especially those officials responsible for emergency management, and several community members, associated resilience with disaster recovery and disaster preparedness. As one public official described "I think of it primarily as an emergency response, but not entirely because you're eliminating then the proactive side, the preparation side of hardening the infrastructure, putting protocols and practices in place". Similarly, a participating resident described resilience as "I guess the ability to weather the storm or bounce back from these events". However, compared to public officials, the residents perceived disturbances more broadly, and their perceptions demonstrated the ability to overcome a variety of adverse events, as one participant described: "resilience to me is in the face of negativity, coming and making a positive of it. . .whatever it might be, a tornado, or COVID-19, or mass shootings and that type of thing, so it's kind of like the adage, we all get knocked down, but our community keeps getting up". Several residents described how they felt impacted by the mass shooting that happened in Dayton in 2019 and efforts to recover. Therefore, it can be argued that residents view a disturbance event (and thus needing recovery efforts) as any event that impacts the human fabric of the community (such as a mass shooting) in addition to events that impact physical infrastructure.

Public officials attributed short-term disaster recovery efforts as largely focused on infrastructure and restoration of services considered essential community infrastructure systems. A public official described that "So for me, resiliency is very much related to those things like natural disasters where if the region or the community experiences a problem or a natural disaster, how quickly can we return the grid back to its state". Similarly, another public official noted "I would say it is very heavily infrastructure-focused though, and the reason that happens is because the disaster is infrastructure-focused. We lose homes, we lose schools, we lose buildings, we lose bridges, we lose trees, power lines. All that stuff is infrastructure". Comparatively, many residents spoke about the importance of restoring the human dynamics, in addition to physical infrastructure, as demonstrated by the below quote:

> "So I think, for me, resilience is really the ability to bounce back, when challenges come, how quickly can we, I think, recover. How quickly can we. . . From kind of the spiritual standpoint. So it's not just on the surface level things are back to normal, but really healing and becoming whole again, in essence."

Within that context, residents perceived resilience to be the ability of the residents to band together, heal, connect, and to get through difficult times. Resident perceptions of disaster recovery were also more integrative and holistic in nature compared to public officials. For example, one participant stated that

> "So if we're talking about recovering people who are renters that maybe are thinking they're ready to be permanent homeowners, that can swirl into an affordable housing conversation. And then attached to that, it could turn into, how are we building up our infrastructure that supports folks like that, that may not be living where they used to live, so now their commute to work is different, or maybe they're not near the schools that they used to go to?"

Public officials responsible for emergency management noted that some aspects of disaster recovery could have a longer time frame and mused if certain dynamics of recovery would be a community responsibility. While certain things such as clearing out debris, repairing power lines, and clearing out damaged homes could be accomplished within a short-term, other things such as replacing/rebuilding damaged community assets such as a grocery store could take longer and there might be some confusion as to who bears the responsibility of restoring such damaged community assets. For example, a public official pondered,

> "Okay, we don't have any more demolitions, alright, so that's one thing off the infrastructure list, but maybe we don't have a grocery store in the neighborhood

> anymore because it got damaged. Well, is that still part of the disaster recovery effort, or is that part of now the obligation of the community and the businesses?"

Communication infrastructure and processes were perceived as a vital facet of basic resilience. A public official described the how the communication processes and restoration of the energy system after a disaster go hand in hand as

> "We know how to keep the power on, and we know how to get it back on. . .We've got really great processes in place to handle. . . We have processes in place to take calls from police and fire departments with issues that they see, you know, lines down in the middle of intersections, where people are at risk. We have dispatchers. And then the communications efforts that go into that, making sure the media knows what's happening and customers know what's happening and when they can expect power to be back on"

It is important to note that even short-term disaster recovery approaches might need to change as a result of climate change. One public official described the needed change in the approach as

> "I think that actually the chances are pretty good, we will have overlapping natural disasters. At a minimum, we won't have recovered from the first one before the second one hits. At a maximum, we would have a wider spread debris field and disruption. . . And the emergency managers and staff have all grown up with a certain assumption about what this is gonna look like, and I think climate change just throws those assumptions to the wind, no pun intended."

As the above data indicate, while both public officials and residents alluded basic resilience to disaster recovery and preparedness, there were notable differences in perceptions on what was considered as a disturbance event (and thus needing recovery efforts) and the community components (infrastructure, basic services, and human dynamics) that needed to be restored through recovery efforts.

4.2. Perceptions of Adaptive Resilience

While some public officials perceive the ability of a community to return to the status-quo as soon as possible after a shock as resilience, other officials perceive "build back better" or "bouncing forward" within a limited context as a better strategy. To this end, several public officials described similar sentiments such as

> "it's part preparedness, but also if we build back better, then we have better to start with, so we don't have chinks in our armor that if something happens. . .So I guess just having better armor, and if we build back better, we will, and that can mean a lot of different things, including of course, our ability for our community to handle high water or the weather pattern changes that we're seeing, and the ability to not only handle it, but be better afterwards."

Similarly, a resident described the thought process behind restoring the trees in the neighborhood after a storm as

> "If we can put them back, or put them back in different species or varieties because we can provide people with a huge advantage after the disaster. . .Maybe the folks in the neighborhood will feel safer because they have trees that provide coverage, or they have kids and families that wanna live there because of the infrastructure that it provides. You get a whole different sense of a neighborhood"

Both public officials and residents viewed "build back better" as establishing a better version of the current system such as updated infrastructure or restoring the trees in a neighborhood with better adapted species. Public officials responsible for essential community infrastructure systems such as managing the city's water, roads, energy systems, and public spaces perceived "our ability to maintain the services" to be about adapting the system to changing conditions (environmental and demand conditions), especially within

the context of climate change, in addition to disaster recovery and preparedness. Adapting a system for change included maintaining, repairing, and replacing relevant parts of the system, as a public official observed:

> "So I also look at resiliency in terms of the grid as it exists today. The grid itself is well over 100 years old. Not all the parts and pieces are 100 years old, per se, but what we've built and put together. It's probably one of the oldest working machines we have on the planet. So the other piece of resiliency to me is to make sure that we are performing the proper maintenance and replacement of our equipment to keep it as reliable as possible."

Residents, comparatively, perceived adaptive resilience as making incremental changes to community characteristics, features, or assets in order to overcome numerous different and difficult situations of change. Several residents elucidated how Dayton withstood the impacts of the economic downturn (instigated by the departure of several big businesses, and the subsequent efforts to adapt) and/or efforts to overcome racial challenges. These efforts were described as efforts to progress forward "in the face of negativity" with certain historical legacy connotations, as evidenced by the below resident quote:

> "I would say is its ability to keep moving forward and ideally upward even through the trials and tribulations that life will put in its path. In Dayton the loss of the automotive industry, manufacturing industry that we had so relied on, it fed into so many other businesses, and there is a whole supply chain tied to that and a trickle-down effect even to the individual from businesses could be service-oriented businesses, that restaurant was in business and employed 20 people because workers from that plant came to this restaurant, that type of reality, the loss of a large portion of jobs where people had to go out and learn new skills or go back to school and be retrained."

Interestingly, many resident participants from lower socio-economic neighborhoods or majority African American neighborhoods associated adaptive resilience with certain qualities such as hope, optimism, and grit. For example, one resident claimed that

> "Hope is a part of resilience, too, you have to have hope to know that you can get out of the darkness. I would define resilience as an ability to reveal hope and optimism in any situation so we can put our skill sets together to paint the bigger picture... I think that being resilient is being forward-thinking in how we teach our kids, in the opportunities that we give our kids, in breaking down race divides and class divides, and bringing people together. Again, Dayton is a resilient community. Dayton is a hopeful community. Dayton is a roll up your sleeves, get busy and do it kind of community."

Long-term disaster implication visioning seemed to be a part of proactive adaptive resilience efforts to understand the systemic long-term vulnerabilities and implications of changing environmental and demand conditions, as alluded to by a public official: "So that's kind of from a water department thinking about resiliency as far as what's our capacity, how are the needs gonna change and how we're gonna be able to respond to those, and then do we even have the right information and data to respond to those?"

Public officials highlighted the financial challenges that need to be addressed to build adaptive resilience. Similar sentiments to the below quote were expressed by many public officials:

> "No one has the money in this region. I would say you'd find the same thing in every urban area of this country to really meet the needs of maintaining a state of good repair. We made a commitment to fund what we knew would be capital improvements, about 250 million in capital improvements in about a five-year period, knowing if we didn't get it done, there could be major failures within our systems. And like every old urban community, it's old infrastructure, and it needs a huge investment."

Public officials point to certain political dynamics as one of the reasons contributing to the funding challenges. A public official described the situation as

> "It's a really different story when you talk to the political leadership, for them to adopt resiliency plans or for them to adopt climate declarations, it's hard for them to do that and not only here, it's all over. . . And that makes sense that our political leaders are having more difficulty making these types of commitments or declarations because for whatever the reasoning is in our political climate today making these declarations to protect our environment or to reduce carbon emissions is a radical thing to do. So, it's all like emergency planning, that's what we have. Having the financial capacity and as well as people and political support and all that sort of stuff to do what sometimes is perceived as fluffy feel good extra let's protect the environment, that's gonna get pushed when things need to get cut."

Addressing the challenges associated with the political leadership and concomitant financial resources could enable a more robust approach to long-term adaptive resilience building, especially within the context of climate change.

Based on the above findings, it can be presumed that public officials' perceptions of basic and adaptive resilience seem to be influenced by their roles, assigned authorities, and the nature/functionality of the infrastructure systems they are officially responsible for. For example, public officials were largely focused on preparing and restoring systems they were responsible for, to normal functioning after a disaster in the context of basic resilience, and adapting respective systems to changing conditions in the context of adaptive resilience. Comparatively, residents' perceptions of basic and adaptive resilience seem to be influenced by a drive to recover from or adapt to broader disturbance events that impact a communities' human fabric (such as a mass shooting), in addition to events that impact physical infrastructure, and the drive to acclimatize their neighborhoods (including the physical infrastructure and human dynamics) to long-term changes (including economic changes and historical racial legacy impacts).

4.3. Perceptions of Transformative Resilience

Transformative resilience perceptions were largely expressed by the residents. Lack of transformative resilience perceptions expressed by the public officials might be attributed to the financial, resource, and political constraints restraining them from envisioning transformative pathways. For example, many resident participants expressed how the food system could be transformed to make it more resilient as described by a resident:

> "It's like there's so much that could be done around food to create a resilient local food economy and system, but I don't see it happening anywhere. Everyone's talking about food, but no one's talking about creating a policy or system where you're thinking about where it's grown, what's grown, how it gets to people who need it, and bringing people together to create that robust food economy. And I think the city could do things like talk about food access and say. . .these are ideas we have, after we've talked to community about, this is their issue. We'll support them by developing vacant blighted properties into green spaces for farming. Or we'll put money towards supporting people to learn how to become farmers as a workforce development tool, which creates a more resilient community".

The community members perceive the role of public officials related to transformative resilience to involve long-term goal setting (on food security, housing affordability, etc.), facilitating stakeholder initiatives, developing supporting policies, and facilitating neighborhood-to-neighborhood coordination. A resident highlighted the importance of two-way communication within such initiatives as:

> "You have to talk to your community, you have to build trust with your community to see what they need. They'll tell you when they trust you. They'll tell you what you need or what they need, and you'll be able to provide that."

Some residents discussed how cross-sectoral (economic development, food security, urban farming, addressing poverty, etc.) and cross-stakeholder (community, public official, businesses, etc.) networks could address multiple issues in a holistic way. Some participants framed these efforts as "building networks of resiliency." These collaborative networks, if empowered, can yield community action and successes as witnessed by the success of the Gem City Market:

> "So the biggest example of that is the Gem City Market, which is a cooperatively owned grocery store. It's owned by the community and the employees. It's accountable to us because it's owned by us, and there's no third-party shareholders two states away making decisions about it. It meets a compelling community need because as you know, Dayton's impacted by a food apartheid and it's a grocery store in a neighborhood that hasn't had grocery in like a decade."

The above resident perceptions indicate that the residents have innovative ideas, and if empowered could mobilize to address challenges facing the community to enact transformative changes. However, such community-based initiatives might not happen without the direction and guidance of public officials.

4.4. Important Resources, Systems, and Assets Perceived as Important for Community Resilience

Residents attributed the "ability to bounce back" or "keep moving forward no matter the situation" to a variety of local systems, local conditions, and assets such as level of chronic stressors experienced by the residents, level of resources/assets in the community, and neighborhood social dynamics.

Residents frequently identified numerous neighborhood level resources and assets as important for resilience such as banks, grocery stores, community gardens, and good schools (among other things). The resources were recognized as "underlying strengths" that can help a community cope better. For example, a resident described the importance of community resources as "We have a number of resources in place to assist people, we have the Edgemont Solar Garden, which is growing fruits and vegetables. We do have the Business Solution Center, which sits actually in Edgemont on the cusp of Carillon to help business entrepreneurs". Residents also recognized the importance of building local community assets, as evidenced by similar quotes to the following: "We wanna see more neighborhoods with micro-economies, so, I would like to see more grocery stores in proximity. We just talked to Madden Hills Neighborhood Association, they said the same thing, just somewhere they can walk to, a grocery store they can walk to".

Many residents highlighted the importance of strong social capital comprising of strong neighborhood level social bonds, interconnections, sense of solidarity, and pride in the community as representing the human infrastructure necessary for resilience. To this end, one resident noted that "Yeah, I think to be resilient is about flexibility and the ability to hang on and bounce back whatever happens, but I think it's based on strong underpinnings and really it's based on interconnections, deep community roots in terms of people". Many residents identified "standing together" and "embracing different viewpoints" as ingredients to building strong social interconnections as a resident described: "When a white supremacist group came here to Dayton, you know, on Memorial weekend a year ago, a large portion of the community stood up to them. In our community, we do not tolerate hate". In addition, residents outlined several practical instances where knowing your neighbors could come in handy. To this end, a resident outlined that

> "There's an element to it as a neighborhood that involves knowing your neighbors. If you feel comfortable doing it, get your neighbor's phone numbers in case you need to get in touch with them in an emergency. Because sometimes neighbors are the only ones that realize... Let's say there's a big storm and you're out of town and a tree falls on your house. How are you gonna notify that neighbor if you don't have a phone number for them? So, it's real... It's on a level that's neighbor to neighbor."

Many residents highlighted how opportunities for citizen engagement and participation; art and cultural events; walkability of neighborhoods; chili cookouts; porch fests; and other arts and cultural events could nurture the human infrastructure or the "resilience fabric" of the community and how the city government can create more opportunities targeting these areas.

Community resilience was also perceived to be dependent on the level of chronic stressors experienced by the residents such as access (or lack of) to quality education, quality health care, access to internet, level of poverty, food insecurity, historical legacy of disinvestment (or redlined), level of homelessness, etc. Many residents described how chronic stressors can exacerbate the impact of acute shocks such as a tornado, a mass shooting, flooding, or other climate-related disasters. A resident summarized the situation as

> "If you have underlying problems in your community, then those kind of shocks will make them worse often. If you have underlying strengths, then those kind of shocks will not be as traumatic and they will be dealt with better. . . If people aren't healthy because they don't have good medical care and they don't have access to healthy food, so anything that hits them, they're weaker, and they're more likely to suffer harsher impacts."

Public officials also acknowledge the importance of addressing chronic stressors as one official pointed out

> "Well, yeah. I think the parts of the city that have low-income families and residents, and may not have the resources available to them to respond to impacts are particularly vulnerable. And not just to climate change, I think they're vulnerable to a lot of other issues, health issues and just food and access to healthcare and things like that. I think those areas of the city, the low-income areas maybe are particularly vulnerable to any type of stressors that might come either short term or long-term."

Many residents contended that addressing underlying chronic stressors was critical for resilience and pointed out the role of historical discriminatory practices in creating chronic stressors:

> "There's such a close correlation between redlining maps from the 1930s, the opportunity maps where there's low opportunity, to the racial segregation patterns in the City of Dayton. And it's like, they're so interlinked. And it's not that we've done anything wrong ourselves, we're just living with these. . . these policies and decisions that people made 70, 80, 90 years ago. So in my mind, resiliency in my mind is thinking about. . . Has to include this equity piece, because if you're not thinking about it through an equity lens, then you're gonna miss out and you're just gonna continue to perpetuate the injustices and the inequity that's been going on for a century."

Perceptions of public officials indicate that they understand these underlying dynamics as witnessed by comments such as

> "For example, racism, it certainly does on another level, and it certainly detracts from the resilience of those communities when they don't have the investment in infrastructure, both environmental infrastructure and public open space that other communities have. I think that's a key element in resilience in our community, that we really have to step up to these underserved communities"

However, long-term implication visioning by the public officials was lacking in areas such as housing, food access, and/or poverty alleviation. Public officials attribute the lack of staffing, financial resources, and boundaries of functional authority as challenges to addressing chronic stressors, especially in mid-size or smaller cities. The next section provides policy suggestions based on the findings discussed in this section and collates the findings presented to other studies that have examined community resilience.

5. Discussion

5.1. Similarities and differences in Community Resilience Perceptions and Policy Opportunities

It is important to note key similarities and differences in resilience perceptions between public officials and community members. Both public officials and residents perceived basic resilience as pertaining to disaster recovery and preparedness. Public officials responsible for essential community infrastructure systems (such as energy or water) mainly perceived resilience as pertaining to restoration of normal functionality following a disturbance. This finding is similar to other studies focusing on disaster recovery. For example, Ross [10] found that interpretations of resilience as "bouncing back" is the most common following a disaster. Compared to public officials' views of a disturbance event (as an event that impacts physical infrastructure), the residents considered a disturbance event as any event that impacted the human fabric of the community (such as a mass shooting) and/or the physical infrastructure. Similarly, while public officials viewed basic resilience as largely focused on essential community infrastructure systems, the residents perceived basic resilience as relating to restoration of both the physical infrastructure and human dynamics (healing, connecting, bonding, etc.). In one of the few studies to also qualitatively explore community resilience perceptions held by different stakeholder groups, Adekola, Fischbacher-Smith and Fischbacher-Smith [15] found multiple interpretations of community resilience where community council members held different interpretations compared to public officials. Community council members described views pertaining to the ability of the community to come together, react, and get through adverse events compared to public officials who were focused on restoring functionality of the respective systems [15]. Brown [53] also argues that different stakeholders might hold multiple and often contested interpretations and meanings of community resilience.

Public officials also expressed some confusion on who would bear the responsibility for certain long-term disaster recovery efforts (such as reopening a damaged grocery store). This highlights the need for policies to facilitate clear communication initiatives or strategies, especially within long-term disaster recovery efforts. These communication initiatives could also facilitate two-way communications on residents' desires to restore human dynamics after a disaster, and policy initiatives that could facilitate such recovery.

Both public officials and residents attributed adaptive resilience to making incremental changes, respectively, to infrastructure systems or community qualities (or characteristics) to adapt an infrastructure system or a neighborhood to changing conditions, in addition to disasters. Craft [14] also reported the need to improve the level of community engagement, dissemination of information, and to incrementally harden infrastructure as important to building community resilience. Compared to public officials, residents viewed economic changes and legacy racial impacts (such as racial divides and class divides) as phenomenon that need adapting. This finding highlights the need for policy initiatives to incorporate resilience building/thinking as a continuous on-going effort into areas that have not traditionally incorporated resilience thinking such as economic development and community planning. Interestingly, residents, especially those from lower socioeconomic neighborhoods, associated characteristics such as hope, optimism, and grit with adaptive resilience, representing a mindset to get things done. Hope and grit have been associated with studies examining resilience at the individual scale but not frequently at the community resilience scale. Public officials in this study outlined the limited financial resources and issues with political leadership as challenges that need to be addressed to build adaptive resilience. Chondol et al. [12] also found scarcity of resources as a reason for lack of community level capacity building efforts.

The perceptions described in this study shed light on what factors might undergird the differences in perceptions, and further studies should continue to explore these differences. Public officials' perceptions of basic and adaptive resilience seem to be influenced by their roles, the nature/functionality of the infrastructure systems they are responsible for, and the boundaries of functional authority. Comparatively, the residents' perceptions of basic and adaptive resilience seem to be influenced by the drive to recover from or adapt to broader

disturbance events that impact the communities' human fabric (such as a mass shooting), in addition to events that impact physical infrastructure, and the drive to acclimatize their neighborhoods (including the physical infrastructure and human dynamics) to long-term changes (including economic changes and historical racial legacy impacts).

Transformative resilience perceptions were largely expressed by the residents. Lack of transformative resilience perceptions expressed by the public officials might be attributed to the financial, resource, and political constraints restraining them from envisioning transformative pathways. Similarly, in Adekola, Fischbacher-Smith and Fischbacher-Smith's [15] study, local officials pointed to challenges presented by limited government resources in the face of many competing priorities. Residents of this study described how cross-sectoral and cross-stakeholder "networks of resiliency" could build transformative resilience and highlighted the importance of two-way communication and what roles could public officials play to facilitate such initiatives.

Residents discussed how the Dayton food system could be transformed to make it more local, robust, and resilient, replicating the success of the Gem City Market. Several Dayton neighborhoods are already classified and food deserts, and food insecurity could become a profound exacerbated issue within the context of climate change. The success of the Gem City Market demonstrates that empowered community-inspired solutions could build community resilience. Similar arguments can be made for other systems such as water and energy systems. Public officials acknowledged the vulnerability of the energy system "as is" being old and being a centralized production and distribution system. Numerous disaster events such as storms and wildfires could damage the energy system. The experiences of the California Blue Lake Rancheria Tribe's microgrid demonstrate how innovative, decentralized, and localized energy systems (such as neighborhood level microgrids, energy storage, and rooftop solar) could enhance community resilience. Similarly, Greater World Community of Earthships in New Mexico demonstrate how rainwater catchment could help communities to be water resilient in arid conditions. Adaptive or transformative resilience processes could often be endogenous processes linked to local customs [1]. However, residents pointed out how community-level actors need some level of guidance and influence from public officials and the political leadership to envision transformative resilience pathways [1].

Building networks of resiliency as described by the residents would require broad collaborative networks (based on collective impact models) that are empowered to transform food–energy–water systems. As Norris et al. [6] contends, citizen participation (involvement and engagement) in formal and informal community organizations is widely believed to be a fundamental element of community resilience [6]. Therefore, transformative local, community-based, and community-supported food–energy–water systems could make communities more resilient. Public officials and political leadership should facilitate the establishment of broader collaborative community networks with well-defined meaningful roles for participation to craft and activate transformative solutions. Examples such as Cincinnati's Green Umbrella (regional sustainability alliance) and Dayton's own Dayton Regional Green exemplify how residents and community organizations could be empowered and mobilized for action, if the public officials and political leadership provide necessary facilitation and support. Further research should explore how communities collectively can envision, communicate, and craft transformative pathways and ways how public officials and political leadership can provide direction to such efforts.

5.2. Policies to Nurture Social Capital, Address Chronic Stressors, and Communication Infrastructure

Residents highlighted the importance of community assets (such as a grocery stores, banks, and community gardens), strong social capital, and the need to address chronic stressors to community resilience. Consistent with other research, participants of this study outlined the importance of social capital to community resilience. Similarly, Rapaport et al. [41] found that community members' perceived collective social resources, such as

intra-community leadership, collective efficacy, social capital, and trust, ultimately derive from the community's social context. Therefore, Aldrich [44] recommends that it is important for communities to consciously invest in building social capital as a proactive disaster resilience measure with support from planners and other decision makers. Residents participating in this study pointed out how physical infrastructure (such as walkable or bikeable neighborhoods) and social events nurture social capital. Public officials could craft policies to develop the necessary physical infrastructure and provide visibility to neighborhood-level social events to support building social capital. Public officials could focus on more opportunities for citizen engagement and participation; art and cultural events; chili cookouts; porch fests; and other arts and cultural events to support building social capital. In addition, public officials can try to provide a common platform, structure, and communication channels for neighborhood associations to organize and mobilize.

While the public officials understood the need to address chronic stressors, long-term implication visioning to address such dynamics was lacking (in areas such as housing, food access, and/or poverty alleviation) largely due to lack of staffing, financial resources, and boundaries of functional authority. Public officials also did not perceive efforts to address chronic stressors as falling within the purview of resilience building efforts. As the resident perceptions demonstrate, policy initiatives are needed to address chronic stressors and highlight a critical policy gap in building community resilience. Considering the limitations faced by public officials, addressing chronic stressors might require multi-stakeholder networks similar to what is discussed above (similar to networks required for transformative resilience).

In addition to what is discussed above, the importance of facilitating policy for effective communication infrastructure within basic, adaptive, and transformative resilience could be outlined in three ways. First, within basic resilience, communication from public officials in charge of emergency management is critical for people to clearly know where to go, what to do, and resources available during and the aftermath of a disaster. Effective disaster communication could improve perceptions of community resilience [9]. Based on perceptions, expressed in this study, it seems that public officials responsible for emergency management are focused on providing effective communication to residents. Second, public officials view a perceived disconnect between political leadership and the biophysical impacts of climate change as one of the major challenges to adaptive resilience. To this end, Handmer and Dover [16] argue that institutions and policy processes appear to be locked into "change at the margins" type of approach. Therefore, additional research is needed on how to bridge the communication gap and improve framing to make the political leaders understand the long-term implications and realities of climate change, resilience building opportunities available, and why it is important to capitalize on such opportunities. Such research could inform public officials on how to frame and present resilience-building initiatives to the political leadership to gain their support. Third, pertinent to transformative resilience and addressing chronic stressors, building broader collaborative community networks require policies to facilitate strong two-way communication where residents are able to communicate about envisioned potential community-based solutions to public officials, and where public officials (and political leadership) are able to provide direction to such initiatives. Community members' disconnect with local government officials can significantly hamper community-inspired adaptive efforts [45]. Two-way communication initiatives could also provide civic participation opportunities for poorer and more vulnerable groups grappling with chronic stressors to voice their needs and aspirations [38]. Further research could examine how communication platforms, processes, and systems could help to bring these different stakeholder groups together.

This study qualitatively explored community resilience perceptions held by public officials and residents, using Dayton, OH as a case study. Not many studies have explored this topic, especially qualitatively. The findings of this study reveal multiple perceptions and frames held by residents compared to public officials, which can aid in crafting constructive policies. Therefore, further research should continue to explore community

resilience perceptions held by different stakeholder groups in other economic, cultural, and technological contexts as it provides valuable insights for crafting strategies and policies to make communities more resilient.

6. Conclusions

Community resilience has increasingly become a popular topic of research. The aim of this article is to present a juxtaposition of public officials' and residents' perceptions of community resilience along the three-class typology of resilience (basic, adaptive, and transformative) using Dayton, OH as a case study. The findings highlight similarities and differences in resilience perceptions between public officials and community members that can inform creative policy initiatives and community-inspired solutions. Both public officials and residents alluded basic resilience to disaster recovery and preparedness. However, there were notable differences in perceptions on what was considered as a disturbance event (and thus needing recovery efforts) and the community components (infrastructure, basic services, and human dynamics) that needed to be restored through recovery efforts.

To recap, the roles, functionality of the infrastructure systems they are responsible for, and the boundaries of functional authority seem to influence public officials' perceptions of basic and adaptive resilience. Comparatively, the residents' perceptions of basic and adaptive resilience seem to be influenced by factors such as a drive to recover from or adapt to broader disturbance events that impact a communities' human fabric (such as a mass shooting) in addition to events that impact physical infrastructure, and a drive to acclimatize their neighborhoods (including the physical infrastructure and human dynamics) to long-term changes (including economic changes and historical racial legacy impacts). While transformative resilience perceptions were largely expressed by residents, the lack of transformative resilience perceptions expressed by public officials might be attributed to the financial, resource, and political constraints restraining them from envisioning transformative pathways. However, residents exemplified the need for public officials and political leadership to play an active role in guiding and providing direction to transformative resilience initiatives.

Strong social capital, availability of community resources, and effective communication strategies were highlighted by residents as important for building basic, adaptive, and transformative resilience. Residents also described how chronic stressors make the residents more susceptible to harm from disturbance events. Addressing the chronic stressors and activating transformational initiatives need building cross-stakeholder "networks of resiliency", which require effective two-way communication and direction from public officials and political leadership.

The comparability and transferability of the findings of this study depend on the (dis)similarities in setting and context. Dayton, OH is a mid-size city that is not threatened by some of the major disturbances associated with climate change such as sea level rise, frequent hurricanes, or wildfires. However, it still grapples with numerous impacts of climate change. Dayton, OH also has an industrial/manufacturing legacy as described in the background section and many of the neighborhoods reflect consequences of that history. Residents of Dayton take pride in the rich pioneering innovative industrial legacy and qualities it represents. Therefore, the applicability of the findings discussed in this article are limited by similar size, climate impact contexts, and socio-economic trajectories. Despite such limitations in applying the findings of this study more broadly, it is possible that divergent views on community resilience exist among stakeholders in various social–economic–environmental contexts that could inform creative policies to build community resilience. That makes this topic well worth exploring in a range of settings such as climate change adaptation and disaster recovery.

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Perceptions of Sustainability among Children and Teachers: Problems Revealed via the Lenses of Science Communication and Transformative Learning

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Abstract: Scholars and policymakers see sustainability as depending on the inter-relationships between the three pillars of the environment, society, and the economy. However, it remains less clear how key stakeholders with a responsibility for educating the next generation perceive the concept of sustainability and act accordingly. In order to gain new insights, this research scrutinises participant perceptions of sustainability and climate change in two eco-schools in England for primary children (aged 5–11 years). Our case study involved individual interviews with classroom teachers and headteachers, group interviews with fourth- and fifth-year students (ages 10–12 years), and in-class observations. We also analysed data from student exercise books and photographs of school grounds to understand participants' self-reported knowledge and perceptions of sustainability and climate change. Within a framework drawing on theories of science communication and transformative learning (a learning approach based on having challenging experiences), the results show that the integration of sustainability into the curriculum was limited and problematic. That is despite the fact that all students and teachers were aware of the environmental dimensions of sustainability, such as climate change and the overuse of natural sources. These findings suggest that schools are no different to other institutional settings when it comes to dealing with the challenges of integrating sustainability into daily practice. We conclude that there is a need for in-service teacher education programmes to enable and motivate teachers to provide richer teaching-learning environments so as to enable effective learning in schools about sustainability and climate change.

Keywords: sustainability; climate change; primary schools; transformative learning; science communication

1. Introduction

Sustainability as a hybrid concept has had a crucial place in public and political agendas since well before the reports in *Our Common Future* in 1987 [1] and *Agenda 21* in 1992 [2]. As per the United Nations' Brundtland report, sustainability involves "meet[ing] the needs of the present without compromising the ability of future generations to satisfy their own needs" [1]. UNESCO (2005) defines three sustainability dimensions—environmental, social, and economic. This focus reflects that education has considerable potential to facilitate changes in attitudes, values, and behaviours from generation to generation to enable sustainability to become more embedded within society.

Sustainability is gradually becoming an important aspect at all levels of education. Education for Sustainable Development (ESD) was promoted in the United Nations Decade of Education for Sustainable Development [UNDESD] (2005–2014) [3], following the UNESCO Global Action Programme for ESD (Education for Sustainable Development) (2015–2019) [4] and then the 'ESD for 2030' framework from 2020 to 2030 [5]. Over the past two decades, there have been calls to integrate sustainability into the curriculum: "all learners acquire the knowledge and skills needed to promote sustainable development, including, among

others, through education for sustainable development" (target 4.7, [5] (p. 21)). By providing such a common ground, curricula can harmonise and integrate economic, social, and environmental pillars in the minds of those who will soon be making pivotal decisions in their daily lives.

As sustainability is defined as a field beyond disciplinary anchoring by some researchers (e.g., [6]), various subjects faced by school students might contribute to these three pillars in the following way: Environment—natural resources, climate change, rural development, sustainable urbanisation, disaster prevention and mitigation; society—human rights, gender equity, peace and human security, health, HIV/AIDS, governance, cultural diversity, and inter-cultural understanding; economy—poverty reduction, corporate responsibility, and the market economy [7].

School education can act as a catalyst for change through the curriculum, student-centred teaching methods, future-oriented thinking, higher-order thinking skills, critical thinking, interdisciplinarity, and linking local and global issues. According to [8], the current generation of school students is the first to have to deal with global socio-economic, political, and demographic realities. This viewpoint ties our local, everyday actions to global events, necessitating the development of a global awareness to influence change from private to general and address global challenges in a sustainable way.

Education for sustainable development—at the school level and in further and higher education—is aimed at educating individuals in accordance with sustainable development principles, such as knowledge, attitudes, values, and behaviour, through programmes that address environmental, economic, and social issues [9]. The Rio+20 Conference reaffirmed that universal access to primary education and quality education at all levels is an "essential condition for achieving sustainable development" [9] (p. 59). However, these efforts do not as yet seem to have catalysed the necessary changes to meet today's increasingly complex problems [10,11].

The role of school education has also been emphasised by the UN Department of Economic and Social Affairs as being critical for ensuring sustainable development and improving the capacity of people to address environmental and developmental issues. In addition to that, both formal and non-formal education, for both children and adults, play crucial roles in altering individuals' attitudes, enabling them to evaluate and tackle their sustainable development concerns. Furthermore, it is commonly accepted that school education is crucial for attaining environmental and ethical consciousness, values, attitudes, skills, and conduct that align with sustainable development, as well as facilitating effective public participation in decision-making by helping to ensure that the next generation of adults are informed about relevant issues and are able to discuss these issues with their fellow citizens. To give just one example, the standards include that "each practitioner [likely refers to individuals who are actively involved in the field of education, particularly those who work directly with students in schools e.g., teachers, school administrators, educational psychologists, counselors] school and education leader should demonstrate learning for sustainability through their practice" [12].

Climate change is one of the critical goals under the Sustainable Development Agenda. According to the data from the Office for National Statistics collected in September–October 2022, "Around three in four adults (74%) in Great Britain reported feeling (very or somewhat) worried about climate change"; this is the second-biggest concern behind the rising cost of living (79%) [13]. However, the voices of children and young people are largely absent from climate change coverage [14]. On that point, in highlighting one of the greatest public policy issues of our time, one that challenges countries across the world, in a Policy Paper published in 2023, the Secretary of State for Education in England explained the following:

> The challenge of climate change is formidable. For children and young people to meet it with determination, and not with despair, we must offer them not just truth, but also hope. Learners need to know the truth about climate change—through knowledge-rich education. They must also be given the hope that they

> can be agents of change, through hands-on activity and, as they progress, through guidance and programmes allowing them to pursue a green career pathway in their chosen field. [15]

At present, an inspection of the National Curriculum in England shows that such views are not reflected in it. When the National Curriculum is next revised—as a date as yet unspecified—it remains to be seen whether such views are embedded in official discourse.

In common with a number of other countries (e.g., Sweden, Japan, Singapore and Turkey), England has had, since 1989, a statutory National Curriculum, though an increasing proportion of schools are exempted from it (e.g., because they are independent—i.e., fee-paying—or because they are classified as 'academies'). The National Curriculum in England delineates the programmes of study and attainment targets for each school subject across all four compulsory key stages (ages 5–7, 7–11, 11–14, 14–16). The National Curriculum for England stipulates that:

> All schools should make provision for personal, social, health and economic education, drawing on good practice. Schools are also free to include other subjects or topics of their choice in planning and designing their own programme of education. [16] (2.5)

An increasing proportion of schools (independent schools and those that are Academies or Free Schools) sit outside the formal requirements of the National Curriculum but a school's curriculum in England is not entirely determined by the National Curriculum, even for those schools subject to the National Curriculum. From September 2012, all schools have been required to publish their school curriculum by subject and academic year online [16] (2.4). That makes them more open to scrutiny, in this case, in relation to how they address sustainability.

Such scrutiny is becoming increasingly important as, in the last two decades or so, sustainability science, as a transdisciplinary domain, has offered a rich environment for crafting alternative paradigms that are more effective for tackling intricate sustainability issues [17]. This study looks at the impact of this sustainability science in school curricula, which is mainly based on the investigation of the pillars of sustainability—environment, economy, and society—through the lenses of science communication and transformation theory.

1.1. Transformation Theory

Transformation theory, also referred to as transformative learning theory, is a learning theory drawn from the field of education specifically and the social sciences more generally. It:

> (. . .) deals with how individuals may be empowered to learn to free themselves from unexamined ways of thinking that impede effective judgment and action. It also envisions an ideal society composed of communities of educated learners engaged in a continuing collaborative inquiry to determine the truth or arrive at a tentative best judgment about alternative beliefs. Such a community is cemented by empathic solidarity, committed to the social and political practice of participatory democracy, informed through critical reflection and would collectively take reflective action, when necessary, to assure that social systems and local institutions, organizations and their practices are responsive to the human needs of those they service. [18]

This vision for transformation refers to the role of school education, along with other forms of education, as a catalyst for change. In the field of school education, there is no doubt that the environmental crisis and other existential threats (e.g., those from the nuclear industry, pandemics, and AI [19]) require changes in the way many people live, think, and act. Responding to this call—within the frame of reference of transformation theory—will require change in individual lives and through collective action that recognises unsustainability, strives for equitable societies, and creates sustainable conditions. This shift will not be easy, as discussed in [20]: "This change is perhaps already in the air,

however, faintly. But our tradition, education, current activities, and interests will make the transformation embattled and slow" (p. 195). At the same time, repeated and widespread adverse events, such as those arising from pandemics, climate change, and biodiversity loss, force many people to reconsider their lives, thoughts, and actions. This kind of change can occur when transformative learning is effective; it involves shifting frames of reference through critical observations of both habits and perspectives [18]. Our argument is that transformative learning, often seen as being applicable to adults and young adults, is also applicable to children of primary age and may be needed, given the current climate change, biodiversity, and sustainability crisis.

1.2. Science Communication

Integrating a sustainability lens into science communication can be seen as one avenue to being transformative. Science communication can be defined as the skilful use of various tools, media, activities, and dialogue to elicit one or more of the personal responses to science: awareness, enjoyment, interest, opinions, and understanding [21]. Since the 1990s, science communication has emerged as a multidisciplinary field connected to communication, education, the natural sciences, the social sciences, and various other areas. It can be defined as the production, circulation, and reliable utilisation of knowledge among scientists, society, policymakers, industry, and other stakeholders [22]. Over the last 30 years, science communication activities have encompassed a range of approaches [22], from top-down, one-way/unidirectional models, highlighting a deficit in knowledge and means to boost understanding, to interactive public engagement and public participation models. A useful distinction can be made between 'first-order' models of science communication, which stress deficits, 'second-order' models, which emphasise the value of public engagement and dialogue, and 'third-order' models, which ask fundamental questions about the relationship between first- and second-order approaches, the changes that have taken place in the theory and practice of science communication, and its future direction [23].

However, in an age of misinformation, how successfully institutional attempts at science communication handle the issues [24] that capture the attention of various publics, e.g., COVID-19, climate change, and the theory of evolution, is arguable. It has been proposed that the objectives of science communication can be classified into at least six categories: securing the accountability and legitimacy of publicly funded science; enabling informed decisions by laypeople and policymakers in today's technologically driven societies; bolstering democracy by empowering citizens; offering access to the aesthetic aspects of science as a cultural element; serving promotional goals, such as those seen in 'university PR'; and fulfilling an economic role by attracting individuals to scientific careers or preparing a market foundation for technological innovations [25].

Via these definitions of science communication, one can see its relevance to the efforts of scientists highlighting the threats of anthropogenic climate change, which they have been attempting to do since at least 1957 [26]. This extended timeline is not a source of pride, and if it requires such a prolonged effort to engage public attention in the next crucial environmental phase, we are likely to encounter significant challenges, such as the Pacific Islands and many other coastal communities facing inundation from rising sea levels. For this reason, the efficacy of scientific communication can be questioned in terms of its functions in such circumstances as the climate crisis, vaccine rejection, and the problem of access to clean water in a number of countries. Amidst such challenges, it is generally held that science communication is important for fostering informed public discourse, influencing policy decisions, and addressing global issues collaboratively.

Despite their differences, there is considerable similarity between conducting science communication successfully and implementing effective educational strategies in schools and other settings. Both disciplines—education and science communication—share a number of points: tailoring the message to the audience; building trust with the audience; initiating an interactive dialogue rather than a one-way monologue; and seeking what one

communicates or teaches to enhance awareness, enjoyment, understanding, the formation of valid opinions, and interest.

From these two perspectives—transformation theory and science communication—we recognised an opportunity to examine the effectiveness of curriculum decisions and the adoption of a sustainability frame of reference across classroom teachers, headteachers, and students. We attempt to address this issue by answering the following research questions through the examination of actors and activities in two primary eco-schools in England:

1. What are primary teachers' and fourth- and fifth-grade students' knowledge and how do they perceive sustainability and climate change?
2. What kind of features do participant schools have with regard to the environmental, social, economic, and educational dimensions of sustainable development-oriented education?
3. From the participants' perspectives, what are the challenges and opportunities of their schools by having an orientation toward sustainability?
4. What information sources do the teachers and fourth- and fifth-grade students use in learning about sustainability issues?
5. How is environmental and sustainability education enacted and experienced in primary eco-schools from the perspectives of classroom teachers, headteachers, and fourth- and fifth-grade students?

The investigation of these questions, from the conceptual reference points just explained, reveals ongoing challenges, where the integration of sustainability into the curriculum was limited and problematic.

2. Materials and Methods

This qualitative case study is "an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit" [27] (p. xiii). Accordingly, two primary schools in England with a designated focus on sustainability issues jointly constitute the case. Based on the research questions, the study has the following objectives:

Objective 1: To assess the knowledge levels and perceptions of sustainability and climate change among primary teachers and fourth- and fifth-grade students.

Objective 2: To investigate the environmental, social, economic, and educational dimensions of sustainable development-oriented education within participant schools.

Objective 3: To explore the challenges and opportunities perceived by stakeholders within participant schools regarding orientation toward sustainability.

Objective 4: To identify the primary information sources utilised by teachers and fourth- and fifth-grade students for learning about sustainability issues.

Objective 5: To examine the enactment and experiences of environmental and sustainability education in primary eco-schools from the perspectives of classroom teachers, headteachers, and fourth- and fifth-grade students.

2.1. Data Collection Instruments

Interview forms: Individual and group interview protocols were developed separately for headteachers, classroom teachers, eco-team leaders, and students, and these were undertaken in both schools. The semi-structured interview protocol (Appendix A) had two sections. Section 1 focused on demographics, including year of birth, the most recent degree received, and teaching experience (for teachers and headteachers). Section 2 consisted of the main interview questions, e.g., "Can you please try to explain to me what you understand by 'sustainability'?" and "What do you think about the strengths and weaknesses concerning the implementation of sustainability in your school?".

While our research instruments were not initially developed with direct reference to transformation theory and science communication, we found that these theoretical frameworks provided valuable lenses through which to interpret and make sense of our empirical findings. As we engaged in the analysis of our data, we observed patterns and

themes that resonated with key concepts from transformation theory, such as processes of individual and societal change towards sustainability, and uses of media in accessing science and engagement with scientific issues.

In total, 12 fourth- and 12 fifth-year students participated in four group interviews, and two eco-team leaders, two headteachers, and five classroom teachers participated in individual interviews. The interviews were audio-recorded and transcribed. We acknowledge that this sample size is not large, but it is not atypical for a qualitative case study [28], and our findings revealed considerable commonalities among the interviewee responses, which we will go on to discuss, indicating that a quite high degree of data saturation had been reached.

Observations: A total of 35 h (typical of rapid ethnographies [29]) of in-class observations were conducted in School 1 with Year 4 and Year 5 groups in science, geography, English, and mathematics classes. During observations, detailed and timed field notes were generated.

Documents: Student exercise books (Reading, Science, and Geography notebooks, totalling 24 notebooks of about 40 pages each) were collected, and photographs (82 photographs from both schools) of the school buildings and grounds were taken in both schools. The relevant parts of the National Curriculum for England were examined. The student exercise books were examined to look for evidence of sustainability in student activities.

2.2. Study Group

The schools were recruited based on criterion sampling with two pre-determined criteria: (1) being a Green Flag eco-school; (2) being an "Outstanding School" based on the 2011 Ofsted reports (the highest grade on a four-point scale). An eco-school follows a framework that seeks to enable its students to make a difference with respect to environmental issues. Schools that are deemed to have successfully implemented the framework are accorded Green Flag status [28]. Both schools were state schools in London with predominantly white, middle-class catchment areas, subject to the National Curriculum for England.

Fourth- and fifth-year students were invited to join the study based on teacher suggestions. These year groups were particularly suitable for our purposes because of the shortage of research regarding this age range, despite the fact that sustainability is often taught in England from a young age.

Both schools had big school grounds, including a wooded area, green fields, and a range of play areas. The photographs in Figure 1 provide an impression of both schools and their grounds. They include views of the grounds, examples of student work on public display, vegetation, a pond, cycle racks, and recycling facilities to give an idea of the schools' contexts.

In the images on the left side (School 1) of Figure 1, there are examples of student work on the topic of 'Where does our local food come from?', which are displayed on the main school board, a 'Recycle in a Fun Way' poster, the bicycle parking areas, the school garden, and an area for plastic bottle recycling. As reported in an official 2022 School Inspection report, School 1 initiates facilities aimed at enhancing recycling efforts and minimising the use of single-use plastic within the school. The photographs on the right (School 2) show the school pond, recycling bins, publicly displayed student work made from waste materials, and a reusable bag with the text, 'What can I recycle?'.

Figure 1. Photographs to Illustrate the state of environmental sustainability in School 1 (**left**) and School 2 (**right**).

2.3. Data Collection Procedures

After receiving the required permissions, data were collected from the two schools between April and July 2022. School 2 allowed students, the eco-team leader, and the headteacher to be interviewed and the student exercise books to be examined, with photographs of the school, including its grounds, taken, but the school did not give permission for observations or for classroom teachers to be interviewed, owing to the time pressures on the classroom teachers.

All aspects of the study were approved by the University College London Research Ethics Committee (ID Number: Z6364106/2022/04/05). In line with this approval, abbreviations were used for the participants to enable pseudonymisation (e.g., T1, T2, and T3 for the classroom teachers; HT1 and HT2 for the headteachers; S1, S2, and S3 for the students; Sch1 and Sch2 for the schools).

2.4. Demographic Profiles of the Participants

The participating students were 9 or 10 years old. Academically, they were said to be (by their teachers mainly) performing at or above the levels expected for their age.

The teachers' ages and professional experience varied, ranging from those who were in the early years of their professional careers to those with more than 25 years of experience (often in other schools as well as their present school). The ages of the teachers ranged from 27 to 53. Further information is provided in Table 1.

Table 1. Demographic profiles of the teacher participants.

	School Role	Gender	Age	Class Year	Educational Background	Experience (in Years)
T1	Classroom teacher	F	44	5	Teacher training	5
T2	Classroom teacher	F	34	4	Education and psychology. Currently doing a master's degree	10
T3	Classroom teacher (science specialist)	F	48	4	Education	10
HT1	Headteacher	F	46	-	Special education	22
HT2	Headteacher	M	51	-	Anthropology and geography	24
T4	Eco-team leader	F	27	-	Psychology	2
T5	Eco-team leader	F	53	-	Biology	20

2.5. Data Analysis

We used thematic analysis [30] to analyse the transcripts of the individual and group interviews and our observation notes. Because of the intention of the study to examine the range of ways in which sustainability was present (or not), deductive coding was used, meaning that the themes—environmental, social, economic, and educational dimensions of sustainability—were derived from the literature in a top-down, rather than bottom-up, way, on the grounds that this would help us answer our research questions.

2.6. Reliability and Validity of the Study

Qualitative research typically "does not claim to be replicable" [31] (p. 204), as the implicit assumption of a stable (i.e., repeatable) world is in direct contrast to the nature of the qualitative presumption [31]. Accordingly, reliability is not understood in qualitative research in the same way as it typically is in quantitative research. Nevertheless, it is standard in qualitative research to attempt to ensure that the findings are trustworthy [27], a term that combines elements of reliability and validity.

In order to enhance the trustworthiness of the study [32,33], we employed prolonged engagement (the first author satisfied this criterion by observing classes through the summer term for 14 weeks, totalling 35 h of observation), triangulation (in terms of data collection instruments, i.e., interviews, observations, and documents, with triangulation in terms of sources of information, i.e., students, teachers, and headteachers), expert review (for the data analysis), thick (i.e., rich and meaningful) descriptions (throughout the study), and member checking (the transcripts were sent to the adult interviewees for feedback on their accuracy).

3. Results

> "*So, there's something about, you're not necessarily doing it for yourself, but you're doing it for the greater good*". (HT1)

We organise our findings according to our five research questions. The richest data came from the interviews, but we also used data from our observations and the student

exercise books (e.g., Figure 2). Of the four dimensions of sustainability, the most in evidence in each of the schools were the environmental (e.g., climate change and water scarcity) and economic (e.g., consumption and renewable energies) dimensions. When quotations are given, no attempt has been made to 'tidy up' the language used.

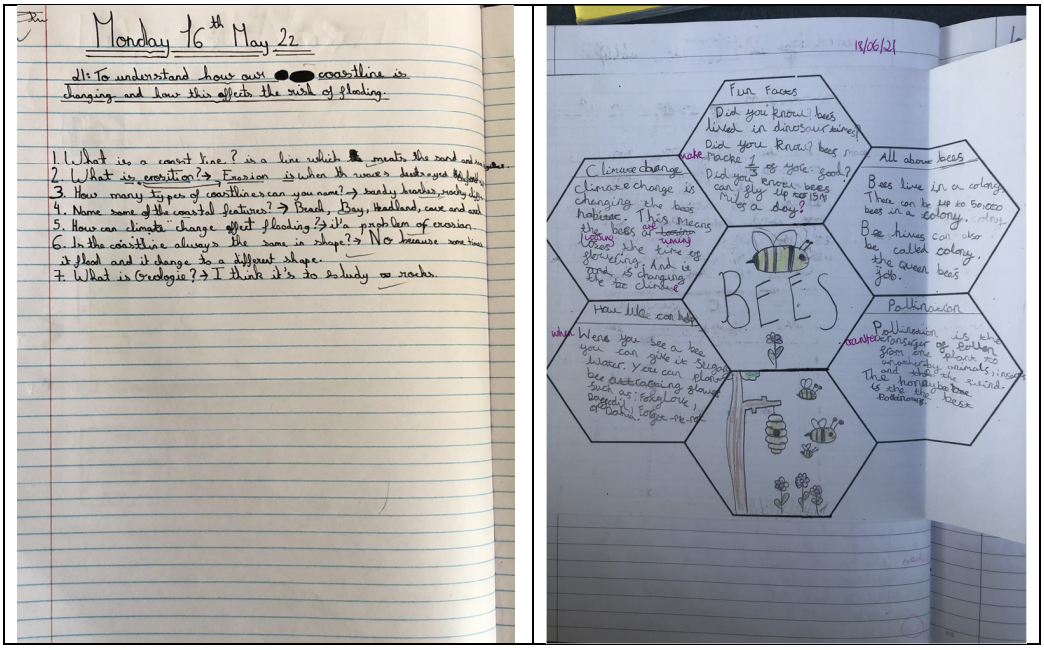

Figure 2. Images from student exercise books showing issues related to sustainability: School 1, Year 5 (**left**); School 2, Year 5 (**right**).

3.1. Teachers' and Fourth- and Fifth-Grade Students' Knowledge and Their Perceptions of Sustainability and Climate Change

Most participants rated their personal understanding of sustainability (see Appendix A) as "reasonable" or "good". Environmental problems, such as climate change and pollution, were conceptualized to be the consequence of decisions and actions by humans:

> (. . .) the issue is, is it's the, the impact we've had, so the global warming side of things, because of our emissions and our actions. And over such a tiny period of time. (T5)

For the participants in this study, the most commonly cited environmental problems facing the world today were global warming (HT1, HT2, T1, T2, T3, S5-Yr5-Sch1); pollution (HT1, T1, T3, S3-Yr4-Sch1, S4-Yr1-Sch1, S2-Yr4-Sch1); climate change (S3-Y4-Sch1, S3-Yr5-Sch1); deforestation (T1, S2-Yr4-Sch1, S6-Yr5-Sch2); energy (ET1, ST1); ozone layer depletion (S3, S5-Yr5-Sch1); food waste (HT1, S3-Yr4-Sch1); floods (S4-Yr5-Sch1); toxicity (HT2); overpopulation (T1); consumerism (T2); and carbon footprint (ST1) (Figure 3).

Both students and teachers invariably stated that students find sustainability to be important, and students reported that their teachers and parents also value environmental issues:

> I think that it really matters. Some people do it [give importance to a sustainable life], but we need more people around the world doing it. (S4, Yr5, Sch2)

> We can watch David Attenborough. And then, my parents tell me about. (S3, Yr4, Sch1)

> (. . .) And what we've got is significant, and irreversible damage being done to people's way of living in terms of their ability to perceive themselves as individuals and countries to sustain themselves. So I think what is going to inevitably happen is that there will be a rush for resources. And those resources

> permit even more finite, what will probably happen is there'll be huge pressure on migration northwards towards more temperate environments. (HT2, Sch2)

For example, participants agreed that human activities affected the environment: "the way we affect the environment is like, is good and bad at the same time" (S5-Yr 4-Sch1). S2-Yr4-Sch2 gave an example of the negative impact of people on the environment—the use of vehicles, instead of increasing the use of bicycles or walking.

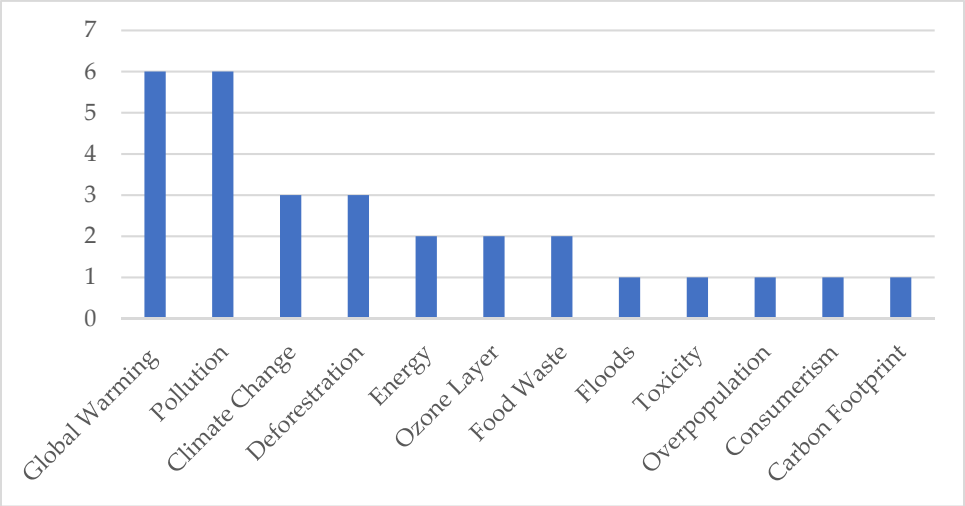

Figure 3. The most frequently cited environmental issues facing the world, as stated by interviewees.

In a dramatic reflection on the urgency of environmental action, HT1 articulated a pressing concern regarding the current trajectory of human impact on the planet. Delving into the insights derived from Griscom's book [33], the participant emphasised the approaching threat, cautioning that humanity stands on the brink of real danger: "Before we're in real danger, if you read according to Griscom book, that would be you know, and we, the fact is that we are still burning fossil fuels, we are trying to get across to electric cars. And we've done sorry, I'm quite I'm sort of a bit of like, we've done so much damage. And it's about educating the children about how not to continue that and what can change". This statement encapsulates the essence of a broader narrative emerging from participants within the study—highlighting the need to instil environmental awareness in children and foster a collective commitment to mitigating the detrimental effects of past actions.

For most of the participants, families, governments, and big companies (HT1) were seen to have the biggest roles in sustainability. According to the Year 4 student group interview, governments could allocate more funds to support the public and schools to be able to plant more trees in their gardens (S5), prevent people from cutting down trees (S2), and add extra zones [the ultra-low emission zone (ULEZ) is a zone in certain areas of London where vehicles need to meet strict emissions standards to enter without incurring a daily charge] as the cars are using too much fuel (S4).

Emphasising the role of the government in a similar vein, HT2 advocated for a shift in the curriculum, urging governments to prioritise essential aspects over outdated learning approaches:

> I think governments need to give schools resources. I think governments need to give schools time. I think governments need to take the pressure off from all the accountabilities that schools have so that schools have the space and energy and resources to develop the things that are really important. (. . .) Governments have a responsibility, I think, to do that, instead of what I think is quite an archaic and old-fashioned view of learning.

The Year 5 students at School 1 stated that they felt that governments could take more initiative on sustainability issues. Their recommendations ranged from advocating for the

construction of wind turbines to supporting the production of environmentally friendly vehicles. In a parallel vein, the Year 4 students at School 2 demonstrated a proactive approach to environmental stewardship within their school community: "teachers can give them extra time to pick up rubbish" (S6). The students in the School Club called 'Star Squad' [an example of an eco-group, discussed below] engaged in weekly gatherings where they not only discussed environmental concerns but also took tangible actions. For instance, they dedicated time to picking up litter and went to the school allotment, actively clearing weeds and removing what they saw as other impediments so as to contribute positively to the environment. This juxtaposition of perspectives and initiatives highlights the diversity of approaches within different school cohorts, collectively emphasising the importance of both advocating for systemic change and fostering hands-on, grassroots efforts for a sustainable future. In many ways, it is clear that the students were open to the possibility of transformational learning; indeed, a considerable number of them actively sought it.

However, some statements indicated that it was seen to be difficult to influence parents (HT1): "Parents don't like to be told and how they should do things. So, I think [it's] requesting parents say not to use the car to drop their children off to school is would be very difficult. (. . .) Our influence on them is very limited". On the other hand, for ST1, "I think some is better than none. But the thing is, you can launch these things. And I think if you if you infuse the children, if you encourage the children and work towards something, I think the families almost have to come along with it. Even if they don't really want to. And if you put positive reasons to support their child in it, I think they would do it".

The interviews showed that many participants take their own personal measures toward a sustainable world. These measures include using their own plastic bags, recycling, growing plants in their gardens, using their own thermoses in cafes, and avoiding the use of disposable plastic straws. The adoption of such practices, even if they might be seen as somewhat modest, underscores a commitment to sustainability at an individual level and a positive response to the science communicated to them.

Within the realm of personal understanding of sustainability, the reflections of one participant shed light on the interconnectedness of ethical considerations and environmental awareness. As articulated by the speaker, the analogy of an elephant confined within the limited space of a zoo prompts contemplation on the ethical implications of human actions towards animals:

> Like you can't just have an elephant in a zoo. Because the elephant, there's not enough space for a zoo. And you can't have and then illegal to like, hurt like, so. Why is it so it's illegal to kill someone if they're human, but it's not illegal to hunt animals? So, I think they should put like more laws to stop like hunting animals and stuff like that. (S3-Yr5-Sch2)

The student here questions the legality of hunting animals in contrast to the stringent laws protecting human life, highlighting a perceived inconsistency in our societal values. The natural tendency for many young children to feel empathy for animals could be harnessed when teaching about issues of sustainability that go beyond human considerations.

3.2. The Features of the Participant Schools with Regard to the Environmental, Social, Economic, and Educational Dimensions of Sustainability

The distinct advantage of being designated as eco-schools appeared to play a pivotal role in shaping the sustainability initiatives of both schools. However, challenges in implementing efficient recycling practices surfaced, revealing the complexities associated with waste management within the school environment, as elucidated by HT1:

> You know, proper efficient recycling, which, you know, I don't think happens, I think it's quite difficult when you've got a lot of people coming into the school. So, we're trying to recycle, we've only got one recycling bin, but we've got five general wastes. So, when the recycling bin is full, you know, the recycling such that it's tipped into the [waste]; the cleaners are really bad at recycling.

The struggles with recycling infrastructure and custodial practices highlighted the need for enhanced waste management strategies. In addressing environmental concerns, both schools actively promoted sustainable commuting through organised "scoot day[s]" (where students scooted to schools) and participated in national competitions, emphasising the commitment to reducing car usage. HT1 cited an ongoing challenge of sustaining these initiatives, underscoring the balance between belief in their importance and the practical difficulty of maintaining momentum. The integration of sustainable practices, such as growing food for the school's kitchen, demonstrated a commitment to environmentally conscious choices, as voiced by HT1. However, the inherent challenge of sustaining these initiatives over time, as expressed by HT1, emphasised the need for continuous dedication: "I think the strength side that we believe in it, and we want to do things, I think the weakness is keeping it going".

The collaborative approach to sustainability was evident from the teachers' emphasis on developing projects with families and the teachers' focus on recycling practices at School 1. These initiatives showcased a commitment to engaging the broader community and addressing environmental concerns collectively. In essence, while the advantage of being eco-schools laid the groundwork, the challenges highlighted by participants underscored the ongoing dedication required to foster a lasting culture of sustainability within and beyond the school community.

3.3. Perceived Challenges and Opportunities in the Schools as a Consequence of Their Focus on Sustainability

The findings from the discussions with key stakeholders shed light on both the challenges and opportunities in implementing environmental education within the school setting [34]. The identified weaknesses primarily revolve around time constraints, the perceived additional workload for teachers, and budget limitations affecting the school's environmental impact. HT2 candidly acknowledged the struggle to allocate adequate time and space for environmental education, emphasising the need for a fundamental shift in how these initiatives are integrated into the daily operations of the school.

Financial constraints emerge as a significant hurdle, often leading School 2 to opt for the most cost-effective solutions: "We don't have the money to spend on improving our environmental impact. Because we go for that we have to go for the cheapest or most cost-effective solutions and options" (HT2). This compromise, while understandable, is recognised as potentially compromising the integrity of the school's commitment to environmental stewardship; it reduces the effectiveness of the science communication that the teachers provide for their students and makes any sort of transformational learning less likely. The desire for improvement is palpable, yet the practical challenges in allocating resources persist.

However, amidst these challenges, there are several promising opportunities that participants recognise can help propel both schools towards a more sustainable future. HT1 suggested the collection of rainwater, presenting a tangible step towards resource conservation. Additionally, the initiative to grow food on-site, incorporating it into the school's kitchen, stands out as a more effective approach to fostering a deeper connection between students and nature, as stated by T2: "Growing your own food, and then that food is used to cook in the kitchen. And so, not only is that I mean, they still need to buy food, and but what the benefit of that would be, is children then see the direct relationship between planting, growing, cooking and eating". This initiative, if implemented, not only promotes sustainability but also cultivates a mindset where students understand the lifecycle of food from planting to consumption.

The challenges identified include concerns about recycling, alignment with the National Curriculum, and financial limitations. These challenges, when approached strategically, can become stepping stones to positive change. For instance, addressing recycling challenges can lead to improved waste management practices, contributing to a cleaner environment within the school premises. Comparably, the 'walk to school' programme

at School 2, encouraging parents and children to commute sustainably, showcases a commendable effort to instil eco-conscious habits from an early age. As one teacher put it, "Like one thing they do reach the parents like so the walk to school thing is where we encourage like parents and children to walk to school and we track it we so there is that involvement" (T2). This sort of measure can be seen as a proactive step towards integrating environmental education more effectively into the community and the curriculum.

3.4. Information Sources Used in Learning about Sustainability Issues

The participants in the study employed a diverse range of information sources to attempt to deepen their understanding of sustainability issues. Social media was seen as a dynamic platform for science communication, with HT1, T2, and S4 from School 1 highlighting its role in sharing and accessing information within a community context. For adults, communication with other adults served as an invaluable source, providing real-world insights and diverse perspectives (e.g., HT1, T2, and T5). School education, both in terms of climate change curriculum and general sustainability-focused education, remained a cornerstone, according to participants such as HT1, S3-Yr4-Sch1, S3-Yr5-Sch2, and S3-Yr5-Sch1. Television, especially David Attenborough's programmes, played a significant role, engaging HT1, HT2, S3-Yr4-Sch1, and S3-Yr5-Sch1. Participants such as T2 drew on a mix of podcasts, books (including Griscom's work), and newspapers to glean information, highlighting the importance of varied literary and auditory sources. YouTube was a visual medium for learning, attracting such participants as S3-Yr4-Sch1, S2-Yr4-Sch1, S2-Yr4-Sch2, and S5-Yr5-Sch1. T5 actively used YouTube to upload videos on environmental issues. Parents, particularly those with journalistic backgrounds, such as HT2, significantly influenced other participants' knowledge acquisition by talking with them (e.g., S4-Yr4-Sch1, S2-Yr4-Sch1, S3-Yr4-Sch1, S2-Yr4-Sch2, S3-Yr 5-Sch2, and S2-Yr 5-Sch2).

Interactions with friends played a notable role, as seen with participants S2-Yr 4-Sch1 and S2-Yr 5-Sch2, where informal discussions contributed to a collective understanding of environmental concerns. Books emerged as resources for acquiring in-depth knowledge, with participants S4-Yr4-Sch1, S2-Yr4-Sch1, S2-Yr 5-Sch2, and S3-Yr 5-Sch2 turning to them to delve into various aspects of sustainability. Eco-groups within schools, involving participants such as S5-Yr5-Sch1, S2-Yr4-Sch2, and S6-Yr5-Sch1, provided a platform that interviewees suggested offered collaborative learning and hands-on experiences, fostering a sense of shared responsibility toward environmental stewardship, opening the way to the possibility of more transformational learning. Newspapers, a traditional but still relevant source, played a role in helping participants, such as S3-Yr5-Sch1 and HT2, to stay informed about current sustainability issues.

This tapestry of channels indicates the commitment of many of the participants to a deeper understanding of sustainability issues afforded through science communication. By 'science communication', we are referring to the multiplicity of science-related topics that are communicated to members of the public, of all ages, including both teachers and primary school students. The openness of both students and their teachers to this diversity of channels suggests that it is realistic to hope that teachers might help students develop their criticality and, thus, exercise their judgement about the myriad of accounts of sustainability that they come across.

3.5. How Is Environmental and Sustainability Education Enacted and Experienced in Primary Eco-Schools

> "*And I think it's possible to do that. It's a combination of all those little bits, all those schools doing those little bits together that will help to add up to make some big impact*". (HT2)

The teacher and student perspectives on the integration of sustainability topics within educational programmes revealed important insights. Teachers generally expressed that sustainability issues should be embedded within the curriculum, even from Reception [the year before Year 1, where children are aged from four to five] (e.g., ET1). Participants

generally agreed that geography and science are key subjects for integrating sustainability, although concerns about the depth and explicit coverage of the issue of sustainability persisted. Sustainability was also seen to fit into the personal, social, health, and emotional (PSHE) curriculum. While the science curriculum was acknowledged as addressing sustainability, some participants, particularly T3, expressed concerns about its outdated nature and the need for it to change in light of recent technological advancements:

> (. . .) the science curriculum does talk about sustainability, but not as much as probably could. I think it is outdated. I think it needs to change now because you know, technology is changing. (T3)

> I don't think it is in the science curriculum. It should be. (. . .) it needs to be more in-depth in geography. (T4)

Teachers, including T4, highlighted the vague and insufficiently in-depth nature of the geography curriculum, emphasising the importance of explicit coverage on critical issues such as climate change:

> I feel like the geography curriculum is very, at the moment, quite vague. It is not very in-depth as it could be. They say like, I have bits and bobs here and there, but I don't think it's anything explicit. I think there should be a whole thing about climate change. (T4)

Students, according to T3, benefit from open-ended projects, fostering a deeper understanding of sustainability issues. Despite efforts in curriculum design to reflect community values and create responsible citizens, a gap was described in embodying sustainability ideals during curriculum delivery.

In the exploration of sustainability education within primary eco-school curricula, the insights from HT2 provided a foundational perspective. HT2 emphasised the fundamental role of sustainability in the school's vision, rooted in idealism and morality. HT2 articulated four elements—celebrating diversity, being upstanding/activists, living by the school's values, and embracing environmental responsibility and sustainability—that were deemed crucial for enabling children's future success. Sustainability was recognised as integral to the school's purpose.

HT2 further illustrated the practical aspects of sustainability within the school, focusing on issues such as plastic in the oceans and temperature change. The necessity of incorporating sustainability into the curriculum was highlighted, and HT2 acknowledged the challenges of implementing meaningful change, attributing these difficulties to financial constraints and the prioritisation of short-term outcomes. Despite these challenges, HT2 envisioned high-profile initiatives, such as creating a sensory garden and enhancing a local park's environmental sustainability, as opportunities for positive impact:

> I want the geography subject leader and science subject leader to really make sure we showcase those where we are doing our sustainability work. I want, so we've got two projects next year; one is here, which is the sensory garden, and one is down the road. There's a small park called (. . .). And they want to make that park a better environment, both from an environmental perspective, but also from a, yeah, to make it a more sustainable place. And so we're going to be involved in those so I want to try to get the school involved in those things (. . .) because lots of our children will use that park I want us, our children, to be part of that. (. . .) I think we should get involved in because that's our local space, that's where we can have a positive environmental impact.

The commitment to showcasing sustainability efforts and involving students in meaningful projects can be seen to underscore a school-wide dedication to instilling environmental responsibility and sustainability in the school ethos.

When the teacher participants were asked, "In which educational programmes do you think sustainability topics can be more integrated?", they mostly responded with "geography" and "science". However, the National Curriculum, which includes both

geography and science, was criticised for having loose links to sustainability. Teachers, particularly T1, stressed the limitations imposed by the National Curriculum, citing a lack of adequate content on sustainability as a weakness. Environmental problems, notably climate change and pollution, were viewed by participants as consequences of human decisions and actions, highlighting the urgent need for comprehensive sustainability education from an early age.

The findings demonstrated a consensus among participants on the need for a more robust integration of sustainability topics in educational programmes, particularly within the National Curriculum. The teachers expressed a passion for meaningful sustainability lessons, emphasising the importance of nurturing children's well-being in an interconnected world. However, challenges were seen to persist, including perceived inadequacies in the National Curriculum, indicating the necessity for policy changes and a more concerted effort to embed sustainability education into the core of primary education:

> So, what can we do in education? I think first, it is like respecting the child. And I think education needs to slow down in order for that to happen. (T2)

> I believe the problem starts with the National Curriculum. One of strengths about the sustainability in school is the passion and ability of teachers to teach meaningful lesson to the children by encouraging children to maintain or sustain their wellbeing first in an interconnected world. One of the weaknesses is that not enough content is included in the National Curriculum about the sustainability. (T1)

For HT1, the government sees sustainability as mainly the schools' responsibility:

> I would say is that I feel the government's answer to every problem is that schools should teach it. So, no matter what it is, so obesity, schools need to do with its money, sustainability, schools need to do (. . .) Every single problem in society, schools are told that they need to do with it (. . .) which is very overwhelming.

In contrast, HT2 referred to the crucial role of education as follows:

> (. . .) they [students] are to be to celebrate the diversity and inclusivity of all people, races, genders, etc, to be upstanders and activists, to live by the school's values, and to be environmentally responsible and sustainable, and live sustainably. Those are the four things that I think will enable our children to be successful in their futures. So, that sustainability part is fundamental to what I think this school is here for.

These problems can be seen to require different solutions. One of them was a revolutionary approach, as stated by HT2:

> So, it needs people who are actual revolutionaries, I think, whether that be Extinction Rebellion, whether that be people protesting the British Grand Prix yesterday [3 July 2022], whether that be people like Greta Thunberg, but I actually think it's going to be people that might now be considered on the fringe, and radical.

Both schools had eco-groups that included an eco-group leader and students from various years. An eco-committee was selected democratically from Years 3–6 at School 1 and Years 4–6 at School 2, which increased the confidence of those students who applied and were elected. Interviews with the eco-team leaders showed that a large number of students were involved in environmental research, which provided an opportunity for in-depth discussion within the eco-committees and transformational learning.

Teachers' and students' characteristics (experience, age, gender, and field of study) did not seem to make significant differences in terms of their responses. However, students from eco-teams were more knowledgeable and talked more about sustainability issues when compared to their peers. The data gathered from interviews, observations, and the class exercise books indicated that students seemed to have enthusiasm and were aware of their responsibilities as 'powerful agents of change' with regard to sustainability and

climate change issues. From a science communication perspective, it was evident that the students had learned from their schools, families, and the media about climate change.

In-class observations and interviews showed that both schools made connections with environmental issues in some curriculum areas, particularly geography, science, and art. Overall, School 2 seemed to have a better dedication to environmental education with curriculum link evidence (e.g., a tree-planting project) provided by the eco-team leader. As a final point, the teachers in both schools expressed interest in expanding their knowledge as well as their students' understanding of sustainability and climate change. In this context, the teacher participants from both schools stated their interest in participating in in-service training programmes.

4. Discussion

The level of knowledge and meaningful discussions taking place among teachers, headteachers, and the fourth and fifth graders in these schools on topics related to climate change and sustainability suggests how welcome these topics are to participants and the possible effectiveness of the teaching and engagement strategies to enable transformational learning. The proactive approach to education can be seen not only to enrich the learning environment but also to equip students with what we perceive to be valuable insights into crucial global issues.

However, the results indicated that there is a tension between different understandings of sustainability. This tension often reflects the tension between maintaining existing socio-economic and political structures and embracing more transformative, holistic approaches to sustainability. Furthermore, an interdisciplinary approach to the topic can be understood to be one of the keys to successful, indeed, transformational, learning, that is, treating it not as a separate subject to be taught on its own, such as 'environmental education' or only as part of the natural sciences, but rather as an integral part of every school subject's curriculum and study plan.

Regarding school education, the following skills and characteristics of ESD learning methods outlined in [35] were considered: student-centred teaching methods; future-oriented thinking; higher-order thinking skills; critical thinking; interdisciplinarity; and linking local and global issues. The Rio+20 Conference reaffirmed that universal access to primary education and quality education at all levels is "essential for achieving sustainable development" (p. 1). The key issue here is that the nature of sustainability issues seems to raise pedagogical issues in changing subject content and requires transformative approaches; this need can cause difficulties in schools that are subject to all sorts of practical constraints.

While challenges regarding time, National Curriculum requirements, and budget constraints persist, the identified opportunities offer a roadmap for schools to enhance their environmental education initiatives. By strategically addressing challenges and capitalising on opportunities, such as rainwater collection, sustainable food practices, travelling to and from school, and community involvement, a school can pave the way for a more environmentally conscious and educationally enriching environment. The commitment to improvement, as voiced by HT2, provides a foundation for a sustainable and impactful educational journey.

The findings underscore a consensus among participants on the need for a more robust integration of sustainability topics in educational programmes, particularly within the National Curriculum. This would help provide more effective science communication and increase the likelihood of sustainability education, resulting in transformative learning. Considering our observations and interview results, we have found gaps in the current sustainable education curricula in England. Specifically, a parallel result to [36], where teachers express a passion for meaningful sustainability lessons, emphasising the importance of nurturing children's well-being in an interconnected world. However, they frequently lack the confidence, abilities, understanding, and support to do so. In addition, teachers face some challenges, including perceived inadequacies in the official curriculum, indicating

the need for policy changes and a more concerted effort to embed sustainability education into the core of primary education.

Most of the teacher participants emphasised that the responsibility to deal with sustainability issues was the government's but that the government did not seem to take the communication of sustainability, both in formal and informal ways, seriously. In a school setting, we would expect that a government should, at the minimum, have a national curriculum in which space is given for learners to develop their understanding of issues to do with sustainability in its various forms—e.g., biodiversity loss, anthropogenic climate change, soil erosion, and pressures on water supplies. Ideally, such understanding should lead to changes in behaviour in individuals at the school level and more systemically. In parallel with the argument in [37], what is most needed is "concrete support that is close to teaching and the schools' objectives" (p. 1). Such support is likely to be needed if more than a small proportion of schools are able to engage in teaching that enables effective transformation for students. Perhaps the most important manifestations of that support would be (a) a requirement for sustainability to be embedded across the curriculum in primary schools and not just in geography and science, (b) a lessening of other demands on teachers' time, and (c) the provision of high-quality professional development for teachers, a point to which we return below.

Participants reported that they obtained their information about climate change and sustainability from a range of sources, including podcasts, books, newspapers, and YouTube, underlining the varied media drawn on by the 'learning community' as a whole. The influence of parents on students' knowledge acquisition is noteworthy, showcasing the more general impact of familial environments. Interactions with friends, informal discussions, and eco-groups within schools all contribute to a collective understanding of environmental issues, emphasising the significance of social dynamics in knowledge exchange, as also discussed by Illeris [38]. Community of practice theories of learning tend to suggest that learning does not have to reside in one individual. It can reside in the community as a whole; likewise, our data suggest that the community has a wide range of resources, but each individual does not (or not necessarily). Books (participants did not specify the type of the book, whether academic or not) remain resources for acquiring in-depth knowledge, with several participants turning to these to explore various facets of sustainability. From a science communication perspective, one can see the one-way uptake of scientific knowledge about sustainability that study participants combined with dialogue about it. The formation of a community of practice brings along with it a shift in participants' sense of identity, opening up the possibility of more transformative learning.

Eco-groups within schools emerged as a distinctive platform that makes a difference in collaborative learning and hands-on experiences, with evidence that they are fostering a sense of shared responsibility towards environmental stewardship. Those committee members would then be able to share their findings and views more widely with their classmates. These practices, through their adoption of two-way conversations and active participation and openness to the possibility of change, are also important in terms of being consistent with the principles and processes of effective science communication and deep (transformative) learning.

Traditional sources, such as newspapers, continue to play an important role for a number of our study's participants, ensuring that they stay informed about current sustainability issues, though, of course, as with any source of 'information', newspapers have, at the very least, their own perspectives on sustainability and climate change issues (contrast, for example, the more eco-friendly [39] newspapers with the more climate change sceptic newspapers [40]). An optimistic interpretation is that the wide array of media used and accepted reflects the commitment of the community of participants to a well-rounded and more extensive understanding of sustainability, which is consistent with the recognition of the multifaceted nature of contemporary knowledge acquisition in this critical field.

While the study generated rich data and enabled us, through our use of the lenses of science communication and transformative learning, to produce new insights into the

potential of sustainability education at the primary school level, it is limited to the research undertaken in two primary state eco-schools, which jointly constitute a single case, with a specific set of individuals in London. Therefore, the findings may not be applicable to other schools in London or beyond. Nevertheless, we find little in our data to suggest that these schools are exceptional. We suspect that the lessons learned here, specifically the factors that help or hinder effective student learning about sustainability, may apply more widely.

A more significant limitation is likely to be that the data for the study—the opinions of teachers, headteachers, eco-team leaders, and fourth- and fifth-grade students, as well as the observations made by the first author—were gathered over a period of 14 weeks. The study may offer insights into the current state of sustainability and climate change education in the two schools, but it lacks a longitudinal perspective, hindering the ability to track changes over time and to understand trends. A longitudinal study—using interviews and observations to ascertain whether major shifts in thoughts and practices have taken place—would help determine the extent to which transformative learning can, indeed, result from effective science communication in a school setting. Such a study, of course, needs to not be restricted to the schools that participated in this study.

5. Conclusions

This research examined participants' perceptions of sustainability and climate change in two eco-schools in England for primary school children (aged 5–11 years). Our case study made use of a range of data collection methods, principally interviews and observations. Students and teachers alike were aware of the environmental dimensions of sustainability, such as climate change and the overuse of natural sources. Nevertheless, the integration of sustainability into the curriculum was limited and problematic. We draw on theories of science communication and transformative learning to help us understand the reasons for this. Schools are like any institution in that there can be significant barriers to change. In particular, schools are under great pressure, especially in terms of time demands and the need to meet external targets, such as doing well in official inspections. One of our conclusions is, therefore, that schools are no different to other institutional settings when it comes to dealing with the challenges of integrating sustainability into daily practice. Nevertheless, both of our schools exhibit considerable potential for transformative learning despite the political contexts in which they operate, at least in part because of the affordances of the eco-school initiative in which they are participating.

Future research could complement this research by looking at primary schools that do not have a particular focus on sustainability and by looking at the situation in secondary (11–16 or 11–18 years) schools. It would also be valuable to gather data on the perceptions of parents and policymakers. These sorts of insights could confirm the extent to which key conclusions—e.g., about the challenges of sustaining sustainability activities—are widely experienced. This could highlight where policy changes or better resourcing should be committed. The study might be also expanded by studying a large number of schools from different regions or educational systems. A comparative analysis would help identify common trends, as well as variations, in the perceptions and experiences of stakeholders. Future research might also focus on longitudinal perspectives to explore insights into the dynamics of state schools in London, or elsewhere, and the effectiveness of policy implementation.

Finally, this study indicates a need for high-quality teacher professional development courses on sustainability issues to be more widely available. If and when such courses are developed, there will be a need for them to be evaluated not only to determine their effectiveness, e.g., in fostering transformative learning, but so that future iterations of such courses can be improved.

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Appendix A

Teacher Interview Protocol

Section One

If you are happy to let me know, in what year were you born?
Gender:
Your most recent degree (e.g., undergraduate, Masters, PhD):
Teaching experience (in years):
How would you rate your personal understanding of sustainability?

Very good	Good	Reasonable	Little	None
☐	☐	☐	☐	☐

Section Two

1. What do you think are the biggest environmental problems facing the World today?
2. What might be done to solve this/these problem/s? Who might be responsible for dealing with these problems?
    - 2.1. What might schools do?
    - 2.2. What might teachers do?
    - 2.3. What might families do?
    - 2.4. What might the government do?
3. Can you please try to explain to me what you understand by 'sustainability'?
    - 3.1. Can you please name as many sustainability issues as you can?
    - 3.2. Where have you learnt about sustainability? (e.g., formal/informal education, media, etc.)
4. Do please tell me about your understanding of what the National Curriculum expects with regards to sustainability education and climate change education.
5. UNESCO says: "Learning must prepare students and learners of all ages to find solutions for the challenges of today and the future". Do you think the topic of sustainability should have a place in education? How?
    - 5.1. Curriculum and instruction
    - 5.2. School facilities, including physical conditions
    - 5.3. School community (e.g., teachers, students, school administration, staff, parents)
6. Can you please try to explain to me what you understand by 'climate change'?
    - 6.1. Where have you learnt about climate change? (e.g., formal/informal education, media, etc.)
7. Please tell me how you teach about climate change and sustainability issues.
    - 7.1. Aims, goals, objectives
    - 7.2. Content organisation
    - 7.3. Implementation

7.4. Assessment

8. What do you think about the strengths and weaknesses concerning the implementation of sustainability in your school?
9. Would you like to participate in a sustainability training programme? If yes, what would you like to learn about sustainability in this training?
10. Is there anything you would like to add that might contribute to our research? Thank you for your participation.

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Article

Dialogue and Disruption at the Doorstep: Participant Perceptions during a City Walk as a Climate Communication Format

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Abstract: Since there is a broad empirical consensus that linear science communication focusing on disaster framing rarely empowers audiences and prompts transformative action, alternative climate communication formats are needed. This paper explores an alternative climate communication format, which integrates the issue into a local context (Munich, Germany) via transdisciplinary cooperation, specifically through collaboration with local climate educators and tapping into the scientific expertise of local stakeholders. The conceptualized format of a City Walk on the subject of climate justice addresses urban citizens and tests the effectiveness of climate justice as an alternative framing. Drawing on an accompanying empirical study with qualitative group discussions (n = 14, October 2023), this article explores how the format and framing are perceived by the participants. Based on these findings, we discuss the potentials and pitfalls of the format for transdisciplinary science communication. In summary, the City Walk deepened participants' understanding of local climate justice—that is to say, how heat and flooding could amplify existing inequalities, and why adaptation and mitigation measures have not yet been implemented more thoroughly. Here, the crucial point is not whether the shift from climate change being a general topic to a personal one is supported by technical aspects of communication (e.g., virtual simulations). However, perceived local climate justice barriers (like bureaucracy) led participants to prioritize individual action ('footprint') over collective action (e.g., addressing local change). With these results, this study underlines the importance of new transdisciplinary formats for climate communication to address local change.

Keywords: transdisciplinary science communication; climate communication; education for sustainable development; city walks; climate justice; dialogue-oriented science communication

1. Introduction: Need for New Formats of Transdisciplinary Science Communication

Extreme weather events like the sweltering summer of 2022 or flooding in North-Rhine Westphalia and the Ahr Valley in 2021 have underscored the importance of climate adaptation in Germany, especially in populated areas. As a result, the concept of climate justice has gained attention in this context. Pörtner et al. [1] characterize three aspects of climate justice:

> *"The term climate justice, [. . .], includes three principles: distributive justice which refers to the allocation of burdens and benefits among individuals, nations and generations; procedural justice which refers to who decides and participates in decision-making; and recognition which entails basic respect and robust engagement with and fair consideration of diverse cultures and perspectives".*

One aspect mentioned here is participation: Urban sustainable development for just climate adaptation needs ongoing engagement and support from the local communities for its successful implementation [2]. In the concept of locally led adaptation [3], the knowledge of local communities is crucial to identifying adaptation pathways [4] and solutions, while

real-world laboratories can influence modes of urban climate governance [5]. "Public participation in spatial planning" [6] is already used in disaster risk reduction [7], and the same goes for recovery, where community resilience is considered [8]. Climate change communication, on the other hand, often remains one-sided, with the delivery of messages from science to civil society [9] with a focus on a disaster frame [10], which does not lead to empowerment or behavioral change to a sufficient extent. The integration of scientific and stakeholder knowledge for urban climate adaptation in this context poses specific challenges for both the scientists and the stakeholders involved in the process, leading to the need for "boundary workers" [11] facilitating the transmission [12] and understanding of scientific information.

The climate communication format "City Walk" conceptualized, realized, and empirically evaluated in this study aims at bridging this gap. The format is an in-person, dialogue-oriented, and transdisciplinary format for science communication. It aims to not only transmit information (first-order thinking), but also encourage dialogue (second-order thinking) and, moreover, enable perspective taking. This should lead to a deeper understanding of how adaptation and mitigation measures are realized or hindered on a local level, and which role different actors may have here (third-order thinking). These outlined communication goals refer to Irwin's notion of first-, second-, and third-order thinking for science communication [12] (Or, to put the addressed communication goals in a more poetic way: "Stroll through city streets, Climate emotions bloom bright, Empowering hearts". This haiku is offered as an alternative, creative summary of the format and its communicative goals).

The specific City Walk designed and realized in the context of this study therefore includes three crucial aspects: dialogue with experts, social interaction, and the outdoors. The City Walk combines both scientific knowledge from local stakeholders (as on-site input talks) and group discussions about the participants' related emotions (via moderated group discussions). This implicitly addresses climate justice in local climate change adaptation as an aspect of sustainability, SDG 11 (Resilient Cities) and SDG 13 (Climate Action). Answering the following two research questions is the scholarly objective of this study and therefore determines the empirical study design aimed at exploring to what extent the format does in fact lead to the given communication goals:

(1) *To what extent can the framing of 'climate justice' help inspire and open up dialogue between scientific and practitioners' expertise and urban citizens in relation to climate change?*
(2) *How can new formats for transdisciplinary dialogue-oriented science communication help engage people with the climate issue such that their responses incorporate scientific and practitioners' expertise?*

2. Research Field

Climate scientists have long-standing and ambiguous experiences of acting as visible experts in the (mediated) public [13]. There is an ongoing discourse on the role and self-identity of science and scientists in 'post-normal' situations [14], especially in relation to climate change. Should scientists act more like map makers—neutral, but actively selecting and documenting relevant knowledge—or more like navigators—assessing policy-relevant knowledge [15]? Should scientists protest on the streets ('Scientists for Future' [16]) to demonstrate how far removed current policies are from the scientific consensus, or are policy briefs and expert hearings still the most fruitful way to be heard in decision-making processes?

Over the past decade, a multi-disciplinary field of research has emerged around these questions—the 'science of science communication' [17]. The main consensus in this field is that accurate and up-to-date information on scientific findings will not lead automatically to societal progress (information-deficit model [9]). Accordingly, environmental sociology heavily criticizes the belief that scientific information about the anthropogenic source of climate change alone will help people change individual behavior ('knowledge-action gap' [18]). The current paradigm of scientific communication has thus shifted from

linear information-transfer models toward participatory and dialogue-oriented forms of communication [19]

Recent research has elaborated the key characteristics of dialogue-oriented science communication, which can be summarized in a nutshell as the mutual exchange of meanings [20]. In public dialogues (like in talk shows), it is expected that scientists not only 'send' their information but also listen and learn about people's perspective on the issue—their concerns, hopes, beliefs, wishes, and fears. However, to start a dialogue, the objective and issue need to be framed by the initiating partner (e.g., a scientist) to open up and define a room for dialogue: "Framing should be used to design communication contexts that promote dialogue, learning, and social connections and that allow citizens to recognize points of agreement while also understanding the roots of dissent" [21].

The issue of climate change has a long tradition of being framed as a catastrophe. Overall, this framing can be seen as the most dominant and successful framing for establishing climate change as a salient issue for mediated public communication [22,23] and for contributing to a correspondingly high level of public awareness of the problem. At the same time, audience studies have repeatedly shown that precisely this framing leads to feelings of being unable to confront this issue, of being overwhelmed, and of blame [24–26]. A current focus of psychology-oriented research [27] demonstrates the relevance of climate feelings, including anxiety [1,28,29], grief [30], anger and frustration [31,32], and positive emotions [33,34] like humor (ibid.), connectedness (ibid.), and hope [35,36]. Positive and negative emotions play complex roles in climate communication and education [35], such as predicting or hindering policy support [37]. Thus, they require nuanced approaches tailored to specific contexts and individuals [33]. Here, a reflection of one's own climate emotions is suggested as a constructive and empowering coping strategy.

The framing of climate change as a catastrophe provokes defensive reactions in the sense of cognitive dissonance, which can cause people to avoid and ignore the issue [10,23,38]. New formats for communicating climate change as a local, on-site issue often explore art and (media) technology as "mediators". This specific research field is quite fragmented as it is multidisciplinary in nature, and it is often rooted in research on climate change adaptation and/or education for sustainable development (ESD). For example, research by Yavo-Ayalon et al. [39] included a communal extended-reality (CXR) bus tour that depicts the possible impacts of flooding and climate change. These possible outcomes were analyzed via group discussions to examine to what extent this format can inspire action on climate adaptation. One of the major effects of the VR bus tour was an increase in people's awareness of the impacts of climate change on their city. Additionally, participants were found to have a stronger emotional connection toward the community after the rides. One disadvantage of this climate communication format is the use of technical devices, which could imply barriers for certain target groups due to their sensory abilities or being unable to afford the necessary technology.

Another study dealing with emotions in the context of on-site climate communication conceptualizes a participatory and collaborative art installation "situated in East Boston [. . . that] combines public art with digital technology". The installation depicts the receptions of sea-level rise by visualizing local projected flood levels and the public's emotions toward this threat [40]. The corresponding empirical survey concentrated on measuring the emotions evoked by the fact that their city (Boston) will be heavily affected by flooding in the near-future. 'Concern' was the feeling most frequently articulated (compared to four other categories: anger, sadness, optimism, and other), and the accompanying observation of people's reactions supported the idea that rising awareness was the main impact of the art project.

As linear communication with the framing of climate change as a catastrophe has not been fully successful, it opens a door for participatory science communication which emphasizes dialogue. Local, on-site climate communication formats, such as virtual reality tours and art installations, engage diverse audiences despite accessibility concerns. As the roles of scientists in public discourse on climate change evolve, science communication is

shifting toward participatory and dialogue-based approaches and requires new framings of the issue. Utilizing local, on-site climate communication formats like virtual reality tours or collaborative art installations can enhance awareness and emotional connection, although accessibility barriers may arise. Moreover, a resource-intensive setup may hinder the broad adoption of these formats. In this study, a City Walk presents a promising alternative for engaging diverse audiences in climate action.

3. Conceptual Foundations for the City Walk

The City Walk format is a pedagogically inspired learning arrangement implemented to explore different stations in urban surroundings [41] by foot, with each element or location in the walk [42,43] addressing an aspect of an overarching theme or topic [44]. Overall, this approach is apt to provide a learning experience that integrates different perspectives on a thematical reference point in real-life settings, providing a different kind of information which can supplement studies, articles, reports, and media coverage.

3.1. Conceptual Foundations in ESD

Since the concept of education for sustainable development (ESD) aims at shaping competencies in cognitive, socio-emotional, and behavioral dimensions [45], innovative learning arrangements such as City Walks are particularly well suited to addressing issues of sustainable development.

> *"ESD aims at developing competencies that empower individuals to reflect on their own actions, [. . .] from a local and a global perspective [. . .] [,] to act in complex situations in a sustainable manner, [. . .] and to participate in socio-political processes, moving their societies towards sustainable development".* [46]

A City Walk involves a group of adult learners walking a pre-defined route through an urban environment, stopping at different stations to explore a certain topic. The stations consist of an introductory and final activity highlighting the sense of place [47], with generally two to four thematic stations between them, which can be augmented by media input, experts, discussion prompts, etc. The format breaks with the notion of linear and digital learning, focusing on social exchange in an outdoor experience and new perspectives, even on well-known surroundings and personal feelings. This unusual, sometimes disruptive learning experience (since accustomed perceptions and convictions are being reflected and questioned) fosters reflection on collective and individual perceptions and actions, which in turn can lead to transformation.

> *[. . .] transformation necessitates, among other things, a certain level of disruption, with people opting to step outside the safety of the status quo or the "usual" way of thinking, behaving, or living. It requires courage, persistence, and determination, which can be present at different degrees, and which are best sourced from personal conviction, insight, or the simple feeling of what is right.*
>
> (Para 4.2, Framework for the implementation of ESD for 2030, quoted in [45])

Reflection not only refers to the topic and its various contents, but also to a broad skillset, described as a framework of 12 crucial educator competences in a "rounder sense of purpose" (RSP). The resulting framework comprises 12 competences, each with three learning outcomes and several underpinning components [48,49]. The RSP framework provides structure for educators to practice an action-oriented, transformative pedagogy that engages learners in participative, creative, and critical thinking and acting processes, and the various competences cover reflection (criticality, responsibility, decisiveness), practice (transdisciplinarity, creativity, action), involvement (attentiveness, empathy, values), and integration (systems, futures, participation) [50,51].

For the City Walk discussed in this paper, the skillset "dealing with emotions" [50] is a focal point. Accordingly, the competences focusing on and involving empathy are very important:

> *"The educator helps learners to respond to their feelings and emotions and those of others. [. . .][, to] listen to their own emotions and those of others; understand and apply strategies for dealing with fear, conflict, or despondency, differentiating between unfounded hope and realistic sources of hope [. . .] [and to] develop their own and others' coping mechanisms and sources of resilience when confronted with potentially overwhelming sustainability related issues".* [50]

Essential characteristics of all ESD-related formats, such as City Walks, are as follows:

a. A holistic approach, which seeks integrative thinking and practice;
b. Envisioning change, which explores alternative futures, learns from the past, and inspires engagement in the present;
c. Achieving transformation, which changes the way people learn and the systems that support learning [52].

Aiming at transformation as an ultimate learning goal, this approach resonates with findings that the more time an individual spends outside and interacts with their surroundings, the more likely it is the person will engage in activities that foster planetary health [53]. Not only is it possible to address topics of sustainable development, such as climate justice, but phenomena related to sustainable development are also demonstrated at interactive stations. Furthermore, participants have the opportunity to discover best practices, engage in perspective shifts, and learn about actionable options.

While peripatetic philosophizing or learning stems from antiquity, walking through a landscape or urban parks for the purpose of recreation and enhancing the awareness of those natural surroundings is a habit that became popular in the era of industrialization as a counterweight to industrial settings. Social walks exploring literary or historical themes can be traced back over a century [54]—with the aim, for example, of walking in the footsteps of literary figures or learning about artists and their oeuvre. Politically motivated City Walks emerged during the same period, when nationalist students in Germany and Austria around the end of the 19th century sought verbal and physical confrontation with opponents [55]. The recently emerged ESD City Walk format, by contrast, is non-confrontational. Even though verbal interaction might be purposeful and thus intended, the focus lies primarily on the interaction among the participants and the leader, rather than with others in the city. That being said, contemporary pedagogical walks in formal and informal educational settings can be understood as a counterweight to individualized digital practices [56].

City Walks as an ESD format have been documented as a learning environment in non-formal education [44,57], focusing on social and political topics such as overconsumption or postcolonialism [58]. The format is said to have high potential for connecting real-life issues [57] with new perspectives on people's familiar surroundings in a "meeting-space" (German: "Begegnungsraum", [44]). However, climate justice, especially with respect to one's personal climate feelings, has not been explored in this context thus far, and there is little evidence on the reception of the pedagogical setup of the communication format in different settings [54]. As such, the study in this paper is intended to make a major contribution to the field.

The City Walk described here as "Climate justice at the doorstep" [59] has three crucial aspects: dialogue with experts, social interaction, and the outdoors. By sharing their ideas and viewpoints around climate justice, the participants make it a social issue among themselves. This aspect may also help them connect the different viewpoints they might have; for example, some participants might focus more on how members of their (extended) families experience hot summers, while others bring the perspective of the Global South. In any event, a vast majority of participants agreed that action is required immediately. The presence of experts at the stations is one way of conveying information. In the present case, they gave cognitive input and communicated scientific findings to the adult learners and opened up dialogues.

3.2. Transdisciplinary Approach behind the City Walk

Together with local stakeholders and the implementation partner "Netzwerk Klimaherbst" (NGO), the City Walk was chosen as a climate communication format because it offered a broader view on the participants' familiar neighborhood. Secondly, walking between the stations was expected to promote dialogue within the group.

Addressing people living in Untergiesing or nearby neighborhoods in Munich, the walk's intended goal was to foster a clearer understanding of climate justice and action, to strengthen the skillset of "dealing with emotions" [50], and to inspire new ways to become active about climate change.

The format would be inconceivable without its transdisciplinarity, which is based on the local expertise imparted by the speakers, who work outside academia but have strong scientific backgrounds. In addition, the event's concept was developed in cooperation with a partner from non-scientific practice, namely "Klimaherbst" (NGO), a major organization for climate-related knowledge transfer in Munich [60]. The topic and framing were proposed from the scientific perspective to the implementation partner, who further developed it with suggestions for speakers and content.

Flooding and heat were chosen as core subjects for the walk, due to their high relevance (floodings of the Ahr Valley in 2021; heatwaves in 2022). One of the invited speakers was the head of the local water management office (water supply, hydraulic engineering, and watercourse development). The other speaker worked for an environmental non-governmental organization ("greening office" [61]; greening measures for buildings, roofs, walls, or courtyards (ibid.)). Additional information on how the event was setup [62] and assessed [63], and on the route and contents [64] of the City Walk "Climate justice at the doorstep" [59], including a map and a schedule, can be found in the Appendix A.

3.3. Empirical Methods

While acknowledging that "education [...] does not function according to input-output logic" [65], we designed qualitative group discussions (n = 14) before and after the City Walk to better understand the process of how participants perceive and interpret the City Walk (see Yavo-Ayalon et al. [39]) and to answer research questions (1) and (2).

Before the City Walk, a recruitment questionnaire (see Figure 1) was sent out via email to sketch the participants' background, focusing on descriptive characteristics, values, and climate emotions, as well as knowledge, attitudes, and actions related to climate justice. The questionnaire included open-ended questions aligned with these themes, covering aspects such as age, gender, place of residence, climate emotions, knowledge on climate issues, and important values.

Figure 1. Overview of the methods used.

Qualitative focus group discussions (initial discussion and final discussion, Figure 1) were chosen as the central empirical method to answer the research questions, as this research is explorative in nature and aims at discovering the perception of the participants in an open and non-predefined way. As an established method for qualitative social science research, it does not aim at representativeness in a statistical sense, but at in-depth understanding. The recommendation for sample size is to use a small number of participants (e.g., around 6–8 people), as this setting allows closer social interactions and a more trustworthy atmosphere. Based on our theoretical perspectives, we developed a structured discussion guide [66,67], and thus provided a framework for organizing the discussion around the central research interest in research questions (1) and (2). As an icebreaker, the initial discussion began with graphical 'climate animals' [68], such as the "angry gorilla" or the "busy bee". These devices were intended to make it easier for the City

Walk participants to talk about their own attitudes and actions related to climate justice. The spirit of each climate animal was supplemented by a short text, such as the following for the angry gorilla (also, see Appendix A):

> *"We have a problem here, and it makes me angry! We can't go on like this! We must do something. Fighting is my mode. I'm going to tackle the problem. Immediately. And don't let anyone get in my way! I'll tell them something!".* [68]

A discussion on the topic of climate justice followed, as this was the central framing (research question 1). In the final discussions, each participant was asked if they would choose a different climate animal. For more information on the moderator [67,69] and the questionnaires [34,67,70–74], see Appendix A.

After the group discussion had been transcribed using the AI-supported software Trint and a complementary manual check, a qualitative content analysis was undertaken to ensure the systematic analysis of the central themes in the discussion. Accordingly, the main aspects of the discussion were classified thematically. Then, the participants were anonymized and assigned numbers, such that "P. 1" designates Participant 1 in what follows. The supplementary questionnaires were used as qualitative, contextual information [75,76] for interpreting the data. More information about them can be found in Appendix A.

3.4. Sample Description (Participants)

The results of the recruitment questionnaire (n = 14, 1 missing) help to contextualize the qualitative data (Table A1 in Appendix A), characterizing the participants according to their age, gender, education, first language, and place of residence. Eight people had obtained a (specialized) university degree, while two had completed high school and three had completed vocational training. The participants had large intersections concerning their values nonetheless, with their responses implying an orientation toward nature and the common good. In terms of nationality, they were homogeneous, with none of them speaking a mother tongue other than German. This is untypical for Munich, as the proportion of people with diverse language experiences and backgrounds is quite high [77]. Both phenomena can be explained by the fact that participants signed up for the event through its German website [59] for which some interest in the topic and knowledge of German is required. According to the information in the recruitment questionnaire, most of the participants identified themselves as female. The age structure shows gaps among the younger cohort, which explains the later focus on intergenerational justice in the discussion among older people. Most participants came from Munich. Altogether, the participants represent the typical target group of a climate-related event organized by an environmental NGO like Klimaherbst (The German UNESCO Commission named the elderly and "socially disadvantaged children and young people" [78] as target groups that had not received enough attention in 2012, and several projects are trying to reach diverse target groups, such as [79]. We searched scientific databases without success for scientific sources for the typical characteristics of participants of ESD and climate communication events by NGOs, including the number of participants. The terms "NGO target groups AND climate AND NGOs AND Germany" and "target groups AND diverse AND extracurricular ESD" were used. However, the exchanges with stakeholders of ESD and climate justice reinforced the participants' characteristics outlined above and the number of participants as being typical.), with around 10 to 15 urban Germans interested in the topic and involved to a certain degree already (see Table A2 in the Appendix A) and tending to be higher-educated.

4. Results

In the following, we discuss the results of the empirical study in order to characterize the participants' perceptions of the City Walk. According to the two research questions, the results are structured into a first part answering the first research question, and into a second part with answers for the second research question.

4.1. Perception of the Framing on 'Climate Justice' and Related Climate Emotions

On the cognitive level, the initial discussion was about different dimensions of climate justice and the shared perception of a lack of adequate policies on climate action between the participants. The latter resonated differently with them on the emotional level. The results from the recruitment questionnaire reveal that even though the participants assess climate action as very important beforehand, different interpretations of the term "climate justice" appeared during the initial group discussion. In the beginning, the group discussed the global impacts of climate change—possibly to establish a common set of values and mutual assurance as a basis for further discussions on the social level. Building on that common understanding, the local impacts were picked up by the participants during the City Walk.

The participants' perceptions on climate justice resonated strongly with distributive justice [1]. In particular, those who were professionally or privately involved in tackling the climate crisis emphasized the need to combine theoretical scientific knowledge with social justice in practice (P. 12, 36 and P. 11, 37) (In the following, a person's contribution in the group discussions is assigned to a page in its transcript with "(P. [no.], [page number])", or in the running text with "P. [no.] [text] ([page number])". With the capital "P" for "Participant" and given that the transcript's pages start with page 36 and are in round parentheses, they cannot be mixed up with the participant's numbers (n = 14) and the references in square parentheses. Statements from the recruitment and feedback questionnaire do not have page numbers. The discussions at the stations were not transcribed.) on both the global and local level. Only two people were not yet familiar with the term "climate justice" at all. Once again, the global dimension was mentioned first, in the form of global injustices regarding fossil fuel emissions and the resilience to extreme weather events of nations and individuals [1]:

> *"Climate change, the big picture: [. . .] There are people, especially in the Global South, who are more affected by it".* (P. 7, 39)

Furthermore, the term was connected closely to the participants' reflection on their own privileges living in Munich in the Global North, in the so-called "rich bubble" (P. 7, 39) that most people considered themselves part of. This context was stressed through comparison with a location in the Global South:

> *"The growing areas in the Global South, [...] [have] suffered greatly from the droughts. [...] We just get [...] the grain 50% more expensive. But they [meaning the people living in those areas] suffer so badly that they can no longer feed their children because [they] have no money to buy any food".* (P. 6, 39 and 40)

P. 7 emphasized in the questionnaire that "compared to the global South", the climate crisis has had less impact in Munich, which P. 12 confirmed (41). Coming to the individual [1] and local level, poverty and homelessness were cited as decisive factors for how individuals and cities deal with the consequences of the climate crisis (P. 6 and P. 10, 40; P.11, 41). Heat was already discussed here as an example, even before the associated station (P. 11 and P. 12, 41), and was also mentioned most frequently in the recruitment questionnaire. The increase in other extreme weather events, such as drought or heavy rainfall, which affect fewer people locally in a direct way, was mentioned less frequently.

The role of privileges was also discussed in terms of climate action. Here, the importance of financial resources was stressed—in relation to climate-friendly technologies such as electric vehicles (P. 14, 42), but also in relation to people's carbon footprint:

> *"Poverty is already a contribution to climate change mitigation".* (P.11, 41)

In addition, the role of justice between generations [1] (P. 1 and P. 13, 38; P. 11, 37) was addressed. Concern was expressed about "the environmental conditions we are leaving behind for future generations" [80]—thus, the sample is very much in line with the general German public (ibid.).

In summary, all three sub-aspects of distributive justice [1] were discussed by the participants in the initial discussion. All but one person agreed with the statement, "I feel the consequences of the climate crisis are socially unjust", in the recruitment questionnaire.

On the emotional level, the perceived lack of adequate policies on climate action (P. 3, 37) resonated differently with the participants' attitudes and behaviors, as the initial discussion and the recruitment questionnaire showed. Most participants talked openly about their own climate emotions and identified themselves with the climate animals.

Anger was the climate emotion most people expressed in the discussion:

> *"Nothing is happening, and politicians are not taking the steps that are urgently needed".* (P. 6, 37 and cf. P. 3, 37)

Anger was much more prevalent than fear, anxiety, or sadness. Anxiety was addressed by two participants in the context of mental health [81], especially by P. 10, who linked her depression to the difficulty of finding a personal way of dealing with the climate crisis (37). P. 13 mentioned a "psychological burden" when asked about points of contact with the climate crisis in everyday life. P. 14, on the other hand, emphasized the following: "We only have one chance. Everything else is ... fatal" (38). Two participants who are eager to engage more with the topic of climate action expressed their keen motivation to do that and their enjoyment in sharing their interest with other people (p. 14 and P. 15, 38). Others exhibited curiosity (P. 8, 37), partly out of professional interest (P. 3, 38; P. 3 and P. 5, 37). The older participants in particular expressed feelings of guilt about their own gap between problem awareness and action [18] vis-à-vis subsequent generations, which P. 13 formulated as follows:

> *"Yes, I've actually always been very apolitical. Climate change has really come into my consciousness in the last few years. I wasn't aware of the Club of Rome at all. I was still too young (. . .). I don't have any children, but I have two nephews, and I'd like them to have a world they like to live in".* (38)

In addition to guilt, anger is also closely connected to frustration about the lack of political implementation of climate action (P. 1 and P. 7, 36; P. 14, 38).

Pro-environmental behavior (PEB) [82] was mostly expressed in the group discussion through mentions of the "busy bee" climate animal (P. 2, 36; P. 12, P. 9, P. 5, and P. 6, 37) and references to climate change mitigation, while adaptation was rarely mentioned. Participants who had just started to engage with the topic (P. 8, P. 13, and P. 14) mostly discussed low-threshold measures to reduce their ecological footprint [80]. In contrast, participants who had been working or fighting for climate justice for a longer time concentrated (P. 11) on increasing their ecological handprint [80] through political commitment, their job, or conversations about the climate crisis (P. 1, P. 11, P. 9, P. 10).

In sum, participants' responses to the City Walk provided valuable insights for framing a constructive dialogue between scientific expertise and citizens, avoiding the focus on disaster narratives. The emphasis on climate justice, resulting from the collaboration with Klimaherbst (NGO), resonated strongly with participants across different levels of engagement. Discussions on injustices between nations and individuals were particularly notable among those with greater prior knowledge. The emotional emphasis on intergenerational justice has potential to inspire climate and science communication efforts, especially among older demographics. Furthermore, discussions on distributive and procedural justice (especially on lobbying and power imbalances) stimulated emotional responses. However, participants struggled to acknowledge diverse perspectives (e.g., climate-damaging behavior and lack of response to arguments on policy perfectionism).

The framing of reflections on climate crisis emotions created space for meaningful exchanges. Speakers not only presented as experts, but also shared their own climate experiences, making them more relatable to participants. Reflecting not only on personal emotions, but also on how climate feelings evolve over time, fostered mutual understanding among participants:

> *"[It] is also quite often the case that [...] at the beginning [...] you are a different animal. [...] For example, first [...] the meerkat, which is in a state of shock, first of all checks, oh, what's happening ... Then at some point you get angry and then at some point you become a busy bee".* (P. 6, 46)

On the other hand, not all climate emotions were equally shared by the participants. Some may have been uncomfortable sharing their own vulnerability associated with fear and sadness at the beginning of an event in an unfamiliar group and thus only ticked it in the recruitment questionnaire. Dealing with these feelings in relation to the climate crisis could, for example, be facilitated by the approach of looking at characters in movies or TV series and identifying with them in terms of people's own climate emotions [83].

To answer research question (1), it can be summarized that climate justice provides a helpful framing to talk about climate change, and to discuss different adaptation and mitigation measures on a local level. Addressing climate-related emotions adds an important layer to the discussion, helping bridge the gap from the global to the local level. However, the framing of climate justice and related climate emotions should be assessed as a starting point to deepen that connection.

4.2. Perceptions of the City Walk

The final discussion demonstrated that the participants had gained a differentiated understanding of the problems of climate change mitigation and adaptation during the City Walk on a local level—especially in comparison to their prior knowledge (initial discussion). Figure 2 summarizes these results, which are thoroughly discussed in the subsequent sections. Finally, the overall assessment of the format from the participants' perspective is discussed.

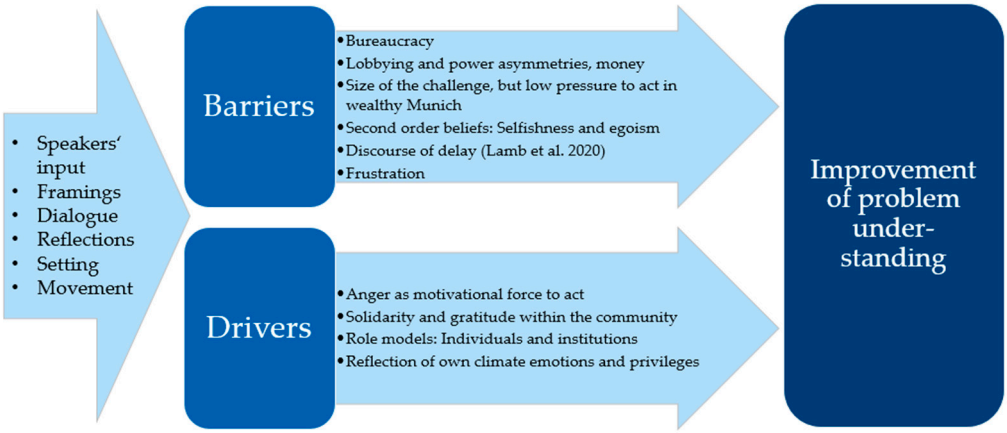

Figure 2. Own visualization structuring the key dimensions in the perception of the participants (reflecting the discourse of delay [84]).

4.2.1. Barriers

The speakers' input confronted the participants with the urgency of action at the local level and at the same time with the solutions that are actually on the table. Many of the participants responded with a reflection on the reasons for this contradiction. Bureaucratic hurdles and power imbalances, exemplified by a lawsuit initiated by a single person (against plans for a green 'super block' in a Munich neighborhood conceptualized as a living lab [64]), were noted. One participant criticized the influence of money, observing that "*money rules the world*". (P. 2, 45). Another expressed frustration, emphasizing that climate action is a marathon, not a sprint, and invoking the "slow turtle" climate animal [68]. The wealth of Munich and its resulting complacency emerged as a barrier, with some feeling that the city does not act, due to its affluence. However, others argued that many believe it is someone else's problem. This divergence highlights second-order beliefs about climate awareness.

Participants recognized the challenge of aligning others' attitudes with climate action, which was described by one participant as "like wading through treacle *to somehow get people on board with you*". (P. 9, 46). Discussing policy perfectionism, one participant stressed the need for global cooperation, noting that efforts in one country may be futile without global participation (P. 4, 38). Referring to the inaction of other countries, this statement of P. 4 supports the findings from Taddicken et al. [85], where German citizens rated climate change awareness in their own nation as being much higher than in the US and China (ibid.). Furthermore, participants described the selfishness and egoism (P. 5, 45; P. 6, 46; P. 1, 40; P. 10, 41; P. 14, 42) of others (e.g., frequent flyers), perceiving it as a barrier to climate action.

4.2.2. Drivers

Conversely, the anger aroused by some of the aforementioned barriers, as referenced by the "angry gorilla" [51] (P. 4, 45; P. 2, 46; P. 11, 47), can also be constructive. Opportunities for action highlighted by the event (P. 14, 38, feedback questionnaire) or a sense of solidarity resulting from distinguishing oneself through actions (41 and 42) can help "channel it [anger] into action" (P. 6, 46). Gratitude was also expressed for the organization of the event, the moderator, the speakers, and the interest shown by people with varying levels of prior knowledge (P. 5, 44; P. 10 and P. 9, 45; P. 6, 46; P. 7, 46; P. 3 and P. 8, 47; P. 13 in the feedback questionnaire). Role models, such as dedicated individuals (P. 10 and P. 9, 45; P. 11, 46), or institutions like those represented by the speakers and Klimaherbst (P. 7 and P. 11, 46), can also contribute to change. Another driver mentioned was reflecting on one's own climate emotions and privileges (see Section 3.2).

Some participants emphasized in the final discussion that their climate stance had not changed, while others reflected on the evolution of their own climate feelings in the context of political and social engagement, indicating a "change of consciousness" (P. 6, 46). However, this process takes time and cannot be substituted by a three-hour experience like a City Walk (P. 6, 46). Nevertheless, the latter can broaden horizons by enabling a change of perspective and dialogue (P. 4, feedback questionnaire) for participants like P. 4, who had indicated limited prior knowledge in the recruitment questionnaire: "It would actually be so easy to change something, but then it is somehow made so difficult" (P. 4, 44).

4.2.3. Strength of the Format from the Perspectives of Participants

The feedback questionnaire sent out by the practitioners (Klimaherbst) showed that the participants rated the event as very good, especially the design of the knowledge transfer and the exchange with others. The "interactivity" (P. 11) and the instructive and multi-faceted design were perceived to have made the event accessible and easy to understand for non-specialists (P. 7). P. 8 mentioned the learning location of the neighborhood in the feedback questionnaire, summarizing the strengths of the format ("No boring, dull lecture—but discussions and interesting conversations outdoors").

Revealing the connections of extreme weather events like flooding and heat to people's daily lives can be perceived as an unexpected, irritating disruption [45] and reduced the psychological distance participants felt toward the climate crisis [86].

By connecting local stakeholders and members of civil society with an interest in the topic, the City Walk brought together groups outside the academic world to discuss the practical topic of local climate change adaptation. The speakers' strength consisted of telling stories about barriers and successes from the field and providing scientific information in that context. Their knowledge on the factual level stems from their scientific background but is applied through their field of work in local practices. Combining this knowledge with the participants' personal experiences with extreme weather events in Germany makes it relatable and more tangible and thus a good basis for dialogue.

Without the speakers' input and the ensuing discussions, some of the participants would not have had an opinion on local climate adaptation, due to a lack of awareness and/or knowledge about the topic compared to climate change in general. On a very

small scale, sending the statement below to the City of Munich added another stakeholder, expanding the transdisciplinarity.

In terms of empowerment to act [46], the event "can be a contribution" (P. 5, 45) to what needs to be done (ibid.). P. 13 specified in the feedback questionnaire that she felt "encouraged [...] [to] keep at it and remain active in [...] [her] environment". By showing them places, ways, and institutions where and through which they can get involved, the participants can perceive themselves as actors at the local level. Going beyond reducing their own personal footprint by getting active politically in any way can be the second step. But first, they need to overcome the demarcation of others as being the active persons, the role models, but not them personally (P. 9, 46; P. 2, 36) [87,88]. Exchanging thoughts and feelings with other participants on their engagement, and seeing their struggles, including on the level of mental health (P. 10), could encourage participants who are not involved that deeply to engage more and empower them to act [46]. At the same time, it can strengthen the resilience of those active, as P. 11 stresses: "For me, it's always very, very good to be at such events" (P. 11, 46). To summarize, the setup of the City Walk in the participants' neighborhood in combination with the speakers' input enabled transdisciplinary dialogue-oriented science communication.

5. Critical Discussion

The results set out above suggest opportunities for this City Walk and similar approaches in other settings. The main limitation of the employed empirical methodology and the respective exemplary case (City Walk in Munich) is the small sample size [76], meaning that only two group discussions were conducted for a single target group in the affluent city of Munich in the Global North. This decreases the potential for the results' transferability to other contexts [75]. To address this methodological weakness, City Walks could be implemented and studied in diverse cultural and social contexts, aiming for a broader and diversified sample. Additionally, quantitative surveys based on this study's explorative findings could test to what extent the results are generalizable. Individual qualitative interviews could analyze changes in the experts' perceptions and the format's pitfalls and benefits.

In the case of the City Walk showcased here, the NGO "Klimaherbst" helped formulate participants' opinions into demands to the City of Munich. Klimaherbst summarized them as follows:

> *"Munich must fulfil its responsibility as a rich city and support poor people in the city with climate adaptation!".* [60]

The statement was passed on to the City of Munich and communicated to the participants in a follow-up email. The City Walk gave them the opportunity to have their voice heard on the issue of local, just climate change adaptation. This process highlights benefits of the transdisciplinary approach of combining the event of a City Walk with academic research. Yavo-Ayalon et al., for instance, created a "draft of a community resiliency plan based on the creative ideas and strategies discussed by the community" [39], which was passed on to the participants and local authorities as a way of kicking off a formal community resiliency plan.

Regarding climate emotions and their significance for people's ecological footprint and handprint, many other aspects would be of additional academic interest, such as the scientific validation and further development of the climate animals or a typification [89] of different phases of climate awareness based on the "five German states of the climate crisis" [90]. Building on knowledge, attitude, and action in each phase, type-specific measures for climate communication and ESD could be developed. Further analysis could be carried out on the motivating function of role models (for example, in relation to avoiding air travel [91]), and on how positive emotions like gratitude (P. 10 and P. 13, 46) can mitigate negative climate emotions [34] and climate anxiety (P. 13, recruitment questionnaire and P. 10, 37).

Especially for people who have been working intensively on the overburdening of planetary boundaries for a long time, either professionally, such as P. 3, P. 5, P. 6, P. 7, and P. 11, or in their political commitment like P. 1 and P. 10, engagement in the current highly emotional discourse can be "very, very exhausting" (P. 6, 46). Referring to SDG 5 (Health and wellbeing), it therefore makes sense to invest in the mental health of climate-active and climate-interested people.

Despite their limitations, the results of this study are consequently relevant to both academia and the stakeholders of climate and science communication and ESD. This study also suggests opportunities for adapting the format to neighboring framings and issues (such as food, transportation, and consumption) and for upscaling the format. The training of climate scientists as science communicators would also be desirable. Additionally, regional multipliers and scientifically informed experts (such as the speakers in this walk) could provide very valuable (knowledge) resources. Moreover, offering the event to employees as in the Climate Puzzle [92] or in different languages could also help attract people from more diverse cultural backgrounds.

6. Conclusions

This study uses a qualitative focus group discussion to generate exploratory results in a newly developed format for climate communication and education. The framing of a dialogue on different aspects of climate justice [1] helped all the actors involved—NGOs, scientists, experts from local stakeholders, and participants—to share their climate emotions [27] on topics such as intergenerational justice. In contrast to the paralyzing disaster framing [10]—often characteristic of expert explanations—the climate emotions of anger, hope, joy, and gratitude were strengthened in some participants through the event.

In summary, the setup of the City Walk in the participants' neighborhood in combination with the experts' involvement enabled transdisciplinary dialogue-oriented science communication. The results resemble those of Yavo-Ayalon et al. [39], who found a closer connectedness through feelings in the participants who had gained awareness about the here and now of the climate crisis and its relationship to their community. Thus, "bringing climate change closer to home" (ibid.), to "the doorstep" [59] of people's familiar neighborhood, can be the irritating disruption necessary for transformation [45].

The crucial point is not whether the shift from climate change being a general topic to a personal one is supported by virtual reality [39], local experts, or other creative learning environments and climate communication formats: that it occurs is more important than the how of the disruption. As such, the journey may vary; it is the destination that we should focus on.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. There was no research ethics approval, as the empirical study and the conception of the City Walk are part of a Bachelor Thesis. However, all participants confirmed the voluntary nature of their contribution, which was in line with the European Data Protection Regulation.

Data Availability Statement: Data are available in a publicly accessible repository. The data presented in this study are openly available in OSF (https://osf.io/6shmy/?view_only=3c9bb07eb3bb46c8a8cdbca598df6310, accessed on 14 March 2024) at https://doi.org/10.17605/OSF.IO/6SHMY.

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Appendix A

The following documents will be available online on ORCID OFS (https://osf.io/6shmy/?view_only=3c9bb07eb3bb46c8a8cdbca598df6310 with https://doi.org/10.17605/OSF.IO/6SHMY) to download:

- German transcript of the group discussions;
- Pictures and English description of the climate animals;
- German discussion guide;
- German schedule of the City Walk;
- Detailed information on the City Walk and the questionnaires in English;
- German recruitment questionnaire;
- German feedback questionnaire from Klimaherbst.

Table A1. The participants' demographic background: age, gender, education, first language, and place of residence.

Age	18–25	26–40	41–65	Over 65	Missing
Gender	1 Female	6 Male	3 Other	2 -	2
Formal education	7 High school degree	3 Vocational training	0 University degree	-	4
First language	2 German	3 -	8 -	-	1
Place of residence	11 Untergiesing-Harlaching	Adjacent neighborhoods	Bavaria	-	3
	4	5	4		1

Table A2. Contextual information on the participants.

ID	Gender	Level of Professional and Personal Involvement	Initial Animal Selected	Final Animal Selected	Other Relevant Attributes
1	Female	Protests (Extinction Rebellion), sustainable consumption	Mixture		Retired, left after Station 1
2	Missing	Sustainable consumption, protests	Slow turtle and angry gorilla	Slow turtle and angry gorilla	
3	Female	Works for a climate NGO, sustainable consumption, volunteering as a (sustainable) City Walk guide	Angry gorilla	Busy bee	
4	Male	None	Shocked meerkat	Angry gorilla and shocked meerkat	
5	Male	Speaker from the local water management office, sustainable consumption	Busy bee	Angry gorilla	
6	Female	Speaker from the Greening Office (Green City)	Busy bee and angry gorilla	Busy bee and angry gorilla	
7	Missing	Works in solar energy, studies engineering ecology	Angry gorilla	Angry gorilla	
8	Missing	None	Busy bee	Busy bee	

Table A2. *Cont.*

ID	Gender	Level of Professional and Personal Involvement	Initial Animal Selected	Final Animal Selected	Other Relevant Attributes
9	Male	Works in the automotive industry, sustainable consumption, protests (Fridays For Future)	Slow turtle	Slow turtle	
10	Female	Protests (Fridays For Future), Health For Future, food bank, sustainable consumption	Startled chicken	Mixture	Sees her depression as connected to the climate crisis
11	Missing	Works for an environmental NGO in ESD, activism	Angry gorilla	Angry gorilla, but happier	
12	Female	Studies engineering ecology, sustainable consumption, protests	Shocked meerkat		Mentions psychological (climate) stress, left after Station 2
13	Female	Sustainable consumption, protests	Busy bee		Left after Station 2
14	Female	Sustainable consumption	Busy bee		Left after Station 2

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Identifying Different Semantic Features of Public Engagement with Climate Change NGOs Using Semantic Network Analysis

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Abstract: Social media platforms have revolutionized the engagement between climate non-governmental organizations (hereafter, NGOs) and their publics on climate issues. This research diverges from the traditional use of metrics like retweets and likes as simple indicators of identical success in 'one-way' climate communication. Instead, it underscores 'two-way' interactions and their connections that may vary by specific public engagement features, such as popularity, commitment, and virality. Using semantic network analysis, we analyzed tweets and replies between high-engagement NGOs and their publics, identifying communication patterns tied to particular types of public engagement. Additionally, we investigated shared meanings in these interactions with semantic similarity metrics and assessed sentiment alignment between NGOs and their publics as potential indicators of public engagement. Our findings suggest that climate NGOs should select resonating topics, ensuring their sentiments align with those of their publics. It's also essential to tailor topics and focus points in climate communication strategies to reflect desired types of public engagement. This study offers insights into optimizing communication and engagement strategies for climate NGOs on social media.

Keywords: public engagement on social media; strategic social media communication; climate change; climate NGOs; semantic network analysis; semantic similarity

1. Introduction

The landscape of information dissemination and accessibility has undergone a profound transformation with the advent of social media, exerting a significant influence on public discourse and engagement across socio-cultural, political, and policy domains [1,2]. Ranging from simple likes, shares, and brief comments easily accessible to a range of public audiences [3] to profound discussions taking place within topic-oriented communities on social media platforms [4–6], these cost-effective communication tools empower activists and ordinary individuals to readily participate in discussions concerning various issues, thereby amplifying their voices effectively. With this influence, social media serves as a conduit for both online and offline activism, mobilizing 'non-expert publics' (hereafter, 'publics') (In current research, the term 'non-expert publics' refers to non-expert individuals who recognize a problem or opportunity, and take action to address it (in this case, climate change), as well as those who have built or can build relationships with relevant organizations (in this case, organizations active on climate change) [7–10]) and advocating for climate policies [11–14].

Among the paramount concerns that have garnered substantial traction on social media is the predicament of climate change—an issue of utmost significance confronting our global landscape. According to the 2018 United Nations' Intergovernmental Panel on Climate Change (IPCC) report, countries worldwide are not doing enough to limit CO_2 emissions. The report highlights the urgent need to reduce global emissions by 45 percent

by 2030 compared to 2010 levels [15]. Additionally, the IPCC, established in 1988, has consistently emphasized the severity of our current inaction and the future consequences of climate change [16,17]. In this context, social media serves as a means to express concerns about prominent climate change issues (e.g., extreme weather), share pertinent information, engage in discussions about climate science, and participate in climate politics [18].

Numerous non-governmental organizations (hereafter NGOs) are actively involved in advocating for climate change-related concerns, connecting global audiences and translating complex climate science for a range of public audiences [19]. Some climate change NGOs have been operating since the 1970s, with notable examples such as Greenpeace, which has been instrumental in influencing national and international discussions on environmental matters, including deforestation, since its establishment in 1971. For these NGOs, social media platforms have been valuable tools to address their diverse communication goals despite limited resources [20]. Specifically, social media has been identified as a crucial tool for climate-focused NGOs, enabling them to establish a direct information flow to a range of public audiences about climate issues, attract widespread media coverage, appeal to both internal and external audiences to take action on these issues, and establish direct communication channels with policymakers [19,21].

While the significance of social media for climate NGOs—key communicators on climate issues—has been acknowledged, we contend that there is a need for further exploration into the dynamics of engagement between these NGOs and their target audiences. While online platforms have been recognized as a means for deliberate scientific discourse with a range of public audiences [5], and dialogic two-way communication between NGOs and their audiences has been advocated for better engagement [22], existing research has primarily concentrated on the content and manner in which NGOs address climate change matters on social media, within one-way communication framework. This framework assumes that NGOs exert a unidirectional influence on publics, often relying on the metrics of public engagement on social media (e.g., number of likes) as the solo indicator of communicational success. In essence, there has been limited investigation into how various stakeholders, particularly publics, engage in discussions with climate NGOs, and consequently, there is a dearth of understanding regarding the organizations' communication strategies and how these strategies relate to these interactions.

In light of the existing research gap, this study challenges conventional public engagement metrics on social media in two ways. First, it questions the notion that *popularity*, *commitment*, and *virality*, which are gauged through metrics such as likes, replies, and shares [23], should be considered indicators reflecting the identical success of communication strategies, as each type of public engagement may be linked to distinct aspects of interactions between the organization and its corresponding audiences [24]. Second, to gain a comprehensive understanding of 'public engagement', it advocates for an exploration not only of communications from the organization, but also of dialogues between the organizations and their publics, thus shedding light on the discourses facilitated by publics.

Therefore, guided by the two-way communication approach, our objective was to investigate the distinct characteristics of discussions related to climate change, with a particular focus on the themes and focal points in conversations initiated by both climate NGOs and publics across various types of public engagement on social media. Using semantic network analysis (SNA), we uncovered distinctive patterns and conversation themes between organizations and their audiences, which reflect the specific types of public engagement on social media platforms. Additionally, our study explored the extent to which these organizations and their specific target audiences maintain alignment in the subjects and central themes of their conversations across these different modes of engagement. This was accomplished through an analysis of the semantic similarity between the discourses of the organizations and their respective publics. We also examined the emotional alignments between organizations and their publics, as it could offer valuable insights into effective social media strategies. Through these explorations, this study enhances our understanding of the dynamics at play in the 'two-way' interactions between

climate NGOs and their respective audiences and improves social media communication strategies tailored to the distinct engagement objectives of each organization.

2. Literature Review

2.1. Climate Change Communication on Social Media

Climate change has been a hot topic on social media, as media attention and civil society mobilization concerning the issue has been manifested in these channels [25]. This is especially true among younger generations, such as Gen Z, as they are actively being exposed to social media posts on climate actions and engaging with social media content on climate actions [13]. The prevalence of climate change discourse on social media has prompted researchers to investigate the themes and focuses of public discussions on this subject. Previous studies have explored the various topics and issues that publics addresses when discussing climate change on social media platforms [18,26]. These investigations have provided insights into the prevalent concerns, interests, and perspectives of social media users regarding climate change. By examining the themes and focuses of public discourse, we aimed to understand public engagement with climate change and the information that circulates through social media channels.

2.2. Engagement with Publics

Engaging publics with an issue through relevant organizations is considered crucial in the fields of science communication and public relations. In those fields of communications, such engagement motivates publics to build a favorable relationship with the organizations and actively seek out the necessary information, such as climate science, to make informed decisions [27–29]. From the perspective of science communication, it is a scientific responsibility [5]. More specifically, the concept of public engagement with science (PES) argues that interactive engagement among scientists, stakeholders, and publics, driven by meaningful dialogue regarding scientific issues, allows publics to play an active role in scientific decision-making and producing social impacts [30]. From the perspective of public relations, engagement with publics and stakeholders has been understood as "part of dialogue and through engagement, organizations and publics can make decisions that create social capital" [22] (p. 384), which was considered as an orientation to ethical communication [27].

In both communication fields, communication between experts, relevant organizations, and publics are essential for engagement. Consequently, social media has emerged as a pivotal tool, facilitating direct 'two-way' communication between scientists or pertinent organizations and an array of public audiences [27,31]. However, prior studies focusing on climate NGOs' social media presence have predominantly emphasized a 'one-way' communication from these organizations. For instance, a study analyzed the framing of social media posts by 298 global climate NGOs, suggesting that these strategic messages could influence public perceptions and behaviors concerning climate change and engagement [19]. Similarly, another study spotlighted the 'one-way' communication strategies of environmental NGOs, investigating their campaigns that challenge the sustainability of corporate actions [32].

Studies concentrating on the communicative interactions between organizations and publics often hone in on publics' social media engagement metrics, such as views, likes, and shares [23,24,27]. This scope, however, scarcely encapsulates the richness of dialogic interactions and the evolution of public discussions on climate change issues on social media (e.g., "What issues do publics want to discuss with climate organizations?"). Thus, the specific themes and focal points of communication between organizations and publics have not been extensively researched. Addressing this gap, Comfort and Hester posited that merely reaching a broad audience might not be an adequate measure of a climate NGO's social media messaging success [33]. They proposed three alternative metrics, including topic and valence (i.e., whether publics aligns with and supports the topics NGOs champion). Building on Comfort and Hester's insights, we venture beyond mere

publics' social media engagement metrics to explore the nature of conversations initiated by both climate NGOs and their audiences.

2.3. Why Climate NGOs?

NGOs have adeptly employed public relations strategies to communicate their agendas and issues effectively with publics [34,35]. In this digital age, social media stands as an indispensable platform for NGOs, not only to elevate public consciousness about their causes but also to engage meaningfully with stakeholders. Specifically for climate NGOs, these platforms bridge the gap between scientists and the wider public, demystifying scientific research into actionable steps and galvanizing both governmental and individual action [19].

Climate change, although globally pressing [36], represents a multifaceted challenge intricately intertwined with climate science, politics, and socio-cultural dynamics. Moreover, key stakeholders in climate change—from scientists and activists to everyday citizens—may possess varying levels of perceptions, knowledge, and action plans regarding the subject [37,38]. In this context, to harness the full potential of social media, climate NGOs need to craft strategies that both simplify scientific research and resonate with public concerns, tailored to their target audiences and the core missions of their organizations [34]. In essence, it is paramount for climate NGOs to identify mutual concerns with public audiences, align with their understandings of key topics, and strategically relate prominent issues to their established frames [19,33].

Effective communication with the broader public is paramount for climate NGOs, enabling the transformation of scientific knowledge into actionable public engagement. Eschewing the narrow scope of public engagement metrics as the sole evaluative tool, we aim to scrutinize how high-engagement, in terms of popularity, commitment, and virality, climate NGOs and their publics interact on social media platforms, identifying central themes, focuses, and the features of communication.

As part of our exploratory investigation, we also examined whether the "shared meaning" between the discourses of these two parties is associated with public engagement, as argued by Taylor and Kent [39]. To measure this shared meaning between climate NGOs and their publics, we utilized semantic similarity observed in their discourses (i.e., posts from the NGOs compared to corresponding replies), following the approach outlined by Cann et al [40]. They proposed that the alignment between organizational communication and target audiences' communication, identified through semantic similarity, serves as an outcome of effective strategic communication.

Additionally, we investigated which climate NGOs achieved sentiment alignment between their organizational messages and the associated responses from their publics, using this as a potential indicator of public engagement on social media. In a previous study [41], researchers found that in the context of vaccination, information flow on social media was more frequently observed between individuals who shared the same sentiments, while the flow between individuals with differing sentiments were less frequent. Similarly, exploring sentiment [mis]alignment between the climate NGO and its public may provide valuable insights into how these groups incorporate shared or divergent issues and opinions in their communication and disseminate information, a crucial aspect of public engagement [42]. Consequently, this approach may serve as a potential metric for assessing shared interests and perspectives on contemporary climate issues.

The following research questions guide this study:

- RQ1: How did publics engage with climate NGOs' social media accounts, in terms of public engagement metrics (i.e., *popularity*, *commitment*, *virality*)?
- RQ2: What are the relationships between (a) public engagement on social media and (b) the shared meaning between tweets from the climate NGOs and the corresponding public replies, as measured by semantic similarity (e.g., Euclidean Distance, Levenshtein Distance)?

- RQ3: Which climate NGOs achieved sentiment alignment between their organizational posts and the corresponding replies they received?

As part of our exploratory investigation, we further analyzed three climate NGOs—(a) Greenpeace USA (hereafter GPU), (b) Climate Central, (c) Environmental Defense Fund (hereafter EDF)—that exhibited the highest public engagement scores, in terms of *popularity*, *commitment*, and *virality*, among our sampled 10 climate NGOs. These organizations also demonstrated alignment in sentiments with their respective publics. This analysis aimed to identify the particular characteristics of each type of public engagement with the following research question:

- RQ4-1: What are the primary themes and focal points observed in the social media communication conducted by (a) GPU and (b) its corresponding publics, which reflect the characteristics of *popularity*?
- RQ4-2: What are the primary themes and focal points observed in the social media communication conducted by (a) Climate Central and (b) its corresponding publics, which reflect the characteristics of *commitment*?
- RQ4-3: What are the primary themes and focal points observed in the social media communication conducted by (a) EDF and (b) its corresponding publics, which reflect the characteristics of *virality*?

3. Materials and Methods

To measure public engagement with the climate NGOs on social media, we adopted and revised three public engagement measures with organizational social media accounts from Bonsón and Ratkai [43] and Haro-de-Rosario et al. [23] (i.e., citizen engagement): *popularity* (i.e., popularity of messages [from the climate NGOs] in public engagement); *commitment* (i.e., commitment of public in the communication with the climate NGOs); and *virality* (i.e., virality of messages among publics' communication). More specifically, popularity measures the frequency of affective reactions from the public to social media messages, while commitment indicates a higher and more sustained level of engagement [44]. Virality represents the breadth of a message's reach [44]. The three dimensions of public engagement have been operationalized as shown in Table 1.

Table 1. Public Engagement Measures (Adopted from Bonsón and Ratkai [43]).

Name	Formula	Measures
Popularity	Number of posts with likes/ total posts	Percentage of the total posts that have been liked
Commitment	Number of posts with comments/ total posts	Percentage of the total posts that have been commented on
Virality	Number of posts with shares/ total posts	Percentage of the total posts that have been shared

This study aimed to explore the relationships between (a) public engagement and (b) shared meaning between social media communications of climate NGOs and their corresponding public. To operationalize shared meaning within this research's context, we utilized semantic similarity metrics [40]. These metrics enable the identification of similarities between terms or texts that convey the same meaning, even if they do not exhibit lexical similarity [45]. More specifically, we used two semantic similarity metrics: (a) Euclidean distance and (b) Levenshtein distance. Euclidean distance is a measure calculating the straight-line distance between the corresponding coordinates of two points in a multidimensional space [46]. Within the context of assessing semantic similarity between two texts, it quantifies the distance between their vectorized representations in a multidimensional space, ranging from 0 to positive infinity [47]. Levenshtein distance is a measurement for quantifying the dissimilarity between two strings, which calculates the number of single-character edits (e.g., insertions, deletions, or substitutions) needed to

transform one string into another [48]. A lower score for the two measurements indicates a higher level of similarity between the two examined documents, possibly suggesting the presence of shared meaning as the organization and its public have common or at least similar themes or focal points in their discourses.

This study investigates the sentiment alignment between a climate NGO's tweets and the replies the organization received. To identify sentiment alignment, we conducted a correlation analysis between the trends of the organization's weekly sentiment score and the ones of the corresponding replies that we computed.

To identify the prevailing themes and focal points of climate NGOs' Twitter posts and following public discourses (represented in public audience replies to the climate NGOs), we used SNA. The method allowed us to identify key concepts—used by the NGOs and publics—and their interpretive contexts, by analyzing the significance of specific words based on their frequency and centrality measure values, as well as their co-occurrences and clustering patterns within the text [49,50]. In practice, previous studies have identified salient themes and frames within texts in various contexts, such as the ESG policies in sustainability reports of corporations, and publics' discussions on childhood vaccination and COVID-19 vaccines [49,51,52].

3.1. Data Collection

We collected Twitter posts (i.e., tweets) posted by ten climate-change NGOs and corresponding public replies that were sent to those organizations from 1 July 2020 to 30 June 2021. Twitter was selected as the representative social media platform for this research because it is suitable for organizations including climate NGOs to share information publicly and engage with publics [53–55]. This time range was selected to encompass various factors such as seasonal climate change issues (e.g., extreme weather conditions, flooding), U.S. national political or policy-making issues (e.g., presidential election, Keystone XL pipelines), and global climate change concerns [56]. The acquisition of Twitter data (i.e., tweets and replies) was accomplished by employing the data collection service offered by exportcomments.com (1 September 2023) [57], which enabled us to extract relevant data including the textual content of tweets and replies, the date and time of posting, the number of likes received by the post, and the number of retweets generated by the post.

The organizations were selected from a list of top NGOs working to stop climate change [58] and then screened based on (a) relevance of their posts to climate change issues and (b) comparable volumes of posts from their Twitter accounts. The finalized list of climate NGOs in this research and brief information about the accounts are available in Table 2.

Table 2. Brief Information about the 10 Climate Change NGO Twitter Accounts in this Research.

	Avg. # of Likes (Favorates)	**Avg. # of RTs**	**# of Followers ***	**# of Total Post ****	**# of Total Replies *****
1. CCL	30.30	22.18	41,080	1507	1338
2. Earthjustice	60.54	249.12	196,989	2556	3408
3. Greenpeace USA	61.62	188.23	213,165	2733	5058
4. EDF	15.68	325.57	207,210	2776	1757
5. Nature Conservancy	58.61	24.48	990,550	2163	3285
6. RAN	10.87	24.38	94,714	1816	633
7. Wilderness	24.08	102.61	102,317	1973	878
8. Saving Oceans	15.23	22.70	108,613	936	250
9. Skoll Foundation	5.79	33.80	445,747	1802	336
10. Climate Central	10.06	10.47	132,427	729	1519
Total			2,532,812	18,991	18,462

1 = Citizens' Climate Lobby (CCL) (@citizensclimate); 2 = @Earthjustice; 3 = @greenpeaceusa; 4 = Environmental Defense Fund (EDF) (@EnvDefenseFund); 5 = The Nature Conservancy (@nature_org); 6 = Rainforest Action Network (RAN) (@RAN); 7 = The Wilderness Society (@Wilderness); 8 = savingoceans (@savingoceans); 9 = @SkollFoundation; 10 = @ClimateCentral. * The number of followers as of 15 October 2021. ** The number of posts sampled in the research period. *** The number of replies to the organization in the research period.

3.2. Analytic Approach

For RQ1, we calculated the three public engagement metrics for each organization following the formulas suggested by Haro-de-Rosario et al. [23].

For RQ2 and subsequent research questions that involve sentiment analysis and SNA, we performed pre-processing on the textual content of organizational tweets and replies that we collected. More specifically, we removed URLs, stopwords, and non-contextual elements, which included punctuation and special characters, except for the '@' symbol used to indicate mentioned accounts. Additionally, we excluded Twitter function words such as 'replying to' to focus on the relevant content for our analysis. We then lemmatized and tokenized for each corpus (e.g., a group of tweets from an organization, a group of replies sent to an organization) using packages such as spaCy [59] and TextBlob [60] on Python.

For RQ2, we computed two semantic similarity metrics, namely Euclidean distance and Levenshtein distance, between each organization's corpus and its corresponding reply corpus. We utilized Scikit-learn [61] and scipy.spatial [62] libraries to calculate the semantic similarities for each organization. To assess the relationships between three types of public engagement and the two types of semantic similarity, we performed a correlation analysis.

To conduct sentiment analysis for RQ3, we employed the Azure sentiment analysis model, developed through Microsoft Azure machine learning (version: 5.2.0), to calculate weekly average sentiment scores [63]. The sentiment analysis model provides a "sentiment label" (positive, negative, neutral) along with a confidence score for each post, ranging from 0 (lower confidence) to 1 (higher confidence). Using the model, we identified sentiment label for each preprocessed tweet/reply. To quantify sentiments and compare changes within the two groups (i.e., tweets from an organization vs. replies to the organization), we devised a "weighted sentiment score" by assigning numeric values to sentiment labels (positive = 1, negative = -1, neutral = 0) and multiplying these values by the corresponding confidence score. Higher scores close to 1 indicated more significantly positive posts, while scores close to -1 indicated more significantly negative posts. Weekly sentiment scores were determined by calculating the average sentiment scores of tweets and replies published during each week. Next, we conducted an analysis to explore the correlations between the weekly sentiment score trends of an organization's posts and the corresponding replies. Our aim was to identify organizations that exhibited a significant and positive correlation, indicating their success in maintaining alignment with the sentiments expressed by the reply public.

To address RQ4, we employed SNA, which involves examining the structure of a semantic network constructed from a large volume of unstructured text datasets [64]. In this method, each word (e.g., 'climate', 'change') is treated as a node within a network, and the analysis focuses on the co-occurrences of these words [65]. These co-occurrences, such as the words 'climate' and 'change' appearing together in a single post, are counted as instances of co-occurrence. Representing the links between nodes, these co-occurrences are crucial for calculating closeness among words (i.e., nodes). SNA allows for a spatial representation of language structure, enabling the visual grasp of relationships between main concepts (e.g., 'climate change' in the current context) originating from specific terms and their connections to other concepts derived from different terms (e.g., 'conservation' or 'wildfire' in the current context) [65]. The visualization capability of SNA empowers researchers and professionals to uncover insights that might not be immediately apparent through traditional quantitative or qualitative analysis, thereby enhancing our understanding of complex and contextual information underlying the text.

Using the preprocessed text from the previous stage, which included tokenization, lemmatization, and the removal of stop words, we first extracted the most frequent words from the corpus and converted these into a list, annotating each with the frequency of its co-occurrence with other words (i.e., weight). For example, we created a link-list showing how often words like "change", "crisis", or "disaster" co-occurred with "climate" in the same post within the corpus of the NGO's posts or replies to the NGO. Subsequently,

employing NeTxt [66], we transformed the processed text and this annotated link-list into a network. In this network, the words serve as nodes, and their co-occurrences become the ties. As a result, we generated a semantic network for each corpus, resulting in six networks, each featuring the top 150 frequent words. For a more detailed step-by-step explanation, you may refer to Segev [66,67].

The generated semantic networks were then exported as weighted edge lists and converted to a format suitable for analysis in Gephi [68], using Python. Subsequently, we imported the data into Gephi to visualize and explore the networks further. Within Gephi, we conducted modularity analysis to identify distinct clusters or themes within each network and calculated various network statistical indicators, such as degree and eigenvector centrality, as outlined by Segev [66] and Luo et al. [69]. These measures helped us determine the importance and prominence of specific keywords within the networks.

4. Results

4.1. RQ1: Public Engagement Metrics

First, the results of our study provide insights into the public engagement on social media for each of the 10 climate NGOs included in our sample. In terms of follower count, Nature Conservancy leads the pack with an impressive 990,550 followers, followed by Skoll Foundation with 445,747 followers. However, GPU exhibits a high level of public response, generating the highest number of replies (5058). The organization also showcases the highest levels of popularity (GPU: 61.62), measured by the average number of likes per post. Notably, Climate Central and GPU stand out in terms of commitment, with commitment scores of 2.08 and 1.85, respectively. Finally, for virality, EDF achieves the highest average number of retweets (325.57), followed by Earth Justice (249.12). See Table 3 for overview.

Table 3. Public Engagement Scores for Each NGO's Twitter Accounts and their Semantic Similarity Scores with Publics' Replies.

	Popularity	Commitment	Virality	Euclidean	Levenshtein
1. CCL	30.3	0.89	22.18	983.11	174,258
2. Earthjustice	60.54	1.33	249.12	1583.78	357,155
3. Greenpeace USA	61.62	1.85	188.23	1326.76	252,773
4. EDF	15.68	0.63	325.57	1583.77	256,464
5. Nature Conservancy	58.61	1.52	24.48	1436.28	331,862
6. RAN	10.87	0.35	24.38	957.85	159,422
7. Wilderness	24.08	0.45	102.61	959.66	182,587
8. Saving Oceans	15.23	0.27	22.7	554.34	86,867
9. Skoll Foundation	5.79	0.19	33.8	1054.25	188,157
10. Climate Central	10.06	2.08	10.47	506.59	75,228

1 = Citizens' Climate Lobby (CCL) (@citizensclimate); 2 = @Earthjustice; 3 = @greenpeaceusa; 4 = Environmental Defense Fund (EDF) (@EnvDefenseFund); 5 = The Nature Conservancy (@nature_org); 6 = Rainforest Action Network (RAN) (@RAN); 7 = The Wilderness Society (@Wilderness); 8 = savingoceans (@savingoceans); 9 = @SkollFoundation; 10 = @ClimateCentral.

4.2. RQ2: Public Engagement on Social Media and Shared Meaning

Second, to investigate the potential relationships between public engagement and the level of shared meaning between a climate NGO and its audiences, we conducted a study analyzing the correlations between public engagement metrics and semantic similarities. In order to assess the extent of shared meaning, we used two semantic similarities measures: Euclidean distance and Levenshtein distance. As shown in Table 4, only two pairs of measures displayed significant positive correlations. Specifically, the correlation between popularity and Levenshtein distance was (0.760 *), and the correlation between virality and Euclidean distance was (0.729 *). These findings suggest that higher levels of public engagement, as measured by popularity and virality, may be associated with a decrease in shared meaning between the climate NGO and its audiences.

Table 4. Correlations between Engagement Measures and Semantic Similarity Measures.

		Popularity	Commitment	Virality	Euclidean Distance	Levenshtein Distance
Popularity	Pearson Correlation	1	0.580	0.342	0.583	0.760 *
	Sig. (2-tailed)		0.079	0.333	0.077	0.011
Commitment	Pearson Correlation		1	0.103	0.462	0.530
	Sig. (2-tailed)			0.778	0.179	0.115
Virality	Pearson Correlation			1	0.729 *	0.552
	Sig. (2-tailed)				0.017	0.098
Euclidean Distance	Pearson Correlation				1	0.931 **
	Sig. (2-tailed)					<0.001
Levenshtein Distance	Pearson Correlation					1
	Sig. (2-tailed)					

Note: * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Third, we conducted an analysis to examine the sentiment alignment between organizational posts and the corresponding replies they received. Based on the assertion that aligned sentiments on social media are indicative of shared interests or attention towards specific issues, as well as the strategic incorporation of publics' agendas and concerns [42], our objective was to investigate the potential connections between sentiment alignment and public engagement driven by shared perspectives on these issues. Among the organizations included in the analysis, three organizations showed a significant positive correlations with weekly sentiment scores of their respective organizations' posts and the corresponding replies: GPU (r = 0.322, p = 0.019), EDF (r = 0.320, p = 0.019), and Climate Central (r = 0.389, p = 0.004). Notably, these organizations also received top scores in terms of public engagement metrics as discussed above. These findings suggest that these organizations not only effectively maintained alignment with their audience in terms of sentiment but also achieved successful public engagement (see Table 5 for overview).

Table 5. Pearson's Correlations of Weekly Sentiment Scores between Posts from Organizations and Replies Sent to the Organizations.

	Pearson	Sig. (2-Tailed)
1: Citizens' Climate Lobby	−0.212	0.132
2: Earthjustice	−0.029	0.836
3: GPU	0.322	0.019
4: EDF	0.320	0.019
5: The Nature Conservancy	−0.114	0.417
6: RAN	0.003	0.984
7: The Wilderness Society	0.243	0.080
8: Saving Oceans	0.137	0.342
9: Skoll Foundation	−0.035	0.808
10: Climate Central	0.389	0.004

Note: Pairwise dropped.

4.3. RQ4: Central Themes and Focuses

To address RQ4, we selected a total of three organizational accounts (GPU, Climate Central, and EDF) to explore the central themes and focuses of the discourses facilitated by these organizations and their publics with SNA. In addition to the commonly used public engagement measures (e.g., the number of retweets), which often fail to capture the emergence, convergence, or divergence of themes and focal points within discussions between organizations and their publics, this approach may offer a more insightful and

holistic view of public engagement in this exploratory study. With the focus, we sampled three climate NGOs: high popularity: GPU; (b) high commitment: Climate Central; (c) high virality: EDF. Then, we identified and compared the key concepts (i.e., words), themes, and focal points between organizational tweets and the corresponding replies, based on (a) the centrality of words, (b) the associations between two words, and (c) the clusters of words within the network [70].

4.3.1. Greenpeace USA (GPU): High Popularity

The keywords with the highest degrees in GPU tweets are "nature" (degree = 1897), "new" (degree = 1202), and "climate" (degree = 995). In the replies, the top keywords include "climate" (degree = 658), "fossil" (degree = 585), and "fuel" (degree = 475) (Table 6).

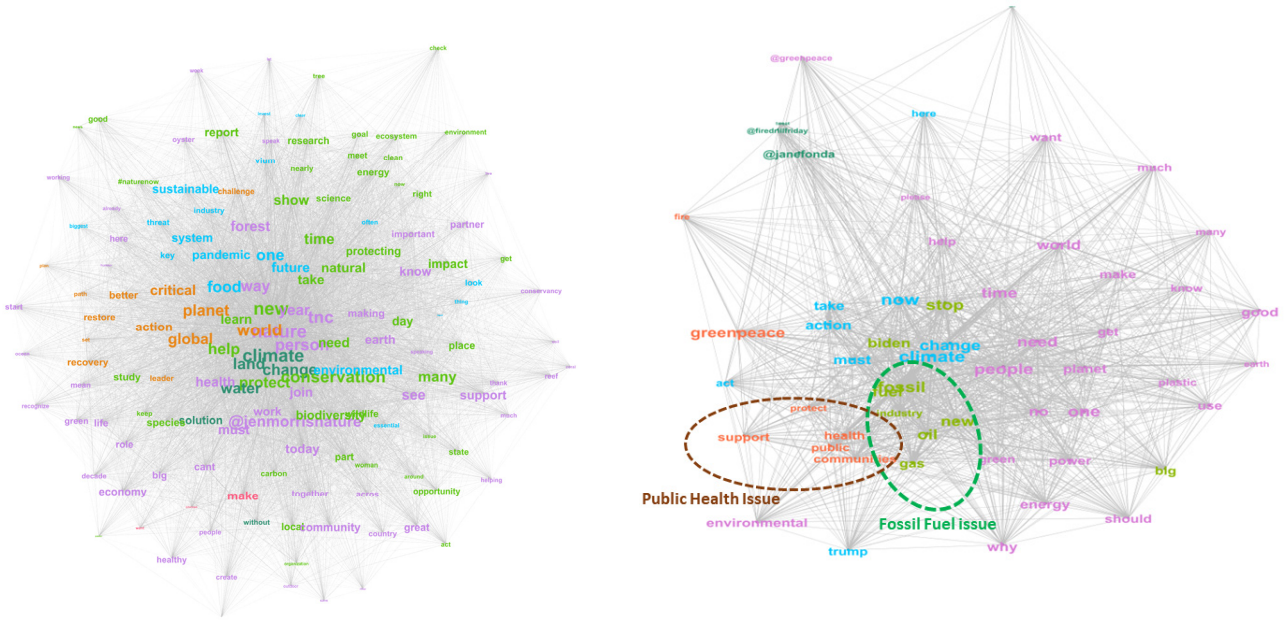
Table 6. Top Key Words by Degree of Tweets from GPU and Replies Sent to GPU.

Tweets from GPU				Replies Sent to GPU		
Word	**Degree**	**Eigenvector**	**Rank**	**Word**	**Degree**	**Eigenvector**
nature	1897	0.376	1	climate	658	0.337
new	1202	0.248	2	fossil	585	0.412
climate	995	0.225	3	fuel	475	0.378
world	840	0.184	4	people	453	0.191
food	781	0.164	5	oil	410	0.213
person	767	0.178	6	now	343	0.171
tnc	681	0.144	7	change	322	0.222
protect	669	0.149	8	need	322	0.146
change	656	0.161	9	new	289	0.171
planet	605	0.126	10	must	282	0.165
conservation	604	0.119	11	stop	267	0.151
future	598	0.131	12	health	248	0.153
global	581	0.129	13	action	240	0.149
way	562	0.125	14	public	235	0.145
land	557	0.128	15	take	226	0.135
one	550	0.113	16	no	220	0.109
year	543	0.130	17	gas	217	0.135
water	523	0.117	18	one	217	0.094
help	517	0.116	19	industry	210	0.171
time	502	0.102	20	biden	209	0.133

Note: Degree: The number of connections that a word (i.e., node) has to other words within the network. The degree of a word reflects the strength of its relationships with other words. Eigenvector (centrality): Eigenvector centrality indicates importance or centrality within a network reflecting both the number of connections a word (i.e., node) has and the importance of those connections.

Table 7 illustrates the weighted associations between words in GPU tweets and replies. Noteworthy associations in GPU's tweets include "climate" and "change" (weight = 68), "nature" and "person" (weight = 56), and "nature" and "new" (weight = 52). In replies, significant associations include "climate" and "change" (weight = 113), "oil" and "gas" (weight = 56), and "public" and "health" (weight = 47).

The most prominent findings from the case of GPU were that GPU's posts and its public's replies had very specific and different key topics and frames in the discourses. For example, the tweets from GPU were commonly used to discuss a range of general and worldwide topics, including "nature", "world", and "planet" and broader climate change-related subjects such as "forest" and "water". In contrast, the replies sent to GPU focused more on "fossil fuel" and "oil", which is more tangible and associated with specific policies and expanded it as public health issue (e.g., Rank 29: "fossil" and "health" in Table 7). See Figure 1 for an overview.



(**a**) (**b**)

Figure 1. (**a**) Visualization of the Semantic Network Map of Top Words in 'Tweets from GPU'; (**b**) Visualization of the Semantic Network Map of Top Words in 'Replies Sent to GPU'. (The different colors correspond to the various modularity classes within the semantic network. The size of each term (i.e., node) indicates its comparative frequency within the corpus. The lines connecting the terms represent their co-occurrence (i.e., ties) in specific posts. The thickness (i.e., width) of each line denotes the tie strength (or weight), reflecting the frequency of co-occurrence between the connected terms. The concept of 'closeness' between two terms is reflected by their distance, suggesting that a shorter distance between terms indicates they are more frequently used together within the corpus and share similar themes, often belonging to the same cluster [67]. While 'Tweets from GPU' represent broad and general keywords such as 'nature', 'world', 'planet', and 'conservation', 'Replies to GPU' correspond to groups of cohesive keywords relevant to public health issues (e.g., 'public', 'health', 'communities', 'help') and fossil fuel issues (e.g., 'fossil', 'oil', 'gas', and 'industry').).

Table 7. Top Associations of Word by Weight of Tweets from GPU and Replies Sent to GPU.

Tweet from GPU				Tweets Sent from GPU		
Source	**Target**	**Weight**	**Rank**	**Source**	**Target**	**Weight**
climate	change	68	1	fossil	fuel	154
nature	person	56	2	climate	change	113
nature	new	52	3	oil	gas	56
nature	climate	44	4	public	health	47
nature	year	41	5	take	action	40
nature	world	40	6	fossil	industry	36
food	system	36	7	fuel	industry	35
new	report	34	8	tweet	@firedrillfriday	34
nature	tnc	32	9	oil	new	31
nature	way	31	10	climate	action	30
nature	protect	31	11	new	green	29
nature	future	30	12	oil	big	24
new	show	28	13	need	get	24
nature	learn	27	14	help	please	24

Table 7. *Cont.*

Tweet from GPU				Tweets Sent from GPU		
Source	**Target**	**Weight**	**Rank**	**Source**	**Target**	**Weight**
nature	health	27	15	climate	must	24
nature	change	27	16	climate	new	24
nature	take	26	17	no	one	23
nature	speak	26	18	need	now	23
nature	conservancy	25	19	communities	health	23
new	climate	25	20	climate	fossil	23
nature	need	25	21	oil	industry	22
energy	clean	25	22	people	power	21
nature	global	23	23	now	must	21
nature	forest	23	24	fossil	stop	20
climate	water	23	25	fossil	must	20
new	world	23	26	climate	people	19
tnc	join	23	27	planet	earth	19
nature	know	23	28	@janefonda	@firedrillfriday	19
nature	help	22	29	fossil	health	19
nature	@jenmorrisnature	22	30	people	act	19

Note: Each 'weight' value represents the frequency of the word pairs presented in individual tweets.

4.3.2. Climate Central: Low Popularity, High Commitment, Low Virality

Climate Central was a unique case, in that its public engagement score was high on commitment, while low on popularity and virality. In tweets from Climate Central, the most frequently used keyword is "climate" (degree = 1112), followed by "temperature" (degree = 654) and "change" (degree = 646). Similarly, in replies sent to Climate Central, the most prominent keyword is "quote" (degree = 1192), followed by "climate" (degree = 1165) and "change" (degree = 719) (Table 8).

Table 8. Top Key Words by Degree of Tweets from Climate Central and Replies Sent to Climate Central.

Tweets from Climate Central				Replies Sent to Climate Central		
Node	**Degree**	**Eigenvector**	**Rank**	**Node**	**Degree**	**Eigenvector**
climate	1112	0.380	1	quote	1192	0.380
temperature	654	0.234	2	climate	1165	0.434
change	646	0.265	3	change	719	0.340
year	546	0.194	4	temperature	536	0.177
warming	504	0.177	5	year	491	0.156
day	489	0.177	6	@climatecentral	445	0.153
new	404	0.157	7	warming	422	0.160
risk	403	0.145	8	level	377	0.129
sea	397	0.148	9	sea	347	0.126
today	394	0.153	10	day	343	0.108
average	388	0.145	11	average	339	0.116
level	386	0.147	12	coastal	319	0.106
weather	374	0.143	13	heat	314	0.104
season	363	0.135	14	rise	301	0.109
coastal	331	0.121	15	flooding	292	0.099
city	312	0.119	16	new	277	0.106
number	306	0.120	17	impact	276	0.120
heat	300	0.104	18	weather	275	0.118
flooding	280	0.100	19	#climatecentral	273	0.096
record	264	0.100	20	#climatematters	273	0.092

As shown in Table 9, the associations of words with the highest weights were "climate" and "change" (weight = 61) in tweets from Climate Central and "climate" and "change" (weight = 120) in replies. Other notable associations in tweets from Climate Central include "climate" and "temperature" (weight = 27), as well as "temperature" and "average" (weight = 27). In replies sent to Climate Central, the association between "climate" and "quote" has a weight of 64, and the association between "level" and "sea" has a weight of 39.

Table 9. Top Associations of Word by Weight of Tweets from Climate Central and Replies Sent to Climate Central.

Tweets from Climate Central				**Replies Sent to Climate Central**		
Source	**Target**	**Weight**	**Rank**	**Source**	**Target**	**Weight**
climate	change	61	1	climate	change	120
climate	temperature	27	2	climate	quote	64
temperature	average	27	3	level	sea	39
climate	warming	24	4	temperature	average	35
sea	level	24	5	quote	change	35
climate	today	22	6	level	rise	34
climate	new	22	7	sea	rise	34
climate	year	21	8	climate	central	32
climate	weather	21	9	quote	temperature	31
sea	rise	21	10	quote	year	29
climate	day	19	11	@climatecentral	climate	28
level	rise	19	12	@climatecentral	#climatecentral	28
climate	central	18	13	climate	impact	26
climate	season	18	14	quote	warming	26
year	day	18	15	climate	warming	26
housing	affordable	18	16	climate	weather	25
climate	average	15	17	coastal	flooding	24
temperature	change	15	18	quote	sea	21
climate	risk	15	19	affordable	housing	21
climate	impact	15	20	quote	season	20
temperature	day	14	21	quote	level	20
coastal	flooding	14	22	climate	today	20
warming	trend	14	23	quote	coastal	20
climate	number	14	24	climate	science	20
climate	city	13	25	climate	changing	19
climate	changing	13	26	change	impact	19
climate	level	13	27	quote	weather	19
temperature	year	12	28	@climatecentral	change	19
day	today	12	29	quote	risk	18
temperature	city	12	30	quote	average	17

While both organizational posts and replies focused on the similar topics such as ocean-related issues (e.g., "sea level") and global warming issues (e.g., "warming"), we identified that publics' replies widely adopted "quote" to bring information from external sources. It implies that the organization and its public tended to focus on accumulating concrete scientific information in the organizational account, which might be less favored by the lay publics who are not 'committed' to the community of the organization. See Figure 2 for overview.

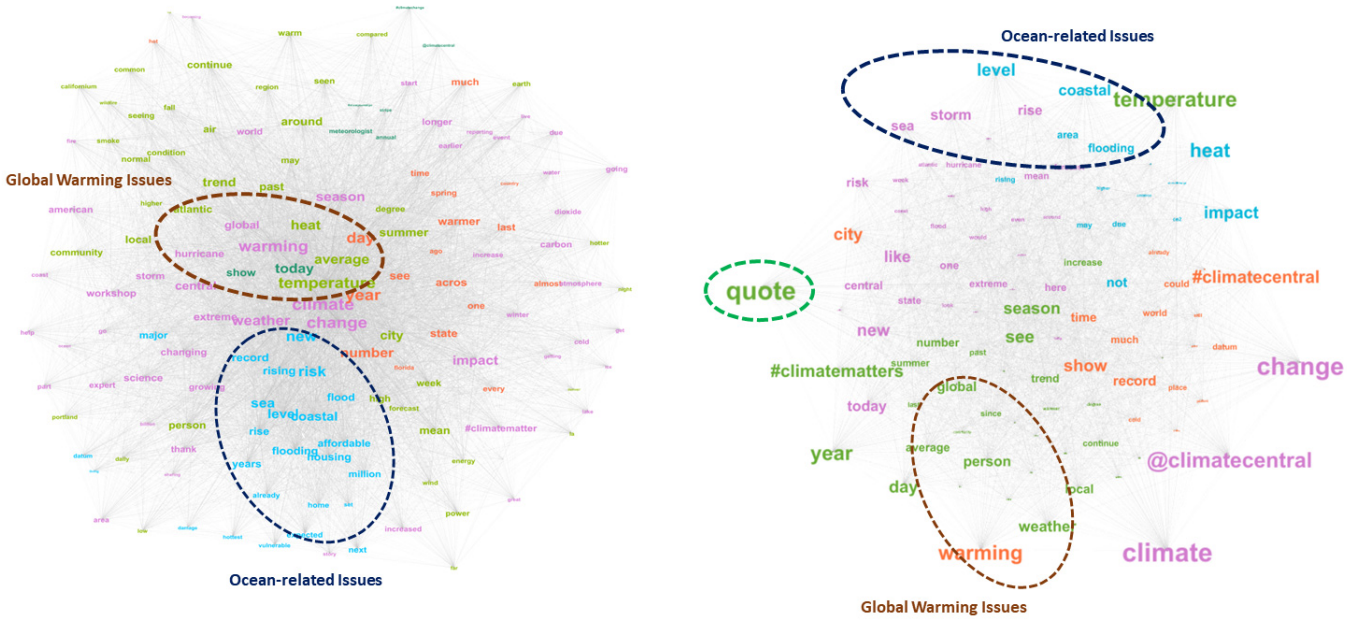


Figure 2. (**a**) Visualization of the Semantic Network Map of Top Words in 'Tweets from Climate Central'; (**b**) Visualization of the Semantic Network Map of Top Words in 'Replies Sent to Climate Central'. (The different colors correspond to the various modularity classes within the semantic network. The size of each term (i.e., node) indicates its comparative frequency within the corpus. The lines connecting the terms represent their co-occurrence (i.e., ties) in specific posts. The thickness (i.e., width) of each line denotes the tie strength (or weight), reflecting the frequency of co-occurrence between the connected terms. The concept of 'closeness' between two terms is reflected by their distance, suggesting that a shorter distance between terms indicates they are more frequently used together within the corpus and share similar themes, often belonging to the same cluster [67]. Both 'Tweets from Climate Central' and 'Replies to Climate Central' feature keywords relevant to global warming and ocean-related issues, with specific terms such as 'sea', 'level', and 'rise'. In the case of 'Replies to Climate Central', the term 'quote' was frequently used, as indicated by its comparatively large size.).

4.3.3. Environmental Defend Fund (EDF): High Virality

EDF was the organization that succeeded in making their posts be shared by their public (i.e., viral). In EDF tweets, the highest degree keywords were "climate" (degree = 4546), "rt" (degree = 2814), and "biden" (degree = 1723). The top keywords in replies include "environmental" (degree = 840), "health" (degree = 773), and "forest" (degree = 769) (Table 10).

Table 11 showcases the weighted associations between words in EDF tweets and replies that EDF received. Noteworthy associations in tweets include "climate" and "change" (weight = 277), "climate" and "rt" (weight = 168), and "climate" and "action" (weight = 154). In replies, significant associations include "climate" and "change" (weight = 83), "forest" and "burn" (weight = 44), and "environmental" and "health" (weight = 43).

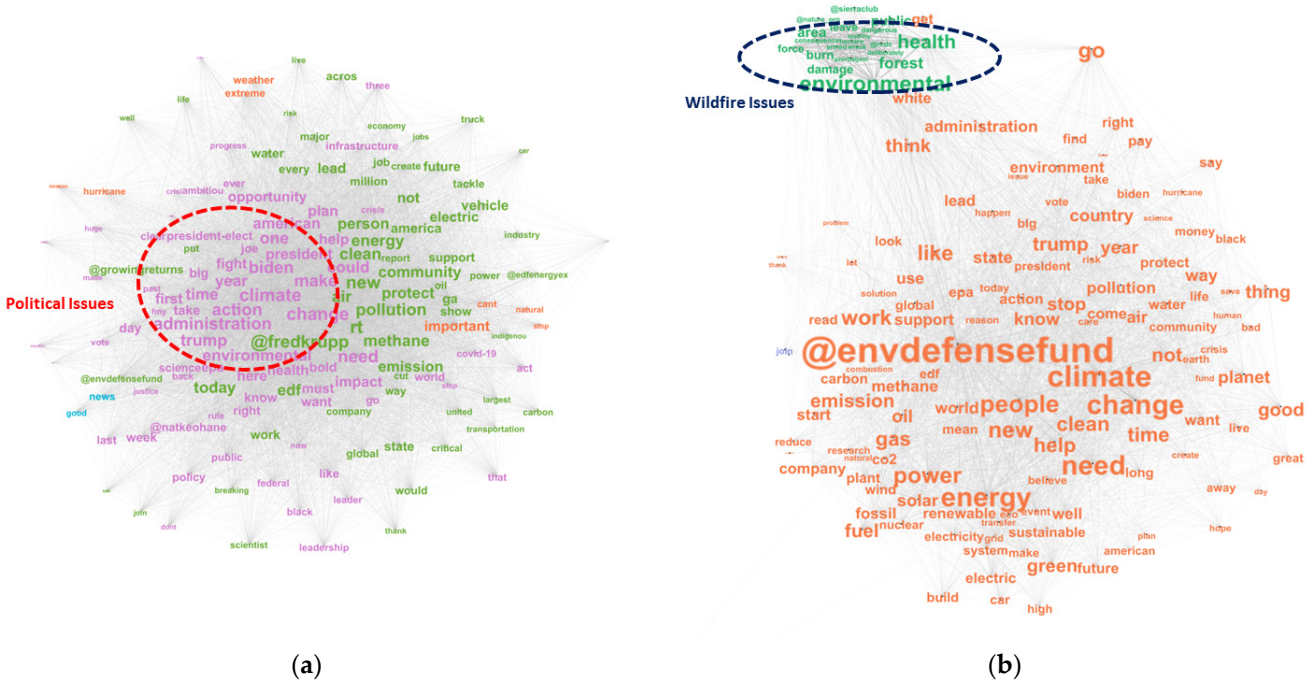
Table 10. Top Key Words by Degree of Tweets from EDF and Replies Sent to EDF.

Tweets from EDF				Replies Sent to EDF		
Node	**Degree**	**Eigenvector**	**Rank**	**Node**	**Degree**	**Eigenvector**
climate	4546	0.492	1	environmental	840	0.243
rt	2814	0.319	2	health	773	0.240
biden	1723	0.236	3	forest	769	0.244
change	1685	0.277	4	@envdefensefund	767	0.035
new	1509	0.193	5	burn	723	0.241
action	1225	0.191	6	public	718	0.238
administration	1173	0.160	7	area	718	0.237
pollution	1080	0.135	8	damage	716	0.237
@fredkrupp	1009	0.142	9	force	699	0.235
need	952	0.120	10	hectare	698	0.241
make	919	0.126	11	leave	696	0.235
clean	916	0.101	12	deliberately	687	0.239
trump	886	0.115	13	dangerous	684	0.236
air	790	0.094	14	wreck	679	0.235
president	770	0.116	15	consequence	674	0.234
methane	741	0.084	16	armed	673	0.234
energy	731	0.088	17	stability	669	0.234
environmental	727	0.088	18	azerbaijani	655	0.229
year	723	0.098	19	climate	581	0.010
emission	667	0.085	20	@nrdc	561	0.193

Table 11. Top Associations of Word by Weight of Tweets from EDF and Replies Sent to EDF.

Tweets from EDF				Replies Sent to EDF		
Source	**Target**	**Weight**	**Rank**	**Source**	**Target**	**Weight**
climate	change	277	1	climate	change	83
climate	rt	168	2	forest	burn	44
climate	action	154	3	environmental	health	43
climate	biden	149	4	forest	hectare	43
rt	@fredkrupp	125	5	health	public	43
administration	trump	111	6	forest	area	42
climate	new	99	7	forest	health	41
biden	president	83	8	forest	damage	41
rt	new	81	9	environmental	forest	41
climate	pollution	81	10	environmental	damage	41
pollution	air	79	11	environmental	public	41
climate	need	75	12	forest	deliberately	41
climate	administration	75	13	environmental	burn	41
climate	bold	73	14	damage	hectare	41
biden	joe	71	15	area	hectare	41
biden	administration	71	16	burn	hectare	41
climate	fight	71	17	burn	deliberately	41
climate	make	68	18	hectare	deliberately	41
clean	energy	65	19	forest	public	40
climate	president	64	20	health	burn	40
rt	change	63	21	health	consequence	40
climate	year	60	22	health	deliberately	40
biden	president-elect	56	23	damage	area	40
climate	@fredkrupp	54	24	damage	force	40
rt	biden	52	25	environmental	leave	40
climate	crisis	52	26	area	burn	40
climate	emission	51	27	forest	force	40
biden	action	47	28	public	burn	40
rt	action	46	29	public	hectare	40
public	hectare	29	30	public	deliberately	40

We observed that the tweets from EDF and replies sent to EDF had different themes and frames than others. For example, while EDF associated the issues of climate changes with politics (e.g., "[T]rump administration", "[P]resident [B]iden" in Table 11), its public focused more on public health issues (e.g., "environmental health") and forest losses (e.g., "burn[ed] forest" in Table 11) associated with wildfire. Interestingly, EDF widely used "rt" (i.e., retweet) in their posts, possibly to motivate their public to retweet. The use of political frames and call for retweets may likely account for its high virality. See Figure 3 for overview.



(**a**) (**b**)

Figure 3. (**a**) Visualization of the Semantic Network Map of Top Words in 'Tweets from EDF'; (**b**) Visualization of the Semantic Network Map of Top Words in 'Replies Sent to EDF'. (The different colors correspond to the various modularity classes within the semantic network. The size of each term (i.e., node) indicates its comparative frequency within the corpus. The lines connecting the terms represent their co-occurrence (i.e., ties) in specific posts. The thickness (i.e., width) of each line denotes the tie strength (or weight), reflecting the frequency of co-occurrence between the connected terms. The concept of 'closeness' between two terms is reflected by their distance, suggesting that a shorter distance between terms indicates they are more frequently used together within the corpus and share similar themes, often belonging to the same cluster [67]. Key differences between the discourses of 'Tweets from EDF' and 'Replies to EDF' lie in distinct key topics. 'Tweets from EDF' address political issues, featuring terms like 'trump', 'biden', 'administration', and 'president-elect.' In contrast, 'Replies to EDF' focus on wildfire issues, with terms such as 'forest', 'burn', 'area', and 'damage.').

5. Discussion

The aim of this exploratory study was to enhance our understanding of public engagement on social media, focusing on the features of two-way communications on social media. In addition to traditional public engagement metrics, we employed sentiment analysis and examined shared meaning with semantic similarity measures in our research. Furthermore, by utilizing SNA, we identified and compared key themes and focal points within climate NGOs' tweets and the corresponding replies they received. Through our explorations, we discovered several noteworthy findings.

First, we observed that climate NGOs developed unique themes and focuses within their discourses. This highlights the distinct characteristic of science/organizational com-

munication on social media, where organizations can participate in or establish topic-driven communities [34]. Social media allows individuals and organizations to engage in focused discussions on particular topics. To effectively connect with and mobilize like-minded individuals who share climate-related interests, climate NGOs may strategically monitor and select topics and issues to allocate their attention and communication efforts. Our study revealed that strategically selecting topics and discussion foci may encourage specific types of public engagement. For instance, Climate Central, by aligning its topics and foci with those of publics in terms of scientific information about climate change (with aligned sentiments with publics (Table 5)), it maintained shared interests with the committed publics and generated a high level of public commitment. In other words, both organization and the engaged publics aligned their perspectives and sentiments on the issues [71], incorporating their discussed issues (This alignment is facilitated potentially by both inviting certain groups of publics who share interests and knowledge about the issues that the specific NGO advocates for, and by mutually shifting their agendas and frames to reflect each other's viewpoints). For example, when the organization focused on the 'extreme temperature' issue, the committed public shared their knowledge and opinions with the organization as below.

Climate Central: "RT @afreedma: This graph helps explain why heat extremes are becoming so much more common/severe in a warming world. [link redacted]"

A public: "On average, July in Raleigh-Durham is 4 degrees hotter now than it was in the 1970s. (See all locations here: [link redacted]) #ClimateMatters"

Understanding the themes and focuses that resonate with the public may enable climate NGOs to tailor their communication strategies and content effectively, thereby enhancing engagement and mobilization.

This finding highlights the significance of effectively managing organizational discourses while simultaneously monitoring public interests and concerns, considering the specific types of public engagement being targeted. Similar to the GPU in our sample, when attempting to engage a broader audience like publics, it would be advisable to concentrate on uncontested climate change topics such as nature, rather than delving into specific issues like "fossil fuel" that may have been raised by more active segments of publics (See Table 7).

Second, our findings highlight the importance of avoiding a one-size-fits-all strategy focusing solely on increasing public engagement scores, such as likes and retweets, in the research context. Instead, we recommend that climate NGOs tailor their communication strategies based on the specific types of public engagement they are targeting on social media [24]. We found that organizations that succeeded in generating specific types of public engagement on social media did not necessarily succeed in generating other types. For example, Climate Central achieved a high level of commitment but had low virality. This could be attributed to the nature of the topics chosen by Climate Central, which focused on climate sciences and meteorology: topics requiring a high level of science literacy from publics. If Climate Central aimed to engage more informed and active participants in the discourse, the low popularity and virality might be an insignificant concern. Conversely, organizations like GPU, which focused on climate topics generally applicable to the wider public, achieved high popularity but avoided highlighting national or regional political issues (e.g., U.S. presidential election). In contrast, EDF achieved high virality by actively mentioning political figures and associating climate change issues with the responsibility of the government (e.g., Biden action, Biden administration). Although EDF's approach might have appealed more to the U.S. public than international audiences, it generated intense virality as engaged individuals shared EDF's messages with like-minded individuals on social media. These examples suggest that organizations need to establish specific objectives regarding the types of public engagement on social media. Accordingly, they should allocate attention and interest to specific issues, as each objective necessitates different communication strategies.

Third, our analysis revealed significant and positive correlations between the weekly sentiment scores of the three organizations, namely GPU, Climate Central, and EDF, and the corresponding sentiment scores of the replies they received. Remarkably, the three organizations demonstrated commendable performance in at least one public engagement metric, such as popularity, commitment, and virality. While the correlations based on weekly sentiment scores may not provide a complete depiction of how organizations align with publics' interests, they do highlight the importance of organizations focusing on current issues that evoke a range of sentiments [72]. By aligning their interests and attitudes with publics on these issues, climate NGOs may enhance public engagement by leveraging the incorporated attentions and shared sentiment surrounding these topics [42].

Furthermore, the study uncovered counter-intuitive findings. Specifically, the semantic similarity between organizational posts and public replies did not have a positive relationship with public engagement on social media. In other words, when organizations generated higher engagement from publics in terms of popularity, commitment, and virality, the use of similar themes and focuses was either insignificant or low. This might be due to the fact that organizations with more engagement are likely to have more diverse audiences, as their posts are shared not only with like-minded individuals but also individuals with different perspectives and opinions on climate issues. Investigating the network attributes of organizations' social media communities could confirm these counter-intuitive findings in future studies.

There are several limitations and opportunities for further development in this study. First, to fully understand the implications of specific themes and focuses in generating public engagement, one must delve further into the influence of specific words and frames used in posts or posts within shorter time periods, such as a few days or weeks. Since Twitter imposes a 280-character limit, we had to explore the semantic features of all posts and replies within a one-year period, which may not fully capture the 'real-time' dynamics of dialogues between organizations and publics. Second, as a case study, we only investigated a few organizations with successful public engagement generation. To gain a more comprehensive understanding, it is important to explore whether our findings are generally applicable to a wider range of organizations and other contexts. Additionally, to comprehend the implications of specific types of public engagement on social media, it would be beneficial to investigate the network characteristics of an organization's communities. For example, understanding how posts become viral can be better understood by examining how these posts are shared with individuals outside an organization's immediate network. By conducting larger-scale investigations and employing additional analytic approaches, we can gain deeper insights into public engagement within this context.

6. Conclusions

In conclusion, our study sheds light on the themes, focuses, and sentiments identified in social media discourses of climate NGOs and their publics, within the framework of public engagement. Recognizing the imperative for climate NGOs to maximize the 'two-way' communication capabilities of social media to educate, persuade, captivate, and understand their target audiences concerning climate change issues, we delved into the interactive dynamics of these discourses. Based on our exploration, we advocate for communication strategies that are more oriented toward the public audience's understanding of and interest in climate issues. This involves:

1. Assessing public perceptions and understanding of climate topics, as exemplified by the challenges faced by Climate Central in making scientific discourses appealing to lay public audiences.
2. Exploring the depth and variety of climate-related issues that captivate publics' interest, demonstrated by the case of GPU, which focused on broader climate issues.
3. Understanding how different publics associate different issues with climate change, such as the disparate linking of climate change with political and wildfire issues in the communications of EDF and its public audiences.

When these tailored strategies align with each organization's specific communication objectives and target audiences (e.g., individuals with interests and knowledge in climate science, in the case of Climate Central), they are likely to contribute to more desirable public engagement in climate change discourses. These shifts in strategies from 'delivering effective messages to the public audiences in order to educate them' (e.g., the IPCC report) to 'understanding and representing the interests and issues of the public audiences' also resonate the call for the shift in first-order thinking to second- and third-order thinking in science communication [73].

Specifically, with the 'two-way' approach indicative of second-order thinking, climate NGOs can not only build consensus on climate change issues but also directly address the uncertainties and concerns of publics [73]. This approach aligns with the principles of second-order thinking by prioritizing dialogue, engagement, and building trust through a transparent and accountable communication style.

Furthermore, by embracing the diverse perspectives and agendas of different public audiences, which is a hallmark of third-order thinking, these organizations can situate climate change within a wider cultural, societal, and political context of the publics as in the case of EDF. This approach goes beyond organization-led initiatives, recognizing the importance of heterogeneity and constructive disagreement as valuable societal resources to address climate change issues [73]. This multidimensional perspective will enhance reflexivity and critical analysis in climate communication, which is crucial for addressing 'wicked problem' [74] like climate change.

We also acknowledge the additional limitations of our study in terms of application, including the need to explore the influence of specific words and frames within shorter time periods, expand the scope of organizations and contexts studied, and investigate network characteristics for a more comprehensive understanding. Continued research in this area can contribute to a better understanding of public engagement and communication strategies of climate NGOs' social media presence.

The current study used SNA, following previous studies [75,76], and recognized the limitations of methods like topic modeling in comparing multiple corpora and identifying nuanced themes within a topic [77]. Newly designed methods, such as contrastive topic modeling [77] and qualitative approaches (e.g., Haupt et al. [78]), which address these limitations, may be considered in our future studies.

We conducted sentiment analysis using the Microsoft Azure API (version: 5.2.0), which offers a parsimonious and accessible analytic approach for communication professionals to capture current public sentiments and potential sentiment gaps between the organization's communication and publics' responses. We propose that the practitioners may monitor what leads to specific sentiments among public audiences during specific periods, with a more careful review of the original posts and replies from these publics. However, to develop more sophisticated sentiment analysis, practitioners need to consider dictionary-based approaches or develop their own trained models for such analysis to reflect their organization's specific context.

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Article

Addressing Epistemic Injustice: Engaging Children as Environmental Communicators to Support the Long-Term Sustainability of Forest Ecosystems

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Abstract: Closure of a forest for biosecurity purposes led to the marginalisation and disconnection of Year 6 children from a local forest of significance to them in Aotearoa, New Zealand. The marginalisation of children's voices and concomitantly of their knowledge, ideas, and values from environmental issues can be viewed as an example of epistemic injustice, which manifests widely in the environmental area, particularly in relation to marginalised groups. To counter this marginalisation and promote epistemic justice, we explored how the creative arts involving a child-driven environmental communication project could foster children's sense of agency by supporting the protection of a local forest affected by a tree disease. We show that the creative arts could facilitate the children's meaningful engagement in environmental issues in a learning environment that fostered child-centric approaches that enabled children to express their visions for sustainable futures in distinctly unique ways that were relevant to them. Furthermore, enabling the children to participate as environmental communicators re-established their relationship with their local forest and rebalanced the power structures that had led to the children's sense of marginalisation. The insights on how this child-centred relational approach can promote epistemic justice and provide a meaningful contribution to the long-term sustainable management of forest ecosystems has implications for other marginalised groups.

Keywords: epistemic injustice; environmental communication; environmental management; biosecurity; power structures; participatory research; transdisciplinary research; mātauranga Māori; art-based practices; behaviour change

1. Introduction

Environmental sustainability, such as the long-term protection of forest ecosystems, is by its very nature a complex issue, as it is characterised by significant scientific uncertainty and embodies diverse and often divergent socio-cultural perspectives [1,2]. This is why complex socio-environmental issues are often referred to as wicked problems [3,4]. As such, effective management of these complex socio-environmental issues demands transdisciplinary approaches that bridge academic, community, and indigenous perspectives so as to embody multiple actors with diverse values and epistemologies [2,5–7].

Given the intergenerational nature of complex socio-environmental issues such as sustainability [8,9], we argue alongside many other scholars for the specific inclusion of

children and youth voices in environmental issues [10–15]. We contend that children should participate as valued knowledge creators and communicators in their own rights and not simply as objects of inquiry or institutional outreach. Environmental communication, as a critical component of environmental management, should offer a platform for a range of voices, including children's voices, to speak out about and on behalf of the environment in an attempt to build people's awareness of environmental issues, shape their interpretations, and influence how complex socio-environmental problems are both understood and managed [16].

1.1. Creating Epistemic Injustice

Power structures can limit children's voices from being heard and marginalise them from making valuable contributions to environmental issues. The marginalisation or exclusion of people, including children, as credible 'knowers' is referred to as epistemic injustice [17].

We explore in this article an innovative child-driven environmental communication project using graffiti art on shipping containers and known as the container art project to enable children to contribute as vibrant social actors and knowledge creators to a local environmental issue. The project partnered with fifteen Year 6 school children, enabling them to use the creative arts to contribute to the management of a local neighbouring forest park that had been closed by the city council to limit the spread of kauri dieback, a forest disease caused by the forest pathogen *Phytophthora agathidicida* that threatens New Zealand's kauri tree (*Agathis australia*), one of the world's largest and longest-lived trees. First observed in 1972, kauri dieback has no known cause, and when present in kauri trees, almost certainly causes their death [18].

The children's school carried the forest park's name and had used the park as an educational amenity that the children had regularly visited before it was closed. The closure had, over time, led to the children feeling both physically disconnected from the forest and frustrated and marginalised by the council for not recognising the important role they could play in contributing to the park's management. We view the children's marginalisation as an epistemic injustice.

1.2. Engaging Children Using Arts-Based Practices

Arts-based practices, including art, play, and performance, provide a range of expressive and alternative modes of communication to enable children to participate in environmental management in ways that are distinct and unique [19,20]. The container art project was an extension project of Toitū te Ngahere: Art in Schools for Forest Health (TTN), a more extensive research programme that had included five schools in New Zealand. TTN sought to explore how arts-based practices could support children's engagement with forest health. The TTN transdisciplinary partnership consisted of specialists from the creative arts, social and environmental sciences, education and mātauranga Māori (indigenous Māori knowledge), as well as Māori and pakeha artists (of European descent) and a range of primary schools, their students from Years 1–8, along with their principals and teachers. Together the team co-designed and co-implemented the TTN programme (see [21,22] for more detail about the full TTN project).

Central to TTN was the recognition of the contribution that both Western science and mātauranga Māori or Indigenous Māori knowledge make to forest health. Mātauranga Māori is a system of ontology that weaves and interconnects all forms of knowledge, at times fluidly overlapping, but never in separation or hierarchically [23,24]. This contrasts with dominant Western ontologies that separate concepts often into hierarchies. A te ao Māori (Māori world) centred approach, calls for an emphasis to be on ngahere ora, or the wellbeing of the forest, rather than framing forest biosecurity solely through the lens of plant pathogens [25]. By placing mātauranga Māori as a central component of TTN's engagement with schools, it could also seek to address epistemic injustices to mātauranga Māori that have often been afforded lesser value and importance in environmental issues [25,26].

While TTN explored more broadly the use of arts-based practices for engaging school children in forest biosecurity, TTN's extension project—the container art project—sought to provide a unique insight into how a child-centric approach using art-based practices could be used to engage children in environmental sustainability to address epistemic injustice. The project directly responded to one of the TTN school's feelings of marginalisation and exclusion from decisions following the closure of their local forest because of kauri dieback.

It drew on a specific pool of children who the previous year had benefited from participating in the wider TTN programme. With no blueprint or roadmap available on how to address epistemic injustice with children, the research underpinning this project asked the question: How do we address epistemic injustice using arts-based practices to enable children to meaningfully contribute to an environmental issue of local relevance?

1.3. Engaging Children in Forest Biosecurity in New Zealand

The inclusion of children's voices is particularly relevant for the sustainable management of forest ecosystems in Aotearoa New Zealand, as intergenerational responses are needed to manage long-term biosecurity issues including kauri dieback. As natural ecosystems are deeply connected to beliefs, rituals, and cultural practices of Māori, the indigenous people of Aotearoa New Zealand, forest pathogens such as kauri dieback have profound cultural impacts [25].

Furthermore, disease management control measures, such as footwear and equipment cleaning stations and forest closures, have significantly impacted people's interaction with the forest [27,28]. These ecological, social, and cultural impacts make kauri dieback a complex socio-environmental issue requiring transdisciplinary responses that includes scientific knowledge, and indigenous Māori, local, and other knowledges that are often marginalised from environmental issues [29]. In this respect, we argue for the inclusion of children in conversations and decision-making processes that focus on forest health.

1.4. Outline of Article

The article begins by exploring the literature to examine how the privileging of Eurocentric approaches to environmental management marginalise 'non-science' voices and lead to epistemic injustices. We present the concept of epistemic injustice as described by Fricker [17], and examine this in relation to the marginalisation of children's voice and agency in environmental issues. We then draw on the writings of Anna Hickey-Moody [19] and Marianne Presthus Heggen [20], who call for 'a more-than-human world' to children's engagement in environmental issues, which values relationships with non-human actors and develops notions of living in a shared world as eco-citizens.

We present our findings of four key areas that emerged in our project as being critical for fostering epistemic justice for children. These were: equitable relationships; opportunities for deep engagement; spaces for individual and collective thinking; and time for deliberation and reflection. In our discussion, we examine our findings by revisiting Hickey-Moody's, Heggen's, and Fricker's work, discussing the key concepts of eco-citizenship, little publics, and the rebalancing of power structures.

Our evidence is qualitative. In this article, we both report on and critically explore our child-centric process for engagement within the context of epistemic injustice. We have not sought to sample a population. Our evidence, gathered from our own reflections and observations and from the children's recorded reflections and their artwork, and the many photos, videos, and other artefacts we captured during this year-long engagement, provide a rich array of data from which we draw our conclusions. While this article focuses on the marginalisation of children's knowledge in an environmental context, the findings and discussion have relevance to those working to address epistemic injustices in other marginalised groups.

2. Literature Review

2.1. Anthropocentric Approaches to Environmental Management

Environmental agencies responsible for managing the environment or setting policy directives, such as those that oversee biosecurity, view the environment as spaces that are boundable and controllable that need to be protected [30]. Environmental messages focus on changing people's behaviour to manage or control their interactions with nature and limit their environmental impacts. The behaviour change approach favours top-down deficit approaches to communication, with science as a reservoir of facts and knowledge and audiences as receivers and adopters of such facts [31]. Environmental agencies focus on educating the public in the hope this will bring about their acceptance of management regimes or policy decisions [32], thereby encouraging pro-environmental behaviours [33,34]. In this anthropocentric approach to environmental management and communication, the state is viewed as the key actor in managing the environment, with science as the principal epistemic authority [30,35].

However, in complex socio-environmental issues, there is a need to move beyond top-down linear approaches to management and communication [32]. This is because these approaches assume people equally share a desire to protect the environment, and so ignore the values-based nature of people's environmental decision-making [28]. In addition, linear approaches under-estimate the importance of working in local contexts and with local communities about issues that are of relevance to them [36,37]. Of most concern is that linear approaches limit the inclusion of knowledges and voices beyond science.

Inclusive, dialogic and co-produced participatory approaches to environmental management are promoted as more effective ways to engage stakeholders to address complex environmental issues like sustainability [38]. However, often these are science-led, with projects following traditional linear approaches that minimise opportunities for collaborative learning and knowledge co-production where science complements rather than replaces local and/or traditional knowledge [39]. Furthermore, participatory approaches remain subject to power dynamics that both limit participation and maintain existing power structures [40,41].

Power asymmetries in environmental management raise fundamental questions about whose voices are heard and whose remain silent. Which social identities are deemed powerful and legitimate, and which are undermined or undervalued? Whose knowledge is included, and whose is marginalised?

Anthropocentric approaches to environmental management therefore present significant challenges for enabling children's engagement in environmental issues because they see children as recipients of messages and not active knowledge creators; they reinforce unequal power relations [42] and do little to bring about change in systems of power that maintain western ideologies and marginalise voices beyond science. This leads to environmental and epistemic injustices [43].

2.2. Epistemic Injustice and Power Asymmetries

Fricker [17] (p. 1) describes epistemic injustice as "a wrong done to someone specifically in their capacity as a knower". Many scholars alongside Fricker contend that ideas, opinions, and knowledge matter for meaning-making, and so marginalising people based on their social identity can affect their ability to participate as active agential societal actors [11,44]. As Fricker says, "it cramps the very development of self" [17] (p. 163).

Fricker identifies two forms of epistemic injustice. The first testimonial injustice assigns a lower level of credibility to a person simply because of their social identity, and so they are not taken seriously or valued for bringing legitimate knowledge to an issue. Testimonial epistemic injustice stems from what Fricker (p. 27) calls "identity-prejudice", whereby social identities are shaped by social imagination that contains sets of assumptions about how social identities are to be viewed and treated [45]. For example, in environmental management, knowledge hierarchies can privilege scientific knowledge over other knowledges such as traditional indigenous knowledge [44,46,47]. Indigenous

Māori scholars argue this is deeply ignorant of Māori knowledge and culture [48] and colonially paternalistic [49].

The second form of epistemic injustice identified by Fricker [17] is hermeneutical injustice. Fricker claims this occurs when society's "collective interpretative resources" (p. 2) do not recognise a person's experiences because the experience simply does not exist as part of collective understanding, and so falls into a "blank gap in the available conceptual resources" and institutional structures that leads to marginalisation. This can be seen, for instance, in New Zealand power structures of colonial educational systems that marginalise Indigenous pedagogies and knowledges, such as mātauranga Māori, leading to lessons and teaching contexts following more didactic and directive-top-down ways. Holistic Māori approaches to education known as ako torowhānui which involve whānau (the family) in their tamariki's (children's) learning are usually discouraged from being part of the school classroom environment [50]. In colonial education systems, power structures therefore marginalise indigenous ways of knowing and doing.

The principal underlying cause of epistemic injustices therefore lies in unequal power structures. In environmental contexts, knowledge practices that are maintained and entrenched in power structures, such as in environmental management and funding structures, leads to epistemic injustice by deeming only some voices as ecologically worthy [51]. In these contexts, children are typically seen as recipients of environmental messages and not as knowledge creators who wish to make a valuable contribution to environmental decision-making.

2.3. Children and Epistemic Injustice

Studies are increasingly recognising that children experience and indeed are harmed by epistemic injustices in a variety of settings, most notably in health, for example [12,52], education, for example [10,44,53,54], law, for example [11,45], development and rural studies, for example [13,55], and in environmental issues, for example [56].

Scholars assign both testimonial and hermeneutical injustices to children's marginalisation. Marovah and Mkwananzi [13] claim children are disadvantaged by both social relations that shape how adults perceive them and through their limited ability to control others. They argue, that this provides a strong case for hermeneutical injustice, since social relations take place in adult-created and centred structures. Klyve [52] suggests that systemic power structures prevent children from making meaning of their experiences, and argue that undermining or undervaluing children's social standing, power, and epistemic legitimacy subjects them to testimonial epistemic injustices. Murphy [56], investigating climate change, found that youth were subjected to epistemic injustice caused by systemic structural factors that excluded them from political and policy-making deliberative processes. Bergmann and Ossewaarde [57] found that media framed children engaging in youth climate marches as 'dreamers' and 'truants'. Such framings affect a child's sense of epistemic worth. This may account for New Zealand researchers finding Year 12 and 13 youth had increasing levels of pessimism about environmental issues, and a decreasing sense of agency about how to meaningfully respond to these issues, compared to Year 9 and 10 youth [58]. The marginalisation of youth from public deliberations about global environmental issues has led to calls for more deliberative democratic processes to re-balance the power structures that limit children's genuine engagement in public deliberations and environmental and policy decision-making [56]. The container art project is a direct response to these calls for child engagement in environmental deliberations and decision-making.

2.4. Addressing Children's Epistemic Injustice

In considering how to address epistemic injustice through child participation using the creative arts, we draw on the extensive research and writings of Hickey-Moody, specifically Hickey-Moody et al. [19], and Heggen, specifically Heggen et al. [20], who

argue for child-centric and eco-centric approaches to promote children's engagement in environmental issues.

Hickey-Moody et al. [19] contend that children should be conceived as possessing the agency and capacity to contribute to society from an early age. They rethink western views of the public sphere that limit children's engagement and propose for the involvement of "more-than-human others" in publics which include "animals, plants, the built environment, rubbish, weather and (crucially) possibilities for change" (p. 24) to be recognised and valued. They (p. 26) claim that children assemble "little publics" when they call on or draw the attention of 'others' through, for example, art, play and performance. Taking expressive and alternative modes of communication seriously is viewed as essential if participation in the public sphere is to be widened. Art-based practices are seen as valid modes of civic participation and of "participatory community building" (p. 177), which can shape and change civic life, space, and relationships. When participating in art, children attend and respond to place, environment, ideas, materials, other people, and other beings and, in turn, these things attend to and respond to them in different ways.

Similarly, Heggen et al. [20] also rethink notions of child citizenship and children's connection to nature. They claim children are excluded from citizenship and political participation because of the perception of the child as not rational or complete. They propose an 'eco-centric' approach that is based on an "understanding of humans as part of the diverse life on earth, and that solidarity with the more-than-human world is necessary" (p. 388). This replaces the adult-centred view of children as not-yet-adults, with a more 'child-centred' understanding of children. They propose, "children as eco-citizens practising a child-sized eco-citizenship by their involvement in their local community and their local nature" (p. 391). They also call on the recognition of arts-based practices and play as valid forms of participation because, "In play, children create an imaginative space where their experiences and problems are investigated and where they produce something new" (p. 390).

Hickey-Moody and Heggen's concepts shift children's participation away from children having to be responsible for themselves or for planetary problems and towards valuing children's participation on its own terms, rather than expecting them to participate in the same ways as adults. Children are not seen as 'incomplete', 'fragile', and 'underdeveloped', or in a state of preparation for adulthood, but instead they are afforded "the same rights and capacities as adult citizens", but with a "different foci and goals from adult citizenship" [19] (p. 4). We revisit the key concepts of 'eco-citizenship', 'little publics', and 'more than human worlds' in the discussion section of this article to critically examine how effectively our child-centric approach using graffiti art on containers addressed epistemic injustice for children.

The literature provides a conceptual understanding of how child-centric approaches can engage children in imaginative and child-sized eco-citizenship to move engagement away from anthropocentric top-down approaches that limit the inclusion of knowledges and voices beyond science. However, it is less clear how these concepts operate in settings where epistemic injustices have led to children experiencing marginalisation from an issue of importance to them. As such the container art project fills an important gap in the literature by explicitly exploring how art-based practices may support children's engagement and develop their sense of agency in an issue where they feel they have been marginalised. The case also importantly contributes to understanding whether local initiatives that engage children can rebalance some of the underlying power structures that limit children's engagement in environmental issues. We turn now to presenting our case, methodology, and findings.

3. Case and Methodology

3.1. Background

The container art project was an emergent project that arose during the children's engagement with the Toitū te Ngahere (TTN) team in 2022, when the children and teachers

revealed a range of emotions including anger, frustration, and sadness at not being able to enter a neighbouring forest park due to its closure from kauri dieback. Central to the children's feelings was their repeated expressions of their loss of connection with the forest and frustration at not being able to contribute to the park's management. The park's closure occurred in 2018 when locked gates were unexpectedly installed by the city council at the entrance, with two official signs saying 'track closed due to kauri dieback'. The school had not been offered the opportunity to contribute in any way to the park's 'management' despite it being for many years a valued natural environment, educational amenity, and place the children enjoyed regularly visiting. This exclusion left a strong sense of marginalisation that was repeatedly raised by the children and their teachers during the year-long engagement with TTN.

The TTN team facilitated engagement with the city council who managed the park, initially through 50 individual letters written by the children, where they asked questions about the park's biosecurity status, its future management, and suggested ways they could contribute to its long-term management. This led to the council coming to the school to meet the children where it was agreed they would draw on their TTN experiences by using the creative arts to support the community's awareness and understanding of kauri dieback.

3.2. Case

The school offered two shipping containers on the school grounds to enable the children to use graffiti art to communicate their knowledge about kauri dieback and their visions for more sustainable environmental futures. In April 2023, fifteen Year 6 (10-year old) children, in their final year at primary school, agreed to engage in the container art project. The TTN activities and experiences provided the children with a foundational understanding of kauri dieback and forest health (ngahere ora) using science and mātauranga Māori, and through their engagement in the creative arts, so they could see themselves as epistemically worthy contributors to forest biosecurity [21].

A complementary storymap, with links to it from a large QR code on the containers, the school gates and eventually the forest park gates, records the children's journey with photos, video, and artwork [59]. The local community, who also did not have access to the park, were encouraged to visit the school to engage with the artwork and learn about kauri dieback from the children's perspective.

3.3. Methodology

A postgraduate tertiary student facilitator with experience in youth development and art-based education was contracted to manage the on-school engagement with support from TTN team members. Each weekly engagement session ran for 60 min over three school terms from April to November. These sessions were held during the school day, but the children attended outside their normal classes. Although no school teaching staff engaged in the sessions, on regular occasions a liaising lead teacher, the school principal, other members of the school community, including the school caretaker, and TTN members met to discuss the project and to manage logistics.

As Fricker [17] provides little advice on how to address epistemic injustice, the facilitator drew on three models from the participatory literature to inform the processes for engagement, Hart's [60] ladder of child participation was used to guide levels of engagement. However, to counter criticism that ladders of participation wrongly suggest a vertical hierarchy [61], the facilitator instead viewed the ladder horizontally, visualising it like a keyboard, where the children and the facilitator could move back and forth along stages of participation. For example, there were times where children were shown how to use a spray-can as acts of teaching, and there were times where the adults would remove themselves from a discussion, allowing the children to negotiate and decide on their own, as acts of deliberative democracy.

Additionally, Pohatu's Mauri Model [62] provided an approach to slow down the process of engagement. This model is built around "notions of *Mauri Moe* (the unrealised potential for change), *Mauri Oha*, (the need for change is acknowledged) and *Mauri Ora* (when change has been achieved)" [63] (p. 107, emphasis in original). Keelan [63] (p. 22) claims that, in a youth context, this model promotes "consideration before taking action". For example, it was clear early on the children were able to quickly create independent artworks, making individual decisions and depicting kauri dieback narratives that they illustrated by themselves. The challenge, however, was to develop a mural that shared their collective narrative, and achieving this required time and space to be allocated to understand their collective narrative and how they saw themselves in relation to kauri dieback.

The facilitator also drew from Dorothy Heathcote's *Mantle of the Expert*, "whereby a mantle of leadership, knowledge, competency and understanding grows around the child" [64] (p. 35). This methodology was implemented during collaborative discussions, drawing, painting, and reflection, where the children were constantly negotiating their own artistic material generated alongside their developing body of knowledge about forest ecology, kauri dieback, artistic practices, communication, and more. These negotiations allowed them to refine their own identities and purpose in creating their mural and to enable the facilitator to see what the children were seeing.

As the research was seeking to identify approaches that would foster epistemic justice through an iterative and inclusive action research project, opportunities were provided throughout the project for critical reflection. At the close of each session, time was allocated for the children, facilitator and TTN members to collaboratively plan and reflect on the development of the artwork and the processes of engagement. The facilitator compiled field notes at the end of each session to record her observations and reflections. Videos, photos, and artwork, which are included in the accompanying storymap, provided a record of the collaborative learning journey (see Supplementary Materials). Additionally, at the conclusion of the project, the children participated in a recorded 'go-along' interview walking around the containers with a TTN member to discuss and record their perceptions and reflections of their experience in the project. This interactive and dynamic qualitative research method captures participants' perceptions in a more natural way than structured interviews or focus groups [65]. Project reflections were grouped into themes [66] that collectively informed the key emergent findings presented below.

Prior to commencement, the research received human ethics approval from the University of Auckland as part of the wider TTN project. All children were aware of their engagement in this research project and they signed consent forms along with their principal and parents. The school's principal and staff also expressed full support for the project, its research, and the children's engagement in it.

4. Findings: Developing a Creative Process to Foster Epistemic Justice

Klyve [52] (p. 6) challenges researchers working with children to find ways to address epistemic injustice. The 'container art project' was conceived to meet this challenge by facilitating and fostering epistemic justice to support the children's desire to raise their community's awareness and understanding of forest biosecurity. At the same time, the project also sought to re-build the children's relationship with their neighbouring forest. However, Fricker [17] provides little guidance on how to promote epistemic justice.

Participatory approaches provide general principles and while our three models of participation provide a framework to guide engagement, they nonetheless do not provide a blueprint or specific roadmap for engagement [67]. We began from a starting point that viewed children as vibrant social actors who wanted to contribute their knowledge, ideas, and opinions to support the sustainable management of their neighbouring forest park. However, while some of us had years of experience as social scientists working in community-based research, this project like most participatory action research projects was an iterative learning-by-doing approach, co-created mostly on a week-by-week basis with the children. None of us—children and adults included—had any experience of

having ever painted art on shipping containers. The results we present in this section, therefore, are emergent arising from a dynamic, interactive, co-designed, and co-created child-centred approach.

We present four key themes that emerged as critical findings for developing epistemic justice when working with children. We illustrate each section with children's quotes from recorded discussions. However, as such methods for data collection largely capture only children's verbal reflections, we also encourage readers to visit the project's story-map to see the children's artwork, their videos, and project photos, and in so doing to view a rich array of data to supplement the verbal reflections that are contained in the findings below (see [59] or the article's Supplementary Materials to access the storymap).

4.1. Equitable Relationships

As senior students, the children had experienced the 'before' and 'after' reality of accessing their neighbouring forest park and then not being able to access it due to its permanent closure from kauri dieback. During the TTN project the children had expressed a deep sense of loss as a result of their inability to physically connect with the forest and a sense of powerlessness over a biosecurity decision that was out of their control, but which affected their daily lives. The TTN project had enabled the children to understand why the park was closed. While this provided important foundational learning, the container art project sought to build on this by supporting the children to develop a new relationship with the forest through the creation of the mural on the shipping containers.

By continuing TTN's approach to engagement with the children using the Māori concept of ako torowhānui (holistic learning), the learning process fostered the relationship by being an inclusive, student-led collaboration in all aspects of the project that reinforced the children's sense of empowerment. The children valued the collaborative nature of the process. As one child described, "The Tree Frog—I made it. I did the original design and [child's name] redesigned it and I painted it, so it was really collaborative".

To build the children's self-esteem as environmental communicators and to receive helpful feedback on their conceptual design, the children developed a short presentation for a class of new entrants and small group of teachers (see project storymap in Supplementary Materials). This allowed them to talk about the forest with children who had not had the same experience of seeing the forest open and then closed. It also enabled them to interact with an audience to explore how their narrative might be received. The children took the constructive feedback back to their project discussions to explore if they needed to modify their narrative.

To facilitate the children's learning journey and foster their sense of agency and epistemic worth and confidence, it was essential to establish and maintain an equitable, caring, and trusting relationship between the children and the facilitator, and with the TTN members who joined some of the sessions. Acknowledging the children's experience and also their social position in the school was important in the early phase.

The role of the facilitator was central to building a trusting relationship between the children and the adults in the project. The facilitator understood child-centred learning, youth development, and creative practices. While the TTN team joined into the project at various times, it was the facilitator who created the strongest bond with the children. Active and careful listening by the facilitator and the TTN members was critically important, as this demonstrated to the children their views, ideas, opinions, and justifications were respected without judgment. One student described the listening of the adults as "about as important as importance gets on a scale".

As a result of the relationship, the children were seen as knowledge creators, rather than through a predetermined adult perspective. This was critical given that the children recognised that their knowledge is often marginalised. As a child said, "some adults think because they are older, they know more, and they won't listen to anything you say". This was reinforced by another when they claimed, "when you are talking to adults, they pull a

very big poker face to make you think they are listening, but they are just nodding, and it is going through one ear and out the other".

The children's experiences coupled with the meaningful relationships they developed, reinforced their sense of epistemic worth as knowledge creators communicating about forest systems and forest health. The children's growing sense of epistemic worth was a direct result of the supportive guidance that flowed from the children's relationship with the facilitator and the TTN project team. As a child said about contributing to the community's resources of kauri dieback, "I feel very proud to know that you have done something".

4.2. Opportunities for Deep Engagement

A key objective of the learning process was to foster the children's confidence to develop their own artistic interpretations of forest health, using graffiti as an artform. To build confidence, the facilitator created a sense of excitement about using graffiti by introducing the children to the history of urban and graffiti art. They learnt about graffiti as vandalism, acts of writing, or 'scratching' messages in paint on walls. They learnt about the practice of graffiti art through the 1970s and 1980s, when graffiti 'writers' shifted to being graffiti 'artists', no longer solely interested in their content, but instead in how their message was created [68]. This created excitement amongst the children by their engagement with an art-form with a 'dark' political history.

A core practice initiated by the facilitator involved 'reading murals'. To do this, the children toured their school, identifying murals and artwork on walls around the grounds, spending time looking at them, then sharing one single word that came to mind when they viewed them. By using one identifying word, the children could share their thoughts without needing detailed explanation. This allowed space for others to respond non-judgmentally. Children started to recognise urban art in their community. They would come to the sessions excitedly sharing a few words of what they had 'read' in a mural they spotted from the back seat of their parents' car. This practice was integrated into how the children would read each other's creations as they emerged during the project's various stages.

The children needed to also develop artistic confidence. The facilitator got the children to begin by working on pieces of paper with paint sticks imitating the act of creating artwork on a larger canvas. Paint sticks encouraged a less specific way of drawing than a pencil or felt-tip pen, creating larger strokes with less detail. The paint stick provided a sensory experience where outline, colour, and shading changed with different strokes. Spray cans were introduced, and the children put together 'placards' about the environment for a school drama production. They also experimented using spray-cans on the container, practising the outlines of their own drawings. Although each child displayed various levels of mastery, these experiences contributed to both their individual and collective decisions about the artwork, as they considered bold, graphic reinterpretations of their illustrations to match their skill-base.

To promote the children's sense of agency, they were tasked with generating all of their own material. This celebrated their skill as child artists and their contributions to the collective narrative. The children benefited from the freedom the facilitator gave them of being able to develop far more material than would be needed, as this provided the opportunity to create and consider their own thoughts, opinions, and knowledge without being inhibited by the limitation of space. It combined both Pohatu's [62] and Heathcote's [64] participatory methods by empowering children to draw from and value their own knowledges, ensuring there was always time to deeply consider their individual and collective creations before taking action.

The children grew to recognise the need to slow the process down so they could consider things before taking action [62]. The children's recognition of engaging slowly in a process is represented by the following child's comment, "You have to go through the process, you can't just skip to the painting. If we did not learn about it, we would not understand it".

Combined, these experiences of deep engagement in a process of learning about artistic practice and forest health, developed the children's knowledge, skill base, and confidence to paint a mural the size of two shipping containers. It fostered in the children what Fricker [17] calls epistemic courage and epistemic worth. It resulted in the children recognising the value of meaning making to environmental communication. The children wanted their artwork to be meaningful and not simply beautiful as the following quote reinforces, "It does not matter if it looks good, it just has to have a meaning".

This desire for meaning in their narrative, over simply beautifully painted shipping containers, emerged as a direct consequence of their deep engagement as evidenced in the following children's comments. "It's not like we just painted—it's meaningful. Around the school there are lots of murals, some of them have a bit of meaning and some look really cool but they don't have a meaning". And another, "I have seen people painting things, little pictures of unnecessary things . . . there is this mural on my dairy and it's got like a skateboard on it to stop people spray painting, but it does not mean anything. They could have at least put some meaning into it". This prioritising of the narrative is further evidenced in the children's two visions of environmental futures painted on the shipping containers—a world with and a world without kauri dieback.

In addition their deep engagement in the process of learning led to them feeling proud for having persevered in a long learning journey, as evidenced by the following quotes; "You really need to trust the process". And another stated, "[Child's name] and I wanted to quit because we thought it was going to take too long, but we are both really glad that we stayed in". While another said, "We were kind of thinking, if you did quit you would not be able to finish it and you would then never know how good it was to finish it and to feel proud".

4.3. Spaces for Individual and Collective Thinking

Fricker states the marginalisation "cramps the very development of self" [17] (p. 163). To build self-esteem and develop individual thinking, workbooks were given to each child to provide a private space to journal their thoughts, feelings, and opinions in words and drawings and to practise sketches in their own time and during the sessions. Some children took their workbooks everywhere with them not knowing when inspiration would arrive. During a session, children would share a new creation and then work on transferring it from their workbook to a larger sheet of paper. To help them to share their sketches, children were asked to choose their favourite piece to enlarge, which avoided the facilitator from directing the child's choice of art. Children would sometimes seek their peers' opinions, creating opportunities for collaboration and empowerment that uplifted their self-esteem and reinforced their worth as knowledge and artistic creators.

The workbooks allowed the children to document their research and discoveries. The success of these books in building children's sense of epistemic worth about their continually growing knowledge of forest health was seen in the 'jottings' that children shared from these books. Some focussed on native animals which they independently researched, noting characteristics of endemic species to develop in their drawings. Others explored forest health and the positive and adverse effects of environmental and human impacts on te ao kararehe (flora and fauna). This learning was self-led and often involved personal discoveries that were not always shared.

While the workbooks encouraged individual thinking, a 'Design Wall' in the classroom in the form of a tree, known as toi rākau, provided a large space where children's sketches, drawings, and images could be pinned up for all to see. As the design wall grew and "turned into a big massive artwork", the children returned to 'reading' the artwork, slowly identifying repetitive images and colours. These observations were key for the children in making their later collective design decisions, informing for example their collective thinking around colour and motifs.

Group discussions were central to enabling the children to think as a collective to develop their narrative. Open-ended questions were used by the facilitator to provoke

discussion. For example, "If you make half the mural the sea and the other half the land, how would someone looking at the sea-side know your story of kauri dieback?" or "How do you wish to present your contrasting stories of kauri dieback and kauri/ngahere ora? How can you show 'risk and uncertainty or not knowing?"

These discussions enabled the children to develop the mural's collective narrative. They decided to present the land, the water, and the sky to show a connected natural ecosystem. They identified images from their design wall, such as maunga (mountain), te ra (the sun), and awa (body of water) as important elements in their narrative. They layered this with flora and fauna, including birds, frogs, mushrooms, and flowers. A key motif was a half-dead kauri tree. This reflected a real tree on a road near the school. It was a tree known to all, and this dying tree had been a dominant image in many workbooks. The children therefore drew from their own personal experiences and from their local environment.

By transferring their design wall to a smaller cardboard model of the shipping containers using a process of collage, the children were able to 'read' their mural using the previous technique of reading murals with one word. This revealed that their mural did not yet tell a story.

The children then decided to collectively focus their narrative on two contrasting environmental futures; a living forest and a dead forest, described colloquially by the children as the 'dead-side' and the 'alive-side'. The dead-side, painted in grey and white, showed a dire future which would be brought about by not responding immediately to the threat of kauri dieback. As one student stated, "if we sit back and relax now and leave it for another 10–15 years it will be too late". In contrast the brightly coloured alive-side, was as one child described, "This side is hope. So the hope is like—you see there is really green grass and there is no plastic and there is nothing in the water it is all clear. Everything is healthy".

Student-led collaboration enabled the children to think innovatively and creatively. They developed artistic iterations of microbes from the pathogen that causes kauri dieback inspired by a virtual reality show they experienced during one of their sessions. They referred to these as the 'kauri monsters'. These innovative fantastical characters were added to the mural in a size similar to the children themselves. On the white-and-grey-coloured dead-side of the mural, the brightly coloured kauri dieback monsters (pathogens) stood out to look "really evil and cartoony", and the choice of yellow and red colour made them "look more germy". Reflecting on their artwork as a way of communicating an important environmental issue, a child said, "I am very glad we did not just say it, I am glad that we can also show it".

The opportunities for individual and collective thinking that were provided in the project resulted in the children developing a message that had deep meaning and a strong narrative of alternative futures. Their innovative creations captured in their workbooks and transferred to the design wall for all to see led to their clear and central message that embraced both their individual and collective desire for action, urgency, and humans to take responsibility for the environment. As the children called out in unison at the conclusion of the project, "Look after the earth, save the kauri and start now". One child added, "Everyone must do their part. Everyone must do a little bit". They had developed epistemic confidence and wanted to share with their community their knowledge, vision, and call to action for kauri dieback and ngahere ora/forest health.

4.4. Time for Deliberation and Reflection

The slowing of the engagement process to enable time to consider before taking action as Pohatu [62] recommends, provided the time and space for deliberations. The facilitator provided space and time for the children to deliberate around a large table to reach decisions through consensus decision-making. However, on some occasions, the children could not agree. To promote the children's sense of agency they were invited to find their own ways through any disagreements, or as a child described, "we had to figure

it out". On a few occasions, on a few challenging decisions, they opted for a voting process. This occurred when choosing the containers' base colour, when diverse and divergent opinions emerged. Although not all children initially agreed with the chosen pale green colour, when eventually painted on the containers all agreed it was a "brilliant choice".

Opportunities for reflection are recognised as an essential component in adult learning as a way to think about and learn from one's experiences [69]. Similarly, reflection time was an essential component in the children's deliberative process. Reflection time often stimulated new ideas which were welcomed at all stages. Reflection time gave opportunities for the children to share what was working and what was not. It was in this reflection time that the children recognised and acknowledged how important the design wall was for their process of collective creativity. One student remarked, "It was the first time I forgot what work was mine and I knew even if I missed a class, all of it was our story". This shows evidence of a child valuing the importance of collective creativity and collective responsibility. Such thinking is essential for developing formative ideas around collective responsibilities needed by humanity to address environmental sustainability.

These experiences engaging in deliberation and reflection resulted in the children developing a changing relationship with the environment, one that recognised human impacts and responsibilities for the planet, as one child remarked, "I am a lot more vigilant person about the environment after these two years". While another student expressed her changing emotions about caring for the environment when she remarked, "If I am going to be honest, when I was little, I did not think it was fun to take care of the environment and now I kind of do think it is fun".

5. Discussion

In this section, we revisit Hickey-Moody et al. [19] and Heggen et al.'s [20] key concepts of 'eco-citizenship' and 'little publics' to examine our findings about how to address epistemic injustice using art-based practices. We also examine in what ways the container art project rebalanced the underlying power structures that Fricker [17] and others [70] argue drive epistemic injustices.

5.1. Developing Children as Eco-Citizens

The container art project provides evidence of how children can speak more broadly as eco-citizens practising what Heggen et al. [20] (p. 391) call "a child-sized eco-citizenship". Our findings show that these experiences allow children to engage with a "more than human world" that is relevant to them (p. 388). The children's engagement and growing sense of epistemic worth fostered positive relationships with nature through their engagement in the container art project, as evidenced by their comments, and their completion of the containers' mural which embodied a narrative showing contrasting environmental futures. Heggen et al. [20] highlight the link between curiosity and motivation to engage children in eco-citizenship. The container art project shows that when children are motivated, they can develop deep engagement in a process that allows them space and time to develop their individual and collective thinking with regard to vulnerable ecosystems. They show deep concern and interest in the future of the planet and can visualise different environmental futures depending on how quickly humans act. They want to be listened to and they want to be able to share with others their environmental views and visions.

Behavioural change approaches, which are favoured by anthropocentric positionings of environmental management to gain public acceptance of biosecurity controls, limit children's engagement and involvement in environmental issues since they view children only as recipients of messages and not as active vibrant knowledge creators. The container art project shows that child-centric approaches to learning which value children's views, knowledge, and opinions, can empower children in epistemically just ways to slow down, to dream, and to act to support positive environmental change.

Creative art practices undertaken in a child-centric learning environment, as documented in this research, can provide a way for children to express a sense of eco-citizenship.

The children in the container project found it exciting in a slightly dark way to use graffiti as an art form. Graffiti art on shipping containers offered a space for young children to comment and contribute from their own perspective through the act of narrative building, meaning making, drawing, and painting. Giving children agency to be 'dreamers' and 'activists' contrasts with the media's negative framings of these stereotypes [57]. As the children in this project show, it is exciting for children to develop 'how' a message will be communicated, and not solely 'what' they will say. Art-based practices provide an effective and engaging way for children to present material to wider audiences in meaningful child-centric ways.

5.2. Fostering 'Little Publics'

The findings show the importance of providing opportunities for children to critically think and deliberate about their understanding of their world and to collectively share in open and transparent ways. Collaborative tools such as the design wall and the reflective times provided opportunities to move beyond individual thinking, to work collaboratively, and to develop collective thinking.

The sessions which fostered discussion, debate, and other deliberative processes provided space for the children to develop their unique perspectives showing how "little publics are, by constitution, spaces in which young people are heard" [19] (p. 22). It also provided a space for children to bring into their publics the more than human world. This was evidenced in their mural which included mountains, rivers, the ocean free from plastic pollution, animals and birds—including a duck, gecko, and Myrtle the Emu, the half dead/half alive kauri tree from their neighbourhood which featured prominently in the centre of the mural, the 'kauri monsters' or pathogens, the factory billowing out smoke contributing to global warming, and the contrasting environmental possibilities—where humans act now to protect the environment and where they do not (see project storymap in Supplementary Materials).

A child-centred approach promotes epistemic justice by valuing children's perspectives. The container art project gave the children a sense of agency to express themselves in a distinctly unique way. Hickey Moody's concept of 'little publics' and art-making became valid acts of participation, enabling the children to communicate their environmental narrative and visions in ways that were relevant and meaningful to them.

5.3. Re-Balancing Power Structures

To address epistemic injustice requires the underlying power structures that cause such injustices to be rebalanced, as these lead to exclusion and marginalisation [17,70]. Local initiatives, however, are often criticised for not impacting on structural inequalities and for their limited ability to bring about any social change beyond those who participate [15].

Power structures were evident in the collective understanding and institutional structures of the agency responsible for managing the forest park, that did not recognise the children's experiences of connection with their neighbouring forest and then of their loss when it was closed. They also did not recognise the children's sense of marginalisation and feelings of exclusion from the environmental decision-making processes of a forest park that mattered to them and which they often visited. The children's sense of marginalisation was compounded by the suddenness and unexpectedness of the forest closure, the limited communication around the closure, and the agency's lack of ongoing engagement with the community over the long-term management of the forest.

Although the agency had not intentionally sought to marginalise the children, they nonetheless created a hermeneutical epistemic injustice. The agency's focus primarily on meeting regulatory obligations limited their ability to recognise those affected by their actions [36]. Furthermore, the agency had given little consideration to the likely wavering over time of community's acceptance of the forest park closure. We are not questioning the legitimacy of the decision to close the forest. However, the container art project shows that with such decisions comes social consequences and, concomitantly, we would argue,

responsibilities for environmental agencies to prevent affected communities from feeling marginalised and disconnected from their local natural environments.

Evidence from the container project showed that it did impact the underlying power structures that had led to the children's sense of marginalisation. The agency responsible for managing the park did visit the children at the school following the research team's approach, where they read the children's letters, engaged in dialogue, and explored options for ways that the children could be involved in the park's management. It was at this session that an extension project was proposed for a group of senior children to extend their engagement and learning from the larger TTN project and create artwork on forest health for the park's gates. The container art project emerged out of this dialogue.

While the agency was not actively engaged in the project's weekly engagement with the children, they have agreed to support an installation of posters derived from the container art on the park gates with a QR code to the storymap which tells the story of the project and which invites people to come to the school to view the containers and learn more about kauri dieback and the children's vision for environmental sustainability. In addition, the agency has expressed an interest in exploring how the project might act as a catalyst for other schools in the region to undertake similar initiatives to install children's art on the gates of other forest parks closed by kauri dieback.

Projects working with children should consider engaging policy and environmental agencies in their work. When this is done in a mutually respectful way, as occurred in this project, agencies and children can learn from each other and can explore ways to creatively engage children in environmental communication. The children's artwork has contributed to society's epistemic materials on kauri dieback and forest health through both the container art and the accompanying storymap. By facilitating the children's engagement through art-based practices and through their relationship with the agency, the children developed what Fricker [17] calls "epistemic courage". This enabled the children to establish a new relationship with the forest park, one that no longer required them to physically enter it, but instead where they could advocate for its protection. The agency's eventual recognition of the children as knowledge holders developed in the children a sense of epistemic worth.

The container art project also rebalanced the power relations that are often evident in the learning process. In addition to the child-centric approaches discussed above, the project also drew on TTN's approach to engagement with schools, which used the Māori concept of ako torowhānui (holistic learning). This approach embraces the various cultures students and teachers bring to a project, as a 'critical multiculturalism' to traverse and contest more normative individualist, disciplinary, and teacher–student hierarchical Western teaching techniques that isolate tamariki (children), particularly Māori, from their culture [71,72]. Holistic inclusive approaches to learning can benefit a wide range of learners by empowering them in the learning process. Furthermore, by drawing from Måori concepts of holistic learning, the container art project sought to address epistemic injustices that have also afforded lesser value to Indigenous Māori knowledge and approaches in educational settings.

6. Conclusions

Children represent one example of a marginalised group that faces epistemic injustices. This article deepens understanding about how to address children's sense of epistemic injustice in environmental sustainability contexts through their engagement in art-based practices. The children in both TTN and the container art project wanted to contribute to solutions to address forest sustainability and their reflections and artwork displayed both a sense of urgency to act and a responsibility towards protecting the forest and the wider natural world. The container art project shows that local environmental issues can provide suitable opportunities for children to engage and contribute to sustainability. This is particularly important when children feel marginalised from decisions that affect their ability to interact with their local environment. While the container art project worked with

only 15 children, the artwork and its accompanying resources extend beyond the children who participated.

The children's engagement in the container art project, and their reflections on their learning indicate that a child-centred approach which fostered an environment where the children's views, values, knowledge, and opinions were respected, enabled them to re-establish their relationship with their local forest park. Importantly, their re-established connection with the forest was no longer reliant on the children needing to enter the forest. By contributing to the forest's management as environmental communicators, the children told others about kauri dieback, and in doing so became advocates for the forest's closure to protect its kauri trees from kauri dieback.

We challenge largely top-down approaches of science outreach with children that focus solely on informing or educating children through didactic approaches to build their awareness and interest in science, as these treat children only as audiences of science messages. Programmes like the container art project that engage children as active learners and are child-driven and centred, can foster deep levels of engagement, and facilitate children's involvement in environmental communication. At the same time, children can develop meaningful relationships with nature. Importantly, they can also rebalance the power structures that may create epistemic injustice. When children, even young children are marginalised from decision-making, particularly around local environmental decisions, this can lead to a strong sense of loss, disconnection from nature, frustration, and even anger. Given the intergenerational nature of sustainability, children should have opportunities to contribute to addressing environmental issues.

Art-based practices can be seen to be particularly valuable for engaging children, as they enable children to be innovative and creative as knowledge contributors and to express their hopes and dreams for environmental futures in ways that are relevant to them. The marginalisation of art-based practices from science engagement can itself be viewed as an example of epistemic injustice. The container art project shows that engaging young children in programmes where they have opportunities to be creative and imaginative, and where the facilitators value their knowledge, ideas, and opinions, can foster children's epistemic courage and worth, and address epistemic injustices that otherwise continue to marginalise children from environmental issues and decision-making.

Limitations of the Research and Future Research

We recognise that transdisciplinary researchers partnering with schools, or with any organisation or community where there are marginalised groups, must commit significant time and resources to any engagement that seeks to address epistemic injustice. The siloed nature of science and academic institutions, and the westernised structures of schools with curriculum requirements and structured timetables, create significant barriers for this type of engagement.

We acknowledge that these projects are context specific, driven by local issues and local knowledge, so they cannot be replicated in an experimental sense. However, we hope others will draw from the key insights presented in our findings and discussion, and be inspired to explore similar engagement in different contexts.

Supplementary Materials: The following supporting information about the container project, which details in a storymap the project's engagement methods, and includes pictures and video, including a timelapse video of the painting of the containers, can be viewed at: https://arcg.is/1zXL9C, accessed on 1 February 2024.

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Elite Speech about Climate Change: Analysis of Sentiment from the United Nations Conference of Parties, 1995–2021

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Abstract: The Conference of Parties (COP) is the longest running forum for international discussion of climate change and offers rich data in the form of speeches. Studying how elites have historically communicated about climate change can help us understand their approaches to address climate change. In this study, we analyzed 2493 COP statements from 1995 to 2021 to describe how sentiment is used, and to see whether specific issues associated with climate policy (adaptation, mitigation, financing, development, disasters) are discussed in particular sentiment contexts. Quantitative analysis (sentiment analysis with multi-level modelling) revealed that leaders expressed high levels of positive sentiment in these diplomatic statements, but also some negative sentiment. Over time, representatives at COP used more positive, angry, and fearful sentiments in speeches. Representatives of wealthier and more developed countries expressed themselves differently than those from less wealthy and developing countries. To examine sentiment surrounding policy issues we used embedding regression. Countries expressed different sentiments about adaptation, mitigation, and development depending on their development status, and about disasters depending on their wealth. Shifts in sentiment over time were observed when results were plotted graphically, and these shifts may be related to specific events and agreements. Using these two approaches, we highlight how those with the power to make top-down changes to address climate change have historically talked about this issue.

Keywords: climate change; climate change negotiations; UNFCCC; computational social sciences; text analysis; sentiment analysis; climate change communication

1. Introduction

Severe climate change impacts such as increased extreme weather events, forced migration and displacement, and sea-level rise are occurring or will soon occur [1]. Addressing climate change through mitigation of greenhouse gas (GHG) emissions requires collective action and cooperation across the world. Adaptation is also required to help people and communities cope with a changing climate, but this requires transfer of technology, knowledge, and funding to ensure that those most impacted can adapt. To facilitate this kind of cooperation, international environmental agreements have been established which codify cooperation and shared climate goals [2,3]. One example of the use of these agreements is the United Nations Framework Convention on Climate Change (UNFCCC), which created a forum for leaders from around the world to discuss climate change mitigation, adaptation, and climate impacts. In our work, we explored the proceedings of the UNFCCC to gain insight into the types of sentiment expressed by high-ranking representatives in speeches about climate change delivered at an international forum, and predictors of such sentiment. Sentiment in speeches can reflect the public position and attitudes of speakers [4,5], and in this case allowed us to see how elites (i.e., people with power, high-ranking decision-makers and officials, politicians) engage with the issue of climate change.

Using state-of-the-art computational approaches, we analyzed archived statements from the Conference of Parties (COP) spanning from 1995–2021. We had three questions: first, how has sentiment in elite speech about climate change shifted over time? Second, does sentiment in speeches differ as a function of characteristics of a representative's country? Third, what sentiment is associated with specific issues of adaptation, mitigation, financing, development, and disasters?

1.1. Sentiment in Elite Speech and Climate Change Emotions

Systemic changes from leaders will be necessary to address climate change, and examining the communication methods of elites who may be positioned to make these changes could provide insight into their attitudes. Leader and political communication in its various forms has been the subject of much scholarship to understand social phenomena [5–7]. The tone and focus of public discourse within a nation can be influenced by leaders, and leaders will alter their speech depending on public attitudes [8]. Authority figures have strong social influence [9,10], so the ways that they discuss issues are likely to influence individual attitudes and behaviors.

Sentiment is a feature of leader speech that has been studied [4,11]. Detecting expressed emotions in speech provides insight into leader attitudes towards specific issues. In the climate change domain, the role of emotion in communication has also received considerable attention [12–16]. In this study, we focused on fear, anger, sad, positive, and negative sentiments, because there is work in the climate communication domain which suggests experiencing or eliciting these emotions has an influence on attitudes and behaviors.

Fear, for example, is associated with a motivation to engage in protective behaviors to avoid a threat. In the context of communication about hazards, however, it has been found that evoking fear is insufficient on its own to promote protective behaviors; additional kinds of information must also be included, such as provision of possible solutions to avoid or mitigate the threat [17–19]. When talking about climate change, leaders may attempt to evoke fear as a call to action—to draw attention to a threat that needs to be addressed.

Anger can indicate experienced harm, assignation of blame and responsibility, and motivate collective action [20,21]. When people perceive that the majority feels angry about climate change, this increases their support for climate policy [22]. While we might expect that leaders would avoid anger in the name of diplomacy, there is a history of leaders expressing anger as a means of eliciting concessions from those they are communicating with [23]. It has also been found that leader speech containing anger can precede acts of aggression [7,24]. Climate change is a justice issue [25,26] and leaders may use the international stage to draw attention to this injustice and express anger to increase support for policy change.

Individuals experience sadness in response to a loss, and the emotional experience can promote reflection, rest, and signals distress to others to elicit helping [27]. Messages about climate change which convey sadness can increase individual pro-environmental behavior [28]. Leaders at COP might use sadness to draw attention to losses they have experienced (e.g., disasters), or to try to obtain assistance.

Positive sentiments such as hope and optimism are important at the level of an individual, particularly in the face of an existential threat such as climate change that requires long-term engagement [29,30]. It has been theorized that positive emotions promote collective action, for instance, because feelings of enthusiasm might increase loyalty towards political leaders and thus willingness to take action [31]. Pro-environmental attitudes and behaviors may also be increased through positive emotions [32].

When communicators choose to use sentiment, different emotions being elicited or expressed have different implications for the audience. Leaders might strategically use different framings to evoke emotions in the audience. Impassioned speech could be used as a means of garnering support from an international audience. On the other hand, leaders might hesitate to use emotional language for the sake of diplomacy. Some work has also found that expression of emotion as compared with neutral language can undermine a

communicator's credibility [33,34]. The emotion in speech might also be influenced by and reflect societal events [35]. Studying sentiment in the speeches delivered at COP provides insight into the attitudes and potential motivations of leaders and may reveal trends in sentiment over time. Besides describing the sentiment in these speeches, we delved into two questions: first, how has sentiment in statements changed over the course of the COP, and second, how do other contextual factors (features of the speaker's country, topics of discussion) relate to sentiment?

1.2. History of the Conference of Parties

To study elite speech on the topics of climate policy and impacts, we used the context of the UNFCCC. The UNFCCC is an international treaty adopted in 1992 to address climate change [36]. An important feature of the Framework Convention is that it separates party members into Annex I and Non-Annex I countries, representing developed and developing nations, respectively. The UNFCCC established the COP as a forum for parties to negotiate commitments. At these annual conferences, politicians, ministers, and other governmental staff, along with some observers (such as NGOs and research groups) are provided with the opportunity to communicate and negotiate. Key agreements, including the Kyoto Protocol, which entered into force in 2005, and the Paris Agreement, which entered into force in 2016 [37], resulted from these conferences. Longer discussions of the development and history of the UNFCCC and COP are available elsewhere [37–41]. Our interest was in studying statements from COP1–COP26 to describe elite sentiment about climate policy and issues.

1.3. Existing Analyses of COP Statements

Researchers have studied communications from the COP using a variety of methods. Traditional qualitative approaches have included the discourse analysis of a set of speeches from the Convention on Biological Diversity [42] and the study of whether Annex membership influenced the negotiation processes by coding statements to identify whether they declared support for other parties [43]. These examples employed traditional human coding approaches which allowed for in-depth exploration and interpretation of statement content. However, these approaches are limited by the number of statements that can feasibly be included. Computational text-as-data approaches offer alternate methods of classifying, describing, and extracting the contextual meaning of text [44], and we employed these methods in our study.

Some analyses of the COP have utilized computational analysis, reflecting the growing interest in the field for using these methods for large corpora. For instance, Genovese [45] analyzed text to see whether being part of a coalition can result in the convergence of views depending on the similarity and affinity of the members of that coalition. Using word embeddings, they identified the relative positionality of countries using speeches from COP16–COP22. By creating similarity scores between pairs of statements, they evaluated whether statement similarity was explained by membership in coalitions, shared Annex membership, similarity in climate risk, and other features of the countries (e.g., language, geographic distance, ideological similarity) [45]. This study found that the statements of members of homogenous groups in the UNFCCC were similar, and belonging to a coalition increased statement similarity. Another study from Mehmood and Honkela [46] employed a feature extraction approach to generate a term-frequency matrix, which they then represented visually in a two-dimensional space using a Self-Organizing Map to clarify statement similarity. Besides identifying similarities across statements, they were also able to include contextual information about the speaker's country (e.g., socioeconomic characteristics) and tested whether this information related to similarity. While these two studies make use of new computational approaches to studying text, both used a limited number of statements, and did not examine sentiment.

1.4. The Current Study

Given the volume of speeches delivered over the past two decades, human coding approaches would be infeasible. One of the strengths of computational text analyses that we leverage in this study is that they can extract information from large quantities of text data. Sentiment analysis allows us to evaluate the level of emotive expression. In dictionary-based sentiment analysis, terms in a document are compared to the terms in a dictionary that consists of lists of words which have been assigned a sentiment score [47]. Counting instances of terms associated with sentiment, and weighting in multiple ways (e.g., the proportion of the frequency of sentiment scored terms to the length of a document), an overall sentiment score for a given document can be calculated [48]. This bag-of-words approach, is useful for broadly describing and understanding a phenomenon through large bodies of text [49], and in our study allows us to understand sentiment at the document (statement) level in relation to the time period and representative's country characteristics.

However, this approach does not account for context, which is a recognized limitation of bag-of-words sentiment analysis [50,51], including the inability to incorporate negation into the computation of sentiment. Another method we use to analyze sentiment while taking the context into account is embedding regression [52]. This state-of-the-art approach allows us to understand sentiment towards specific policies and issues while considering characteristics of the representative's country. Because words tend to be used in certain contexts, each word in a sentence can be numerically expressed using the distribution of co-occurring words, and a sense of meaning can be extracted through these word embeddings. By using distributions of words surrounding key terms, embedding approaches allow us to better understand those terms in context, and in relation to other relevant terms and word lists [52].

1.4.1. Sentiment Trends over Time

In this study, we employ sentiment analysis in combination with two analytic methods, multi-level modeling and embedding regression, to study three questions. First, how has sentiment changed over time from the first conference in 1995 until the 26th in 2021? The impacts of climate change have accelerated in the past decades, along with GHG emissions. Since the start of the UNFCCC, there has been increased research on, documentation of, and understanding of climate change and its impacts [1]. These phenomena likely influence sentiment. Further, because there has been a failure at a global level to meet targets set for GHG emissions, and the time to prevent potentially catastrophic environmental tipping points is becoming shorter and shorter, frustration might increase in speeches. While there have been efforts towards sustainable solutions to climate change, overall progress has been insufficient, and impacts of climate change have increased, which may result in greater negativity, more fear, and more sadness in acknowledgement of these losses and failures, and greater anger towards a failure to achieve targets. We also believed positive sentiment might decrease due to less expressed hopefulness or optimism. However, key events which took place might disrupt this trend (e.g., increased positivity and less negativity following COP21 and adoption of the Paris Agreement).

1.4.2. Sentiment towards Climate Policy and Impacts

Second, how do leaders talk about different issues in relation to sentiment over time? There are different facets of climate policy and impacts that leaders have focused on. Sentiment is highly contextual in terms of the topics that a speaker delivers, which can generate a document with a mix of opposite types of sentiment. In embedding regression, we can identify seed words which we then examine in context. Here, we chose to focus on 'adaptation', 'mitigation', 'financing', 'development', and 'disaster'. In its initial version, the UNFCCC had the overarching goal of mitigating GHG emissions to limit concentrations of such gases to prevent "dangerous anthropogenic interference with the climate system" (p. 4, UN, 1992). While mitigation was a major goal, the view of some was that adaptation efforts were akin to giving up [44]. One argument was that relying on or planning for adap-

tation would impede mitigation efforts [53,54]. However, it is apparent that adaptation is needed—climate impacts and increasing vulnerability of people around the world demand action. While mitigation requires global efforts, adaptation can be achieved at a smaller scale if those implementing adaptation have access to the necessary resources [54]. Within the UNFCCC, adaptation was discussed during the first conference, yet the adaptation fund was not established until COP6 [55]. An adaptation committee was established in 2010 to better coordinate support for adaptation projects [56], although at the same time the adaptation fund was considered to be severely underfunded. At COP15, parties agreed that $100 billion USD would be needed yearly and yet the following year the fund contained only $30 billion.

The second set of terms relevant to the UNFCCC are 'financing' and 'development'. Annex I countries were initially expected to be the leaders on mitigation and adaptation under the Kyoto Protocol, but the Paris Agreement calls on all parties, including Non-Annex I parties, to establish GHG commitments [37]. However, the overarching principle that parties with more wealth, greater access to technology and expertise should still be leading the way and helping other parties achieve their goals remains. Sentiment towards financing might vary, such that representatives from Annex I and higher income countries discuss positive aspects of financing (e.g., money they have contributed), whereas those from lower-income or developing nations would discuss financing in the context of calls to action. Next, development is an important issue under the UNFCCC, given that one of the conditions is that the efforts to address climate change should not impede development or developing nations [37]. The development of high income countries relied on fossil fuels which developing nations are now discouraged from using. Attitudes towards development may change over time as GHG emissions have continued to increase, in part due to pursuit of continued economic growth and development. Developing nations might express different attitudes about development than developed ones—perhaps greater hope or optimism about their development, or negative sentiment due to concerns about the difficulty of pursuing sustainable development pathways.

Finally, we wanted to examine sentiment surrounding the consequences of climate change. We chose to examine how these elites talk about disasters. Climate change is associated with the increased frequency and intensity of many natural disasters [57]. Studying sentiment towards disasters, whether it be in pleas to take action to prevent harm or in the context of acknowledging losses, is one way that we can understand how the impacts of climate change are being felt. Previous work has found that experience of disasters is associated with increased belief in anthropogenic climate change, and increased concern about the risks of climate change [58,59], and perhaps communication about or reminders of disasters would also reflect this. Besides studying sentiment towards these climate-related seed words over time, there are also interesting questions about variation in sentiment by features of the representative speaker's country.

1.4.3. Positionality of Leaders and Sentiment

Because leaders from different countries have different motivations in coming to the COP, our third main question was how features of their country—income, climate risk, and Annex status—relate to sentiment. There are 197 parties to the convention, and these parties are diverse in terms of socio-economic features, responsibilities according to the UNFCCC, and climate risk.

One characteristic of the convention is that responsibilities and commitments are not equally distributed across parties. Annex I countries are seen to have greater responsibility to address climate change through mitigation and adaptation because of their historical contributions to GHG emissions and their access to resources to be able to implement climate solutions. Although the Paris Agreement changed the way that responsibilities are distributed from legally binding agreements (Kyoto Protocol) to voluntary emissions targets [37], there is still an expectation that efforts on climate change should be led by Annex I countries. In their statements, we would predict that Annex I countries would

want to focus on the positives and achievements (e.g., highlighting how much money they have contributed by discussing financing positively), and would be less likely to draw attention to their own failings, or to spend too much time emphasizing the need for urgent action, because they bear greater responsibility to take such action. On the other hand, Non-Annex I countries which are developing and lower in income may be more willing to draw attention to the negatives: the impacts of climate change that they are not able to deal with effectively (e.g., speaking about the negative impacts of disasters) or concerns for their country's uncertain future. However, an alternate argument could be made that lower income countries would want to avoid negativity and blame (i.e., anger) in their speeches to ensure that other parties are still willing to provide help to their country. As compared with developed countries which have already reaped the benefits of fossil fuels during their economic and industrial development, developing countries are pressured to pursue more sustainable development pathways, even when those pathways are difficult to realize. Discussion of development might be more fraught for Non-Annex I countries which have a right to develop, but who are also constrained and asked to do their part in mitigation following the Paris Agreement. For this topic, sentiment differences may be more nuanced as well, such that differences by Annex may be less apparent than differences by income.

The harms of climate change are not equally distributed and vary greatly as a function of location. Extreme weather events have disproportionately impacted poorer countries [60]. We predicted that sentiment would vary by risk exposure: countries that are highly vulnerable to climate shocks would be more concerned about the issue of climate change. Thus, some speakers would be more motivated to draw attention to climate harms and losses they may have experienced (which will likely include fear and sadness, particularly around disasters), and more blame towards those they may perceive as being responsible for failures to prevent such harms and losses (expressions of anger).

Prior to the computational analyses of these texts, both authors read a hundred statements from each Annex, randomly sampled across years, and this reading informed some of these predictions. In addition to looking at each predictor of sentiment on its own, we wanted to identify whether any of these were uniquely predictive of each sentiment using regression models. In past work, Annex membership, for example, was found to be a strong predictor of statement similarity between parties, above and beyond other characteristics [45]. Certain features might interact to predict specific sentiments. For example, income could interact with climate risk to predict sadness, such that the relationship between climate risk and sadness is strongest for lower income countries, which have less ability to address the climate risks they face, and thus express sadness in the face of inevitable loss. Because the literature on the corpus of interest (and generally on political speech about climate change) is limited, we did not make specific predictions regarding which country features will most strongly predict each sentiment nor about how they might interact.

In the following sections, we will describe the data used and the way it was prepared for analysis. Next, the methods of analysis are explained. First, we explain how sentiment analysis was used in conjunction with multi-level modeling. Second, we discuss our approach using embedding regression, a method designed by Rodriguez and colleagues [52] who refined this analytic approach using earlier work and data from Osnabrügge and colleagues [34]. Although the first method we used allows us to broadly understand sentiment at the document level, using word embeddings in conjunction with sentiment analysis allowed us to understand sentiment in context. The results of these two approaches are then discussed.

2. Materials and Methods

2.1. Corpus and Meta-Data

The primary data used in this study consisted of publicly available records of statements delivered at COP from 1995–2021. Although these statements vary in length, given the time limit provided to speakers, most consist of one to two pages of text. All available statements (N = 3501) were downloaded from the UNFCCC Digital Archives

(https://archive.unfccc.int/ (accessed on 17 June 2023)). All analyses were performed using R. Before pre-processing, all non-English language speeches were removed (n = 960), first by using the cld2 package [61] to detect language, and then by manually checking speech classifications. Next, duplicate records were removed (n = 48). The corpus consisted of 2493 statements, 1886 of which were delivered by representatives of a country (rather than observers or UN leaders). Details and descriptive statistics for the documents, and details on the pre-processing of the text are provided in the Supplementary Materials. The top 150 terms in the corpus following removal of stop words are shown in Figure 1. Although frequency of a word does not necessarily represent its importance, reviewing these top terms helped us to identify the seed words we used in the later analyses.

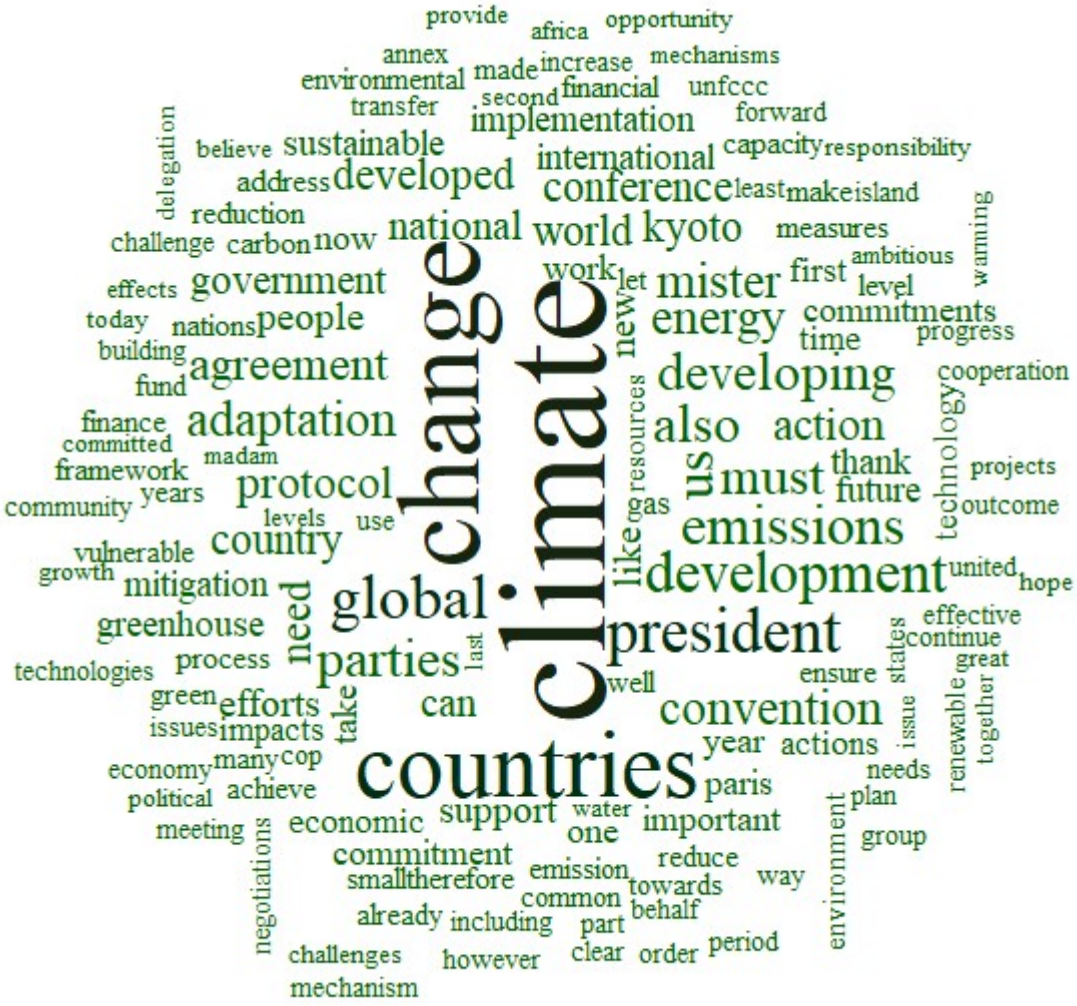

Figure 1. Most frequent terms in the corpus. Note. The size of words in the word cloud reflects their frequency. The seed words used in the embedding regression, apart from 'disaster(s)' and 'financing' emerged in the top 150 terms.

For each statement from a country representative, where it was available, we attached meta-data including that country's income, climate risk, and Annex membership. In the corpus, there were statements from 177 countries, none of which had a dominant presence. Australia, Japan, Kenya, and Indonesia had the most statements, yet each contributed statements that made up only 1% of the corpus. To capture a country's income, we used per capita GDP in 2015 U.S. dollars by year, available through the UN statistics division (https://unstats.un.org/unsd/snaama/ (accessed on 20 June 2023)). After combining this data with the appropriate statement, year, and country, the median income of the countries included in the corpus was $5125, but this ranged from $122–179,465. For

our approach using embedding regression, we then used this GDP variable to create a classification for each statement as low, lower middle, upper middle, or high using the quartiles as cut-off points for each category. We also added the Annex status of the country as of 2022, accessed via the UNFCCC website (https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states (accessed on 20 June 2023)). Although Annex membership does correlate with the income of a country, there are countries which sometimes have low GDP that are in Annex I (e.g., Ukraine), and countries which sometimes have a high GDP (e.g., Bahamas) that are not in Annex I, so we thought it important to include both measures. Table 1 provides further detail on the classification of statements in the corpus. We wanted to capture climate risk experienced, and used an index created by GermanWatch, The Global Climate Risk Index (CRI) for 2021. This index is calculated by analyzing extreme weather events along with socioeconomic information. A country's CRI score is based on information on risk exposure and losses from 2000–2019 (GermanWatch, 2021). However, it is a time invariant measure, so for each country's statement, regardless of the year, only one CRI score is used. The CRI is normally scored such that lower scores indicate greater risk, but we reverse-coded this variable to make interpretation easier, such that higher scores indicate more climate risk. The rescaled risk scores ranged from 0–164, with a mean of 89, and a standard deviation of 40.

Table 1. Features of the statement classifications in the corpus.

Feature	Category	Number of Statements (%)
Annex representation	Annex I	618 (24.8)
	Non-Annex I	1262 (50.6)
	No Annex Classification [1]:	613 (24.6)
Year	1995–1999	444 (17.8)
	2000–2004 [2]	254 (10.2)
	2005–2009	510 (20.5)
	2010–2014	591 (23.7)
	2015–2019	567 (22.7)
	2021	127 (5.1)

[1] Statements delivered by NGOs, UN leadership, industry groups, research groups, and other observers. [2] Because the majority of COP8 (2002) statements have not been archived, fewer statements than expected were available.

2.2. Sentiment Analysis in Multi-Level Models

Once the data had been pre-processed, we conducted lexicon-based sentiment analysis [62] using an adapted version of the NRC EmoLex [63]. Because we were interested in sentiment in the climate domain, we adapted the lexicon to the context. For example, we removed sentiment coding of the term 'change' as this term was used primarily in the phrase 'climate change' (see Supplementary Materials for other changes). To calculate sentiment the number of terms which are coded as having a particular sentiment were divided by the total number of terms included in the document and multiplied by 100. Thus, for positive, negative, fear, anger, and sadness sentiments, the score of a speech can be understood as what percentage of terms express the given sentiment. To calculate polarity, the negative score of a speech was subtracted from the positive score for a speech, such that positive scores would indicate the speech contained more positive than negative sentiment, whereas a negative score would indicate more negative than positive sentiment.

These document sentiment scores were used in our multi-level modeling approach as our dependent variables. Because the statements from a given country were not truly independent (i.e., there is some expectation that countries will have some consistency in their climate goals and action), we used a two-level model in which years were nested in countries, with the dependent variable being the sentiment. We were interested in time trends but needed to account for the clustered nature of the data. In these models, we regressed sentiment on year, income, climate risk, and Annex. The unit of analysis here was the entire document, which provides useful but coarse results about the general or overall sentiment expressed.

2.3. Embedding Regression of Sentiment

The second method of sentiment analysis used word embeddings in a regression-like framework [52]. The embedding regression approach allows us to see how words are used differently by covariates of interest: across time, between statements from different income groups, and between Annex I and Non-Annex I. The bag-of-words approach we used in the multi-level modeling does not allow us to distinguish what the targets of sentiment are, and limits our interpretation of how representative speakers might feel about climate change. For instance, while conventional sentiment analysis ignores all specific contexts which could have differently contributed to the level of computed sentiments in a document because it aggregates all scored terms regardless of specific context where positive or negative sentiments are expressed, specific sentiment about substantive issues (e.g., needed financing for an adaptation program) could be mentioned only once or twice. The embedding regression with sentiment approach helps us attend to more granular analysis, and has been developed to work even with very few instances of a seed word [52], meaning that we can use this approach to better understand sentiment towards these policy issues, even when they are mentioned infrequently.

More specifically, embedding regression with sentiment analysis uses word embeddings, which represent text as a vector of values, the size of which is determined by the size of the window around a focal term rather than by the size of the entire document (i.e., total number of terms) [52]. Therefore, the context of a seed word is more precise and becomes more concrete. The reasoning behind this approach is that word embeddings provide contextual meaning, defined based on the neighboring words around seed words, via distributed representations in the form of vectors, which we can then compare with other vectors for similarity. We can calculate the inner product between these vectors, and when the inner product is high it means that the terms appear in similar contexts, and thus are inferred to have a similar meaning [52]. In the context of sentiment analysis, the embedding regression approach allows us to compare the embedding of a seed word (e.g., "adaptation") to the aggregate embedding of word lists from a sentiment dictionary (e.g., embeddings of "anger" words). Using the adapted version of the NRC we generated wordlists for positive, negative, angry, fear, and sad sentiments. We then embedded the seed words and sentiment words using à la carte embeddings with a six-word window, using GloVe embeddings and the transformation matrix A from Khodak et al. [52,64], which down weights the impact of frequently used but less important terms, following the method described by Rodriguez and colleagues [52]. To implement this analysis, we aggregated embeddings of the seed words, such that each observation represented the aggregate embedding of the seed word from all statements delivered in a given year, income level, and Annex. This results in values of sentiment for a seed word, for example, being calculated for 1997-Low Income-Annex I or 2015-High Income-Non-Annex I. The terms we chose were 'adaptation', 'mitigation', 'financing', 'development', and 'disasters', which were important and frequent terms over time (see Figure 1). Information about the frequency of these terms is provided in the Supplementary Materials Table S6.

3. Results

3.1. Sentiment Analysis with Multi-Level Modeling

First, we examined average sentiment across the entire corpus and correlations of sentiment with our key predictors, see Table 2. Overall, across all statements, positive sentiment was more common than other sentiments, and sad sentiment the least common. The bivariate associations revealed that increases in GDP were associated with less negative, less fearful, less angry, and less sad sentiment. Climate risk was positively correlated with fear and sadness. Annex I countries expressed less negative, fear, angry, and sad sentiments. Time was also associated with increase positive, negative, fear, anger, and sad sentiments.

Table 2. Average sentiment and correlations with income, climate risk, Annex, and year.

Sentiment	*M* (*SD*) [1]	Range	Correlations			
			GDP (*n* = 1866)	**Climate Risk (*n* = 1734)**	**Annex I (*n* = 1883)**	**Year (*n* = 2493)**
Positive	13.96 (2.78)	5.62–25.81	−0.03	<0.01	−0.01	0.06 *
Negative	4.25 (1.78)	0.00–12.85	−0.11 ***	−0.02	−0.15 ***	0.05 **
Polarity	9.71 (3.74)	−4.03–27.96	0.03	0.01	0.06 ***	0.02
Fear	2.11 (1.21)	0.00–8.84	−0.18 ***	0.07 ***	−0.26 ***	0.11 ***
Anger	1.55 (1.02)	0.00–8.33	−0.13 ***	0.03	−0.23 ***	0.20 ***
Sadness	1.45 (1.04)	0.00–10.63	−0.28 ***	0.08 ***	−0.35 ***	0.08 ***

[1] Mean, standard deviation. The values reported for positive, negative, fear, anger, and sadness represent the average percentage of terms in the statements which are associated with each sentiment. For polarity, the score represents the % positive—% negative sentiment. *n* denotes the number of statements included in the analysis. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. *n* denotes the number of statements. For Annex I, we examined the correlations between Annex I vs. Non-Annex I statements, excluding observer statements.

We also examined sentiment by year, see Figure 2. These plots show average sentiment by year grouped by Annex. In observing these figures, it is of interest to compare the ranges of sentiment by Annex. For instance, when looking at sad sentiment (bottom-right panel of Figure 2), we can see that there is little overlap in terms of the range of values for Annex I and Non-Annex I, such that the lowest values for Non-Annex I are similar to the highest observed values of sad sentiment for Annex I statements.

For our primary analyses using these sentiment scores as outcomes, we tested multilevel models, with years nested in countries. For these analyses, we only included speeches from a party (i.e., no observer or non-party statements were included). First, we tested unconditional models to examine whether clustering was necessary (i.e., was there significant variability associated with country). These unconditional models found that there was significant variation by country, indicating the necessity of using a two-level model. We then tested a linear growth model, examining the role of time in predicting sentiment, where years were nested in country. The form of the equation was as follows:

Level 1 (within-country)

$$Sentiment_{ij} = \beta_{0j} + \beta_{1j} Year_{ij} + r_{ij}$$

Level 2 (between-country)

$$\beta_{0j} = \gamma_{00} + u_{0j}$$
$$\beta_{1j} = \gamma_{10} + u_{1j}$$

Mixed equation:

$$Sentiment_{ij} = \gamma_{00} + \gamma_{10} * Year_{ij} + u_{1j} * Year_{ij} + u_{0j} + r_{ij}$$

where *i* represents each individual statement, and *j* represents each country. The results of these analyses are presented in Table 3. At level 1, we calculate the best regression line to fit each country (*j*). β_{0j} represents the average sentiment score when year = 0 (1995). The slope parameter β_{1j} indicates the yearly rate of change in sentiment for each country, and r_{ij} represents residual error in the estimate. At Level 2, γ_{00} represents the average variability in initial sentiment and γ_{10} represents the average rate of change. Further details on the modeling approach are provided in the Supplementary Materials.

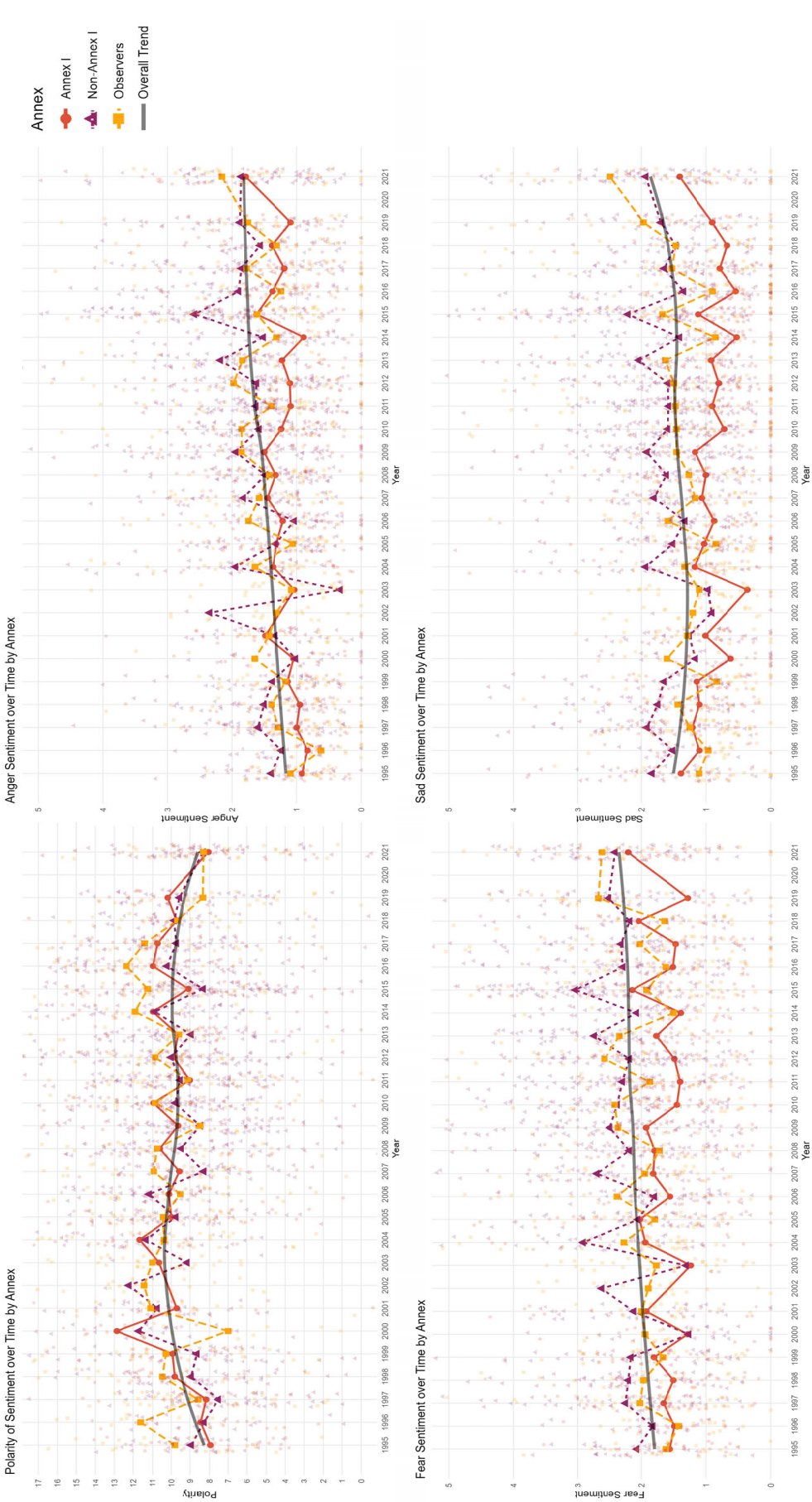

Figure 2. Polarity and sentiment by year and Annex. Note. The plotted lines show the average sentiment by Annex and for the entire sample. The solid line shows average sentiment for Annex I, the dotted line represents Non-Annex I, and the dashed line represents sentiment for Observer/Non-Annex statements. The grey line shows the overall trend for the corpus for each sentiment generated using locally estimated scatterplot smoothing (LOESS). Each point in the background represents sentiment for a single statement.

Table 3. Two-level linear growth curve model, with year predicting sentiment.

	Positive			**Negative**			**Polarity**			**Anger**			**Fear**			**Sadness**		
Predictors	Estimates	CI	*p*	Estimates	CI	*p*	Estimates	CI	*p*	Estimates	CI	*p*	Estimates	CI	*p*	Estimates	CI	*p*
(Intercept)	13.50	13.17–13.83	<0.001	4.32	4.12–4.52	<0.001	9.18	8.73–9.63	<0.001	1.97	1.83–2.11	<0.001	1.23	1.14–1.33	<0.001	1.52	1.42–1.62	<0.001
Year	0.03	0.01–0.04	0.011	0.01	−0.00–0.02	0.100	0.01	−0.01–0.04	0.292	0.02	0.01–0.02	<0.001	0.03	0.02–0.03	<0.001	0.00	−0.01–0.01	0.711
Random Effects [1]																		
σ^2		5.89			2.14			9.85			1.02			0.71			0.66	
$\tau_{00\ country}$		1.51			0.51			3.09			0.28			0.06			0.13	
$\tau_{11\ country \times year}$		0.00			0.00			0.01			0.00			0.00			0.00	
$\rho_{01\ country}$		−0.66			−0.44			−0.60			−0.21			0.09			0.44	
ICC		0.15			0.24			0.22			0.26			0.23			0.34	
Marginal R^2/Conditional R^2		0.005/0.155			0.002/0.243			0.001/0.219			0.009/0.266			0.039/0.257			0.000/0.338	

Note. These models include 175 countries, and 1885 statements. [1] σ^2 = avg. variability in sentiment scores within each year. τ_{00} = variability in baseline sentiment between countries. τ_{11} = random slope for the interaction of year and country, variability in the rate of change between countries. ρ_{01} = correlation between τ_{00} and τ_{11}, relationship between initial sentiment and rate of change in sentiment. Marginal R^2 represents the variance explained by fixed factors, conditional R^2 includes variances explained by both fixed and random factors.

We observed that there was a significant increase in positive, anger, and fear sentiments over time, see Table 3. These models also revealed that much of the variance in the models could be attributed to random effects, i.e., variability between countries. However, there were few differences in variability between countries in the rate of change for any of these sentiments. One unexpected finding was the high level of positive sentiment in comparison to other sentiments. Initial sentiment (i.e., in 1995) was 13.50, and this increased over time. We did not observe the expected increases in negative or sad sentiment over time. The increases we did observe, in positive, anger, and fear sentiment were small, yet significant. While these increased over time, they did so slowly over the 26-year period. The models only account for a small amount of variance in these sentiments, so our next step was to see whether we could better explain variation in sentiment by accounting for other features besides the time the speech was delivered.

3.1.1. Annex, Income, and Climate Vulnerability

Our next set of analyses examined whether country Annex, climate risk, and GDP interacted with year to predict sentiment. Here, the general form of the equation was:

$$Sentiment_{ij} = \gamma_{00} + \gamma_{01} \times Annex + \gamma_{10} \times Year_{ij} + \gamma_{11} \times Year_{ij} \times Annex + u_{1j} + u_{0j} + r_{ij}$$

where Annex would be replaced with the relevant predictor. Due to space constraints, full results for these models are presented in the Supplementary Materials, and the main findings are discussed here.

When the interaction between Year and Annex (or GDP, CRI) was not significant, we re-ran the model without the interaction to be able to describe the unconditional effects of each predictor on the sentiment.

For the relationships between Annex, Year, and sentiment, we found that there was no significant moderation of the effect of time by Annex status for negative, positive, anger, or fear sentiment. Year was significantly associated with increased positive, angry, and fearful sentiment, controlling for Annex status. Annex I status was associated with less negative, fearful, and angry sentiment, controlling for year. For sadness, there was a significant interaction, such that over time, the negative relationship between Annex status and sad sentiment became stronger (i.e., the difference in how much sadness each Annex was expressing increased over time), see Table S3. While sentiment changed over time, as compared with Annex I representatives, Non-Annex I representatives expressed more negative sentiment, anger, fear, and sadness.

Country wealth did not moderate the relationship between year and any sentiment. Year was associated with positive, anger, fear, and sad sentiment, controlling for GDP. Higher GDP was associated with less expression of negative sentiment, anger, and fear. This is not surprising, considering that we found a similar relationship between Annex I status and these negative sentiments.

Climate risk and year did not interact to predict sentiment. When controlling for year, climate risk was not associated with any sentiment, see Table S5.

3.1.2. Summarizing Findings from Sentiment Analysis with Multi-Level Models

Our analyses revealed that politicians were expressing sentiment in these diplomatic speeches, even if it was limited. Sentiment did change over time, and some of our predictions were supported. Anger and fear increased over time, but there was no relationship between year and polarity, sadness, or negative sentiments. Contrary to our expectation, positive sentiment, the most prevalent sentiment, increased over time. We believe that this may reflect an overarching motivation across groups to be diplomatic, and to avoid offending or alienating other leaders. Mixed emotions in these speeches could reflect that while fearful and angry sentiments are increasing over time, the representatives still recognize the need to maintain diplomacy and want to balance increasing negativity with the amount of positivity expressed. Non-Annex I party statements contained significantly more sentiment which was sad, fearful, and angry. While higher GDP predicted less sad sentiment, it was

otherwise not related to sentiment when accounting for time. Surprisingly, there were no relationships between climate risk of a country and the sentiment expressed in their statement, although this might be explained by our measure of climate risk. The CRI is based on 20 years-worth of data but provides a single score per country across that time period, and was thus time invariant. This limits our ability to understand changes in climate risk over time with this measure, and changes from year to year are not accounted for, which might explain the lack of significant relationships. Comprehensive data on climate vulnerability over time for all countries would be needed to better analyze questions about climate risk. While we considered other sources of disaster data, we did not find a suitable data source which had a focus on climate change-related disaster frequency, severity, and likelihood which had data for all countries in our dataset for the period of study.

While these analyses allowed us to observe the broad trends in sentiment, and revealed changes in some sentiment over time, they did not allow us to understand how representatives were using these sentiments–what they were talking about, and what their attitudes were towards different topics. To address this drawback, we carried out embedding regression.

3.2. Embedding Regression

Descriptive information, including the range of sentiment values for each seed word, is provided in the Supplementary Materials Table S6. When interpreting raw scores from these analyses, it should be noted that a positive score (inner product) represents greater similarity of contexts between the seed word and sentiment, and negative scores indicate dissimilarity in the contexts in which the seed word and sentiment terms are used.

First, we looked at the correlations for each seed word between sentiment and income, Annex, and year, see Table 4. These correlations can help us to understand how sentiment of the seed words differed between, for example, Non-Annex I and Annex I statements, where a positive correlation would indicate that Annex I, as compared with Non-Annex I, statements used the seed word in contexts which were more similar to the sentiment. Negative sentiment, fear, anger, and sadness for adaptation were negatively associated with Annex (see Table 4), such that Annex I statement tended to use the term adaptation in contexts dissimilar to these negative sentiments. Income was negatively correlated with negative, angry, fearful, and sad attitudes towards adaptation. As compared with Non-Annex I, Annex I statements also tended to express greater positivity about mitigation. Year was negatively correlated with positive, negative, fear, and sad sentiments expressed about financing. Annex I status was correlated with greater sentiment of all types for development. Although some correlations were marginally significant there was a trend where Annex I status was associated with less negative, fear, anger, and sad sentiments. Higher income was correlated with less negative, anger, fear, and sad sentiments about disasters.

Table 4. Correlations between Annex, year, and income with sentiment for each seed word.

Seed Word	Variable	Positive	Negative	Anger	Fear	Sadness
Adaptation (n = 138)	Annex I	0.08	−0.27 **	−0.37 ***	−0.29 ***	−0.25 **
	Year	0.10	−0.07	−0.09	−0.15	−0.10
	Income	−0.02	−0.20 *	−0.20 *	−0.19 *	−0.20 *
Mitigation (n = 127)	Annex I	0.26 **	−0.03	−0.09	−0.07	−0.01
	Year	0.12	−0.02	<0.01	−0.03	−0.01
	Income	0.01	−0.08	−0.04	−0.07	−0.08
Financing (n = 99)	Annex I	0.12	−0.07	−0.10	−0.06	−0.08
	Year	−0.23 *	−0.24 *	−0.19 $^{+}$	−0.25 *	−0.21 *
	Income	0.09	−0.01	0.01	0.01	−0.02
Development (n = 157)	Annex I	0.20 *	0.26 **	0.19 *	0.20 *	0.23 **
	Year	−0.07	−0.09	−0.14	−0.16*	−0.13
	Income	<0.01	−0.09	−0.10	−0.08	−0.11

Table 4. *Cont.*

Seed Word	Variable	Positive	Negative	Anger	Fear	Sadness
Disaster (n = 72)	Annex I	0.15	−0.25 *	−0.23 $^{+}$	−0.23 $^{+}$	−0.28 *
	Year	−0.14	−0.05	−0.17	−0.09	−0.12
	Income	−0.09	−0.27 *	−0.26 *	−0.25 *	−0.23 *

* $p < 0.05$, ** $p < 0.01$. *** $p < 0.001$. $^{+}$ $p = 0.06$. n represents the number of year-annex-gdp triples which included the term of interest (i.e., one could represent the average sentiment of the term for all Annex I statements for 1996 which were high income). For Annex, 0 = Non-Annex I, 1 = Annex I. Income was scaled such that 1 = Low income and 4 = High income. Annex and income were significantly correlated, r = 0.52, $p < 0.001$.

These correlations indicate that sentiment about these different policy issues does vary between groups, however, we found no simple linear relationship between time and sentiment about most of these topics. The negative bivariate relationships between year and financing sentiment might suggest that this topic was discussed less emotionally over time. Our next step was to conduct exploratory analyses. We ran regressions, using the outcomes of the embedding regressions as dependent variables, to see whether there were unique effects of Annex, income, and year on sentiment for each of these terms. These models involved regressing each sentiment for each seed word on Annex I status, income, and year. The full results of these analyses are presented in the Supplementary Materials, but we described them briefly, focusing on the direction of effects.

3.2.1. Adaptation and Mitigation

Annex membership status was uniquely predictive of negative, anger, fear, and sad sentiments for adaptation, see Figure 3. Non-Annex I use of the term adaptation was significantly associated with more negative contexts as compared with Annex I statements, see Supplementary Table S7, although the variance explained by these models was small (6–13%).

Positive sentiment toward mitigation was predicted by Annex I status, controlling for year and income, see Table S8. Annex I countries were more likely to use mitigation with positive sentiment than non-Annex I countries, and this model explained 8% of the variance in positive sentiment. One possible explanation is that when Annex I countries are talking about mitigation, they are likely discussing their achievements in meeting mitigation targets, rather than drawing attention to deficits. There were no other significant associations for adaptation and mitigation between year, income, or Annex and sentiment.

We examined whether there were significant differences in positive and negative sentiments toward adaptation as compared with mitigation, since we were interested in whether mitigation (the initial goal of the UNFCCC) was viewed more positively than adaptation. When we tested whether these differences were significant when accounting for Annex, year, and income; we did not observe any significant difference in the sentiments used regarding adaptation and mitigation, see Supplementary Table S9.

Another approach to this data was to examine the plots of sentiment (Figure 3) for each word to identify fluctuations, and high and low points in sentiment scores which may be interesting to examine in the context of key events at COP. For instance, there are a number of agreements made at COP relevant to mitigation. In 1997 (COP3) the Kyoto Protocol was formally adopted, and in 2005 it entered into force [65]. If we examine the plot for mitigation (Figure 3), which was the primary goal of the Kyoto Protocol, we can see that there was initially high positive mitigation sentiment from the inception of the COP from Annex I countries which decreased until the early 2000s. At COP7 in 2001, the goal was to finalize preparations for the Kyoto Protocol, rules and procedures which were codified in the Marrakech Accords which were highly similar to the previous year's Bonn Agreement. At this point, it was agreed upon that mitigation targets should be binding, and that parties which failed to keep their commitments should be penalized [55]. Our sentiment analyses suggest that for Annex I countries this may have been a point at which they were less willing to speak positively when discussing mitigation as compared with previously when they were idealizing the climate goals. At COP15, in 2009, there was some

controversy over a failure to adopt a post-Kyoto agreement. At this conference, a document which was drafted by only a few parties before the conference as a proposed replacement for the Kyoto Protocol was leaked [55]. This draft did not make agreements legally binding, called on developing countries to implement mitigation, and made provision of funding to developing countries dependent on them implementing mitigation. Developing countries reportedly expressed anger about the agreement being created without their participation and negotiation, and ultimately no new climate agreement was adopted [55].

Negative and positive sentiment for adaptation appears to peak for Annex I statements around 2008–2010, see Figure 3, whereas negative sentiment for adaptation was highest for Non-Annex I in 1995. If we examine the events during those periods, we know that the Cancun Adaptation Framework was drafted in 2010–11, and the Adaptation Committee was established. Perhaps the fact that the Kyoto Protocol was entering into force, with final commitments being made around mitigation lead to less focus on, less desire to support, and less urgency for adaptation. For Non-Annex I statements, there was an increase in positive sentiment towards adaptation over time, in this case we might expect that speakers from these countries asking for support for or describing progress in adaptation would be framed positively, perhaps to encourage continued financing and support. Although we might have expected more negative sentiment in general surrounding adaptation in earlier years (particularly as compared with mitigation, Pielke, 2007), that was not observed.

These interpretations are purely speculative, as a full accounting of the specific agreements and important events at the COP is beyond the scope of the paper, but we believe that other researchers might make use of this method of probing different terms as a means of studying the course of specific events during COP. Alternate explanations for these trends are also plausible. For example, the Global Financial Crisis in 2008 may have had an impact on sentiment of these leaders. Researchers have found through discourse analysis that following the GFC, some key economic organizations increasingly made policy recommendations for 'green' growth, pairing climate mitigation with opportunities for continued economic growth, yet it seemed that the GFC led to less willingness to pursue mitigation at the expense of growth [66]. Following the GFC in 2009 and 2010, carbon emissions increased to a greater extent than previous years [67]. Leaders during this period may have been more wary of making ambitious climate mitigation commitments at this time due to a desire to prioritize their economic growth.

3.2.2. Financing and Development

Sentiment towards financing changed over time. Controlling for Annex I status and income, year was predictive of less positive, negative, anger, fear, and sadness, see Supplemental Materials Table S10. Over time, it seems that discussion around financing was becoming less emotionally charged, across Annex and income groups, see Figure 4. Although the differences were not significant, controlling for year, observing the plot of positive and negative sentiments, we observe slightly different patterns by Annex. For Annex I statements, positive attitudes towards financing were high initially, then decreased until around 2008, at which point they increased until peaking around 2013.

Sentiments around development were uniquely associated with Annex, such that Annex I status was associated with more positive, negative, angry, fearful, and sad sentiments, see Figure 5. Statements from developing countries used less sentiment when discussing development as compared with developed countries, and we believe there may be a tendency for the developing countries to discuss development in more neutral and less emotive contexts. There was a significant association between income and less negative and sad sentiment, controlling for Annex and year. Statements from lower income nations tended to discuss development more negatively and with greater sadness.

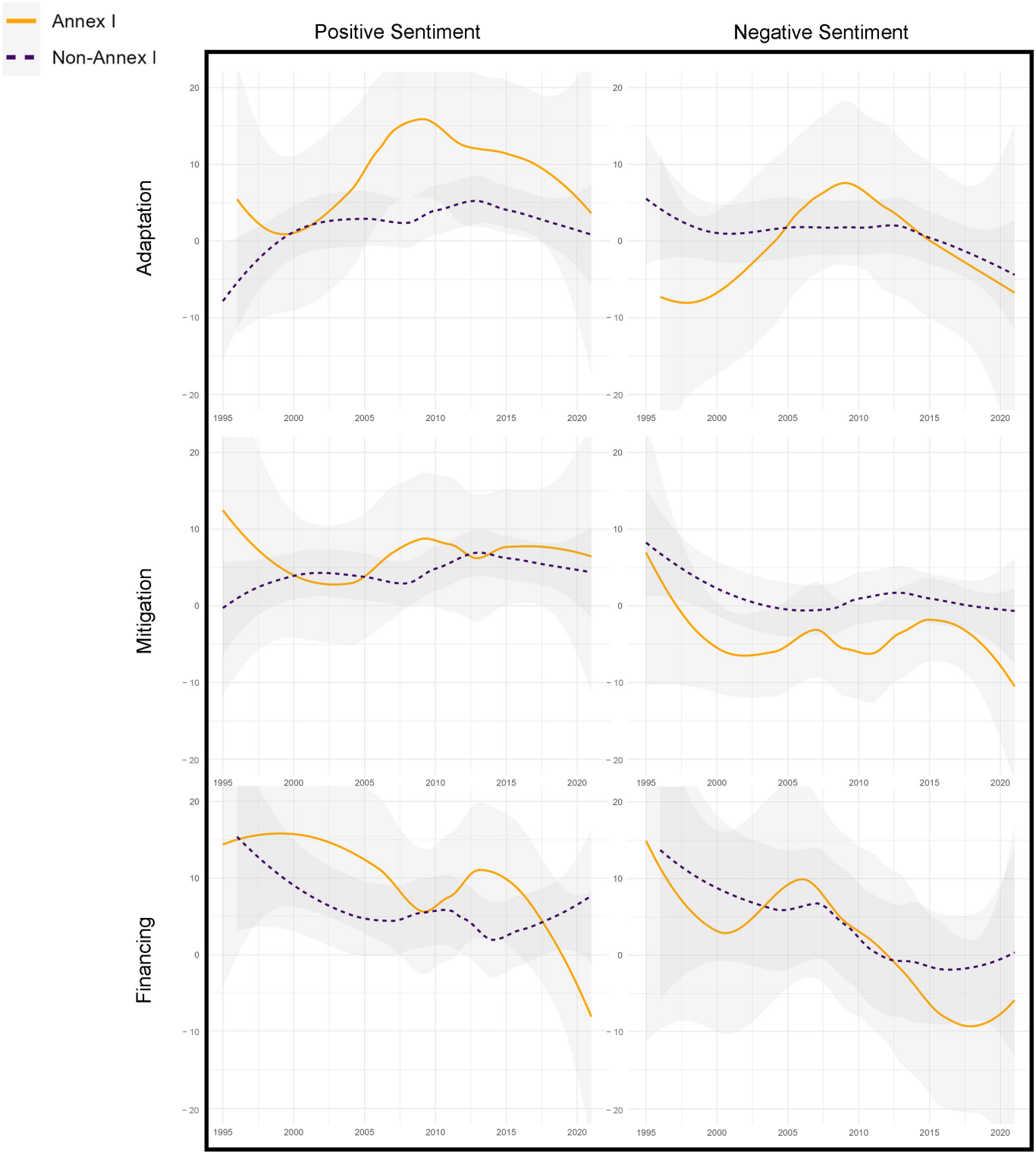

Figure 3. Positive and negative sentiments: Adaptation, Mitigation, and Financing. Note. The panels on the left show positive sentiment scores (*y*-axis) for adaptation, mitigation, and financing over time (*x*-axis) by Annex, where Annex I is represented by the solid line, and Non-Annex I statements are represented by the dotted line. The panels on the right show negative sentiment (*y*-axis) over time by Annex.

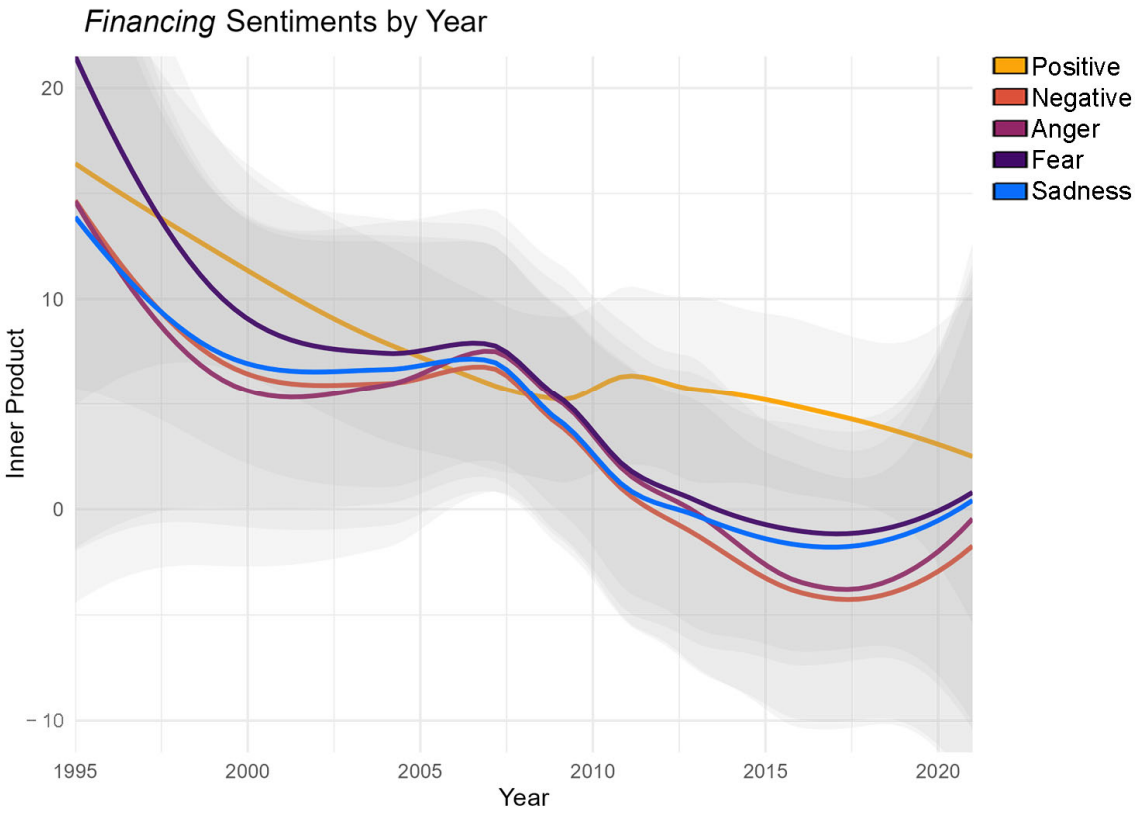

Figure 4. Sentiment over time: Financing. Note. Lines depict the average yearly sentiment across all Annex and income groups.

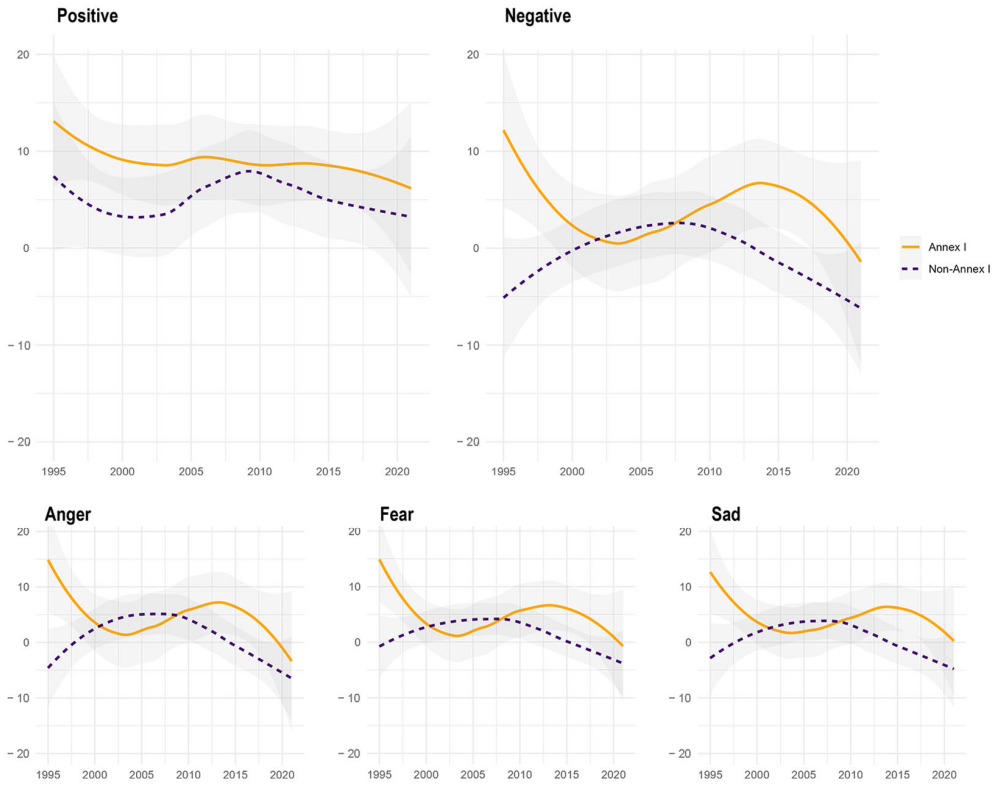

Figure 5. Sentiment over time by Annex status: Development. Note. The *y*-axis represents the inner product for each sentiment (i.e., similarity score), and year is shown on the *x*-axis. Annex I statements are represented by a solid line, and Non-Annex I statements are represented by a dashed line.

3.2.3. Disaster

Although there were significant correlations between income and disaster sentiment and between Annex and disaster sentiment, when controlling for each other and year, neither was predictive of any sentiment, see Table S12. Nonetheless, the bivariate relationships between Annex status and these sentiments remained apparent when examining the plots, see Figure 6. Non-Annex I statements showed a general decline in these sentiments about disaster from 1995 until 2014, then they increased. Annex I statements were not discussing disasters in these negative contexts prior to 2000, and throughout the time we analyzed, even the highest inner products for negative disaster sentiments for Annex I were in the same range as the minimum values observed for Non-Annex I negative disaster sentiment. If comprehensive climate risk or disaster data were available across years, future researchers might try to see whether these trends line up with cases of disaster experience. The divergence between sentiment from these developed and developing countries is stark around 2015, which was the year that the Paris Agreement was signed. One possible explanation for these differences in sentiment after this point could be that this agreement downplayed the 'differentiated' part of the principle of 'common but differentiated responsibilities', in spite of the continued inequities in who experiences climate harms. Developed and developing countries were all called on to mitigate their emissions, yet the impacts of climate change in those developing countries continued to be much worse than in developed countries. These countries may be bringing up disasters in a negative light to draw attention to the fact that although they are now also considered responsible for mitigation and adaptation, that they are unequally and unfairly impacted by climate change. However, there are other possible explanations for this divergence, and further qualitative work is needed to understand these differences.

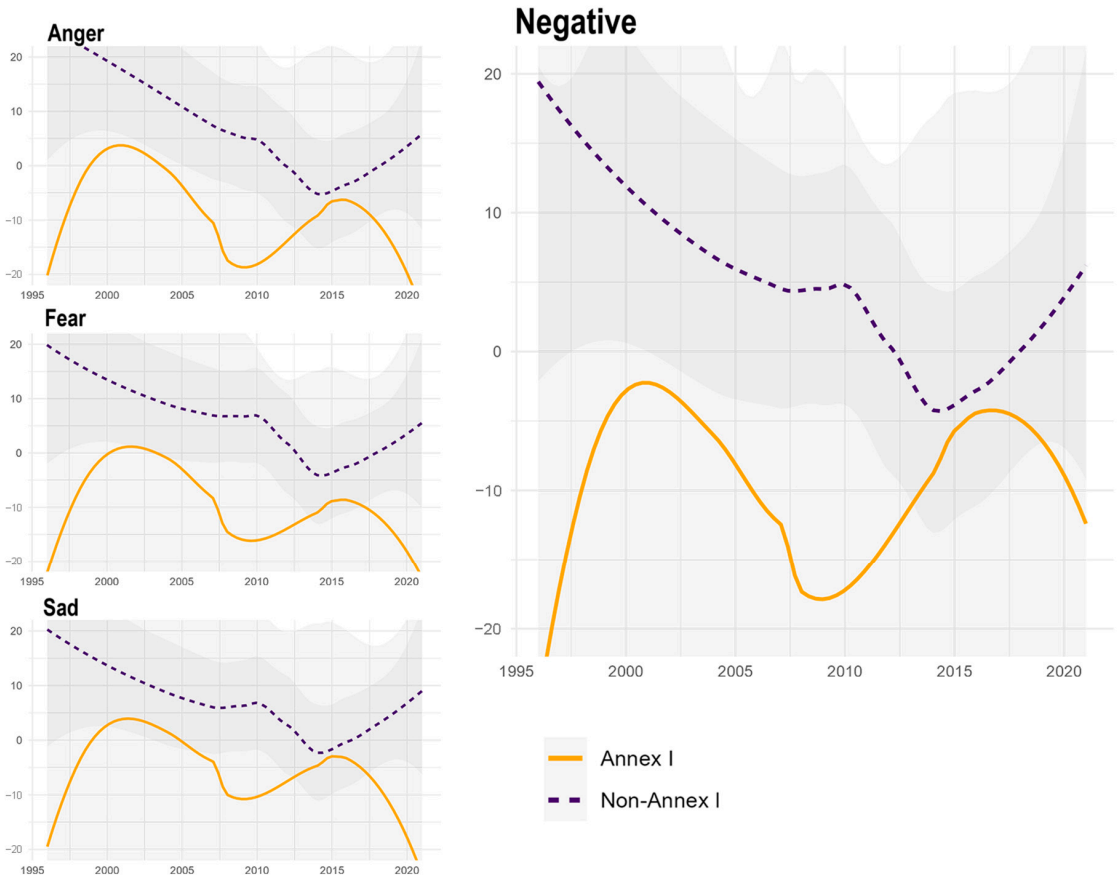

Figure 6. Negative, anger, fear, and sad sentiments by Annex: Disaster. Note. The *y*-axis represents the inner product for each sentiment (i.e., similarity score), and year is shown on the *x*-axis. Annex I statements are represented by a solid line, and Non-Annex I statements are represented by a dashed line.

4. Discussion

Previous work has used computational methods to analyze the statements from COP [45,46], and our work adds to this literature by analyzing sentiment across a longer time period, from the first Conference of Parties until the twenty-sixth. Our findings suggest that while sentiment is used in these statements, the degree of language which is emotive is generally somewhat limited. Sentiment expressed tended to be more positive than negative, however, we do detect the use of negative sentiment, anger, sadness, and fear. We also found that a speaker's country's GDP, Annex, and the year that a speech was delivered were associated at a bivariate with the overall sentiment expressed in statements. Countries with more wealth tended to use less negative sentiment, as did countries in Annex I. Year was correlated with increased negative sentiment. Using a multi-level model, we found support for the idea that fear and anger have increased over time. However, contrary to our predictions, positive sentiment also increased. Further qualitative analysis of these statements might help us to better understand why these changes were occurring. For instance, towards whom is the anger directed, and which subjects are people expressing fear about?

This study also allowed us to examine how particular climate change issues are discussed. Sentiment about climate policy issues such as mitigation and adaptation do fluctuate over time—but relationships are complex and should be examined in the context of events relevant to the issues, such as the drafting of international climate agreements. While these findings allow us to get a snapshot of what the sentiment was like at a given COP, further study might incorporate more information on the COP processes—such as which agreements were being made, which committees were especially active, which coalitions were formed, and so on [55]. The archived documents from these conferences provide a rich history of progress on international climate action, and using information on sentiment allows us to identify trends in how that action was discussed. For example, over time, discussions of financing seemed to be less sentimental. Further study might examine whether there were shifts from using emotional appeals in general to elicit financing or to discuss financing commitments as compared with other reasoning approaches (e.g., highlighting efficacy and other concrete arguments). To understand these and other shifts over time, researchers might use other computational approaches like structural topic modeling, and use covariates of specific events (e.g., pre- vs. post-first commitment period for Kyoto protocol; pre- vs. post- global financial crisis) to see whether any specific historical events might help explain these shifts.

Our finding that communication differs by Annex, particularly when looking at negative sentiments, is in line with previous work finding that speeches differ by Annex in terms of content [43,45]. Non-Annex I party statements about adaptation and disasters were more negative, fearful, sad, and angry than Annex I statements. We believe that the patterns for these two terms might highlight how the needs of the Annex I and Non-Annex I parties differ. Non-Annex I parties might be employing these sentiments around these topics both as a reflection of greater experience of climate impacts and a call to action to address those impacts to avoid further negative consequences. While our work helps to highlight these differences by Annex in the meaning of the terms 'disaster' and 'adaptation', further qualitative work is needed to understand those differences.

Finally, while we focused on how country features and time predicted sentiment, another approach would be to see how sentiment in one year influenced the country's subsequent behavior, for example implementation of climate policy, instances of meeting or failing to meet commitments, or amount of financing committed to UN funds. For instance, the Environmental Performance Index [68] ranks countries using 40 indicators of their performance on climate change, ecosystem vitality, and environmental health. However, this index uses different metrics over time, meaning that comparing these scores over time is not appropriate. Data which cover the entire span of the COP (1995–2021), with complete information on the environmental performance for the majority of parties, are lacking or exist in forms which are not easily compared for use in this kind of analysis. For example,

while parties must report to the COP on their Nationally Determined Contributions, the form of these reports is not uniform, and extracting data that could be compared across parties over the length of the conferences would require considerable effort. Future work might focus on a subset of parties where such information is available, to be able to examine, in depth, how statements reflect elite behavior, or how behavior is reflected in the statements.

There are some limitations of the work that should be noted. First, we focused only on English-language statements, which resulted in the exclusion of more than 1000 statements. A valid criticism of much historical text analysis is that it focus on English-centric text [69]. While automatic translations of English sentiment dictionaries are available, because they rely on coding conducted by English-speakers, they do not account for cultural differences across languages in the sentiment associations for words [70], making it difficult to compare across corpuses. Similarly, automated translations of statements could unintentionally alter the intent of the speaker and fail to accurately translate cultural nuances in sentiment. The exclusion of non-English texts means that we cannot make broad claims about how leaders express themselves outside of English-speaking contexts. Second, the records available of statements were incomplete at the time we conducted the study—archiving these conferences digitally is an ongoing process. We do not know exactly how many records might not be included, but we do know, for example, that we were only able to collect mainly observer statements from COP8 (2002) because most party statements are not yet publicly archived. In addition to this, our research neglects to fully make use of the 2493 statements we collected; observer statements are not included in our more advanced models going beyond simply describing overall sentiment. The speakers represent organizations that vary greatly in terms of size, goals, power, and so on, so treating them as a single group is inappropriate. Finding a way to code or categorize these statements could open a new line of questions regarding the differences in speech from, say, industry-oriented speakers and NGOs focused on human rights. When we make use of these approaches to understand sentiment, we are accepting the distribution hypothesis, which assumes that meaning can be derived from context [52]. While our approach allowed us to look at sentiment for issues across a large body of text, further human-coding of the texts to better understand whether the analyses accurately reflect the nuances of sentiment that deeper analysis reveals would help to support these findings. There are other ways to measure sentiment, for example, we might study video recordings of the proceedings to consider the body language and intonation in speeches to capture emotional arousal [5].

Besides addressing these limitations, future research might also incorporate text from other relevant forums, for example to see whether the ways that a country's representative expresses themselves relates to the ways that politicians discuss climate change within their country (e.g., in parliamentary debates). Other researchers have studied the ways that politicians have discussed climate change in their own country (e.g., frequency of climate change speeches by German members of parliament [71]) or continent (e.g., arguments for and against climate change action in the European Parliament [72]). Because the COP statements identify the specific speaker, it would be interesting to see whether we could create a corpus of parallel statements about climate change by the same speakers in the same timeframes, to compare how they express themselves when communicating about it within their own nation, both to other politicians and to the public, rather than on a world stage. This might allow us to better understand elite international climate change speech in comparison with national elite communication on climate change.

5. Conclusions

The Conference of Parties serves as a container in which elites who have the power to enact systematic change discuss climate change. Managing climate change through mitigation and adapting to its impacts requires large-scale collective action and cooperation, both of which are planned at these conferences. Our work contributes to the understanding of how climate change has been addressed, particularly in terms of emotion on the

international diplomatic stage, by analyzing the ways that representatives of parties to the convention have discussed these issues across a 26-year period. Annex membership emerged as an important factor in understanding differences in sentiment in these statements. Parties who have historically held different responsibilities and obligations under UNFCCC do not express themselves in the same way—Non-Annex I parties tended to express greater negativity. While some changes in sentiment over time were observed, they were not explained in a simple linear way, granular sentiment analysis focusing on specific seed words shows ups and downs in all sentiment across the years which suggests the need for future work. The aim of this article was to highlight which sentiment is used, and by whom, in the history of these climate negotiations. While this work revealed interesting trends and predictors of sentiment, future work is needed to better understand the content and consequences of the sentiment. While our methodology allowed us to examine the entire available archive of statements, qualitative approaches could build on this work, examining time periods which displayed shifts in emotive rhetoric. Ultimately, we need both bottom-up and top-down change to address climate change, and research to understand how elites discuss policy and climate impacts might help us gain insight into their attitudes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16072779/s1, S1. Pre-processing of text. S2. Supplementary methods & results: sentiment analysis with multi-level modeling. S3. Embedding regression with sentiment.

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Advocacy, Ecotourism, and Biopolitics of Whale Conservation in Ecuador

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Abstract: Whale-watching tourism in Ecuador thrives through the spectacular image of a flagship species, the humpback whale. Seemingly, it is an example of an industry regulated and managed in accordance with sustainable principles of nature conservation, thanks to the work of Ecuadorian scientists who advocate for policies to protect whales from harmful exploitation. However, does the use of the whale as an icon of conservation result in its utilization as a mere commodity for profit? Through ethnographic fieldwork including interviews, observations, and textual analysis, it is shown that the Ecuadorian practices of whale conservation have resulted in the whale becoming a subject of governance, by which the wild animals are recognized as entities worthy of ethical treatment. Using the humpback whale as a flagship species, the Ecuadorian scientists practice biopolitics through the strategies of categorizing, monitoring, and regulating human interactions with the whale population. The success of this approach to wildlife governance highlights the role of NGO-affiliated scientists as knowledge producers and policy advocates.

Keywords: biopolitics; conservation; ecotourism; flagship species; whale-watching

1. Introduction

Every year in the month of June, the city of Puerto López in the Province of Manabí in Ecuador celebrates the Festival de Ballenas to welcome the migrants who have journeyed from the frigid waters of Antarctica. The migrants are the humpback whales (*Megaptera novaeangliae*), known locally as *ballenas jorobadas*. The jorobadas move northward along the coast of South America as they journey from their feeding areas in the cold Southern Ocean to the warm tropical waters where the pregnant whales will give birth and others will find a mate. When they approach the shore, the whales can be watched by passenger boats and seem to put on a show for the tourists by leaping out of the water. This has led to the development of a tourist industry called whale-watching, which has stimulated the local economy in Puerto López and other coastal communities, with a resulting increase in the number of hotels, restaurants, and other businesses catering to tourists [1].

The research focuses on the practices of humpback whale conservation on the mainland coast of Ecuador within the context of a growing ecotourism industry around whale-watching. It examines the role of conservation scientists as communicators positioned between transnational advocacy networks and local institutions. An ethnographic research methodology is employed to investigate how the scientists utilize specific conservation practices to govern human-nonhuman relations, while also addressing debates on flagship species and the potential for fostering ecotourism that can be equally beneficial to humans and to wild cetaceans. The research highlights the importance of biopolitics as an outcome of the implementation of international conservation norms at national and local levels.

International agencies, NGOs, and advocacy networks produce the agendas and concepts for biodiversity conservation, but their concepts do not smoothly translate into policies at the local level, where cultural, political, and economic institutions impact the extent and way in which conservation is carried out [2,3]. Widely used concepts in international conservation parlance include *endangered species* and *flagship species*; these concepts

shape public policies for the management of resources as well as the manner of carrying out research to support the policies [4,5]. Flagship species are often connected to ecotourism and used in support of its claim to be an economically viable path to conservation.

The cetacean experts in Ecuador have contributed to two major policy outcomes: the adoption of a national anti-whaling position and the ratification of regulations for whale-watching. The role of whale conservation experts in fomenting these policies in Ecuador illustrates how experts act as communicators to express the needs of conservation to policymakers and members of the public. In the following, the specific research practices of whale conservation are described to argue that research on whales is carried out in a manner that facilitates the Ecuadorian state's capacity to govern whales as well as the capacity to govern marine territories that are identified as the whale's habitat.

In the following, the activities of conservation experts are referred to as *practices of conservation*, denoting not only the scientific activities such as designing research, securing funding, training students, and analyzing data but also involvement in tourism-related events, such as providing workshops for tour boat operators or park rangers. Practices also include meetings with government or intergovernmental agencies, and they include social events to communicate with the public, such as talking to the news media or appearing at public festivals and ceremonies. Through conservation practices, conservation experts translate the concepts of international conservation to the local context.

This location-specific case study contributes to the growing body of international research on flagship species. The main finding of this study is that whale conservation practices in Ecuador help to transform the whale population into a subject of governance, analogous to the way that human populations are governed. In the Ecuadorian case, the management of whale-watching tourism does not simply lead to the conceptualization of the animals as an economic resource for tourism industries. This finding contradicts the other studies, which emphasize the economic value of animal species in the tourist industries allied with conservation [6–9]. However, this finding supports the studies that demonstrate how living things, valued as "lively commodities", are governed through human-nonhuman relations that obligate the ethical treatment, care, and mitigation of threats to the survival of wildlife [10–12].

Finally, this study highlights the importance for conservation of the nation-state as a social entity that wields power to govern and regulate both territories and populations [13]. Foucault's concept of *biopolitics* was to refer only to the use of scientific and statistical techniques for governance, regulation, and maintenance of human populations; however, recent investigations point to the fact that wild animal populations also become subjects of state management in ways that make animals into subjects of governance [14,15]. Biopolitics is practiced through the definition of collectivities such as species, subspecies, stocks, or populations, and it becomes political by utilizing knowledge of the collectivity to intervene in its management. Examples of biopolitical practices affecting nonhuman populations include turtle conservation in India [16], wolf reintroduction in Canada [17], and the practice of rewilding cattle on nature reserves in the Netherlands [18].

The objective of the research undertaken here is to determine how the actions of conservation professionals contribute to the making of the humpback whale a flagship species. In the context of previous studies that claim that ecotourism leads to the exploitation of wildlife species as merely economic resources, this study focuses on the Ecuadorian case to investigate the type of human-nonhuman relations that are formed through the practices of ecotourism, and through the government policies that support ecotourism. Focusing on the actions of Ecuadorian conservation experts who create knowledge about whales, the study identifies the research practices of the conservationists and how these practices contribute to the governance of whales.

2. Materials and Methods

To investigate the forms of communication by which experts create public knowledge of whales for ecotourism policy, the author traveled to Ecuador in 2012 to carry out

observations and interviews. Three methods were used: interview, participant observation, and the collection and analysis of relevant publications and documents.

First, to discover the connection between whale-watching tourism and whale conservation, the author sought to interview the conservation professionals who are known to be proponents of whale-watching tourism, who are based in Ecuador, and who are affiliated with conservation NGOs. Three researchers agreed to be interviewed: Fernando Félix representing FEMM (Fundación Ecuatoriana para el Estudio de Mamíferos Marinos), Cristina Castro representing the Pacific Whale Foundation, and Ben Haase representing the Museo de Ballenas. In addition, two officials were interviewed from the Ministry of the Environment, the agency that has been most directly involved in the management of public areas where whale-watching tourism takes place. Hence, a total of five professionals were interviewed directly by the author.

In addition, the author participated in whale-watching tourism, carrying out participant observation. In the city of Salinas, the author boarded a tourist boat to observe a researcher and graduate students carrying out photographic identification of whale flukes. In the city of Puerto López, the author boarded licensed whale-watching tour vessels four times to confirm that the protocols of whale-watching regulations are obeyed and to observe tourists' reactions to the whales. These observations provided a contextual frame for the research, demonstrating the marketability and attractiveness of whale-watching to foreign and domestic tourists in Ecuador.

Documents of many types were collected and analyzed. These included government regulations and statements by government agencies about whale conservation policies, policy studies, recommendations by NGOs, journalistic reports from the news media, books written by experts to inform the general public, as well as scientific publications by whale conservation researchers.

"Flagship species" is not a scientific concept but one that communicates the social value of a species [19–21]. Hence, to evaluate the relevance of scientific research to the creation of a flagship species, the scientific publications are not reviewed here for their scientific validity or merit. Rather, the purpose of using these materials is to identify the communication methods used by conservation professionals, which in turn can impact policy discussions and practices. This follows the example of other social science studies of human-nonhuman relations, carried out through the observation of wildlife researchers in the field and analyzing the published works through which they disseminate their ideas to society as a whole [22–24].

The combination of three methods (interview, observation, and document analysis) was utilized for the location-specific case study of whale-watching ecotourism in coastal Ecuador to discover the role of wildlife conservation research in the management of human-nonhuman relations. The focus is to identify the ways that conservation research contributes to extending the power of governance over animals and the territories they inhabit [15]. During the investigation, four main practices of humpback whale conservation were identified: (1) collecting data to define the local whale population and to advocate for protected status; (2) setting boundaries for whale-watching and conservation policies; (3) connecting the population of humpback whales to a specific territory; and (4) creating personalized relations with individual whales. These practices were discerned through the careful perusal of research articles, reports by conservation NGOs, press releases, journalists' reports, and official communiques of government ministries.

3. Results

3.1. Ecotourism and Whale Conservation

Whale-watching is a form of ecotourism that presents nature for the enjoyment of tourists by immersing them in natural landscapes. Advocates of ecotourism claim that it contributes to preserving nature by encouraging non-exploitative relations with natural entities and that the experience contributes to tourists' knowledge of nature and ecology [14,25]. Advocates claim ecotourism is a market-based path to nature conservation,

but others argue that it may have the opposite effect, causing harm to wildlife [26]. However, the case of whale-watching in Ecuador provides an example of ecotourism in which conservation scientists have taken a leading role in communicating with the public and with authorities to advocate for wildlife-friendly policies.

Management of ecotourism depends on government agencies to control and regulate access to nature and to protect it for future generations [27,28]. This is the rationale of the National Code of Regulations for Whale-Watching in Ecuador (Interministerial Agreement No. 20140004), enacted in 2014 by agreement of the Ministry of Tourism, the Ministry of Defense, and the Ministry of the Environment [29]. The regulation establishes limits on the number of licensed operators of whale-watching tours, imposes requirements for licensing, and provides detailed restrictions on the speed of boats and their manner of approach to the whales [30]. Government officials arrange training sessions for whale tour operators and explain the regulation at the start of every tour season [31]. As a conservation measure, the regulation represents a crucial form of infrastructure for Ecuador's whale-watching industry.

The Ecuadorian whale-watching regulation is largely the outcome of the efforts of Ecuadorian biologists who study whales and have lobbied the government ministries to adopt policies for whale conservation. Affiliated with international non-governmental organizations (NGOs) that focus on conservation, they also participate in treaty agencies such as the International Whaling Commission (IWC) and the Convention on Biological Diversity. Influenced by the norms that have currency in international conservation networks, the locally based scientists adapt the norms to the Ecuadorian national context. This is an example of transnational advocacy networks, which are far-flung constellations of non-state actors connected by shared values, common discourse, and the exchange of information and resources [32]. Hence, the scientists studying whales in Ecuador are communicators positioned between international networks, national ministries, and the local communities where their research takes place.

The case study presented here will focus on the making of a flagship species, a conservation practice that is associated with ecotourism [21]. A flagship species is one that is emblematic of wildlife conservation and stimulates public support for conservation efforts [20]. The efforts of Ecuadorian scientists to use the humpback whale as a local flagship species involve the production of new knowledge, which obligates the state to see the whale as worthy of protective policies. At the same time, the knowledge they produce is targeted at tourists and members of the public, inviting people to relate to whales in new ways that spill over into respect for the environment. The knowledge provided through scientific investigations of whales is aimed at multiple audiences: the international conservation community, the Ecuadorian government, and the local citizenry.

Does whale-watching tourism contribute to sustainable development compatible with conservation management? The present investigation addresses this question by examining the efforts of conservation scientists to communicate the international ideals of conservation through four main forms of conservation practice. However, prior to describing these practices, the research setting will be described.

3.2. Research Setting

Although the code of regulations for whale-watching is in effect throughout Ecuador's national territory, Machalilla National Park (MNP) has been especially associated with whale-watching [1]. With large swathes of terrestrial (56,184 ha) and marine (14,430 ha) zones, the MNP offers tourists the chance to observe a variety of habitats and species [33]. The cost of travel to MNP is much more affordable than a visit to the Galápagos National Park, making the MNP a popular destination for Ecuadorian vacationers as well as tourists from abroad [34]. MNP is part of the National System of Protected Areas (NSPA) of Ecuador, under the administration of Ecuador's Ministry of the Environment, Water, and Ecological Transition [35]. Including 66 separate protected areas (as of 2021), the NSPA exists to

"guarantee the coverage and connectivity of important ecosystems", including terrestrial, marine, and coastal ecosystems [36].

The establishment of MNP in 1979 caused conflict over the restriction of traditional subsistence activities related to agriculture, livestock, and logging, but crews have continued to operate out of four fishery landing sites within the park [37]. The fishing communities have considerable friction with the park authority over the restrictions on the use of the marine area of the park [34,38]. Ecotourism has propelled the development of the largest town, Puerto López, which has been transitioning from an economy based on fishing to tourism [39]. However, other communities within the park do not enjoy the same opportunities to develop ecotourism and must continue to rely on fishing as a livelihood [38].

The management of Machalilla National Park centers on three main goals: (1) conservation of biodiversity; (2) improvement of the welfare status of people who live in the park and its surrounding zone; and (3) strengthening the presence of the national government in the park [33]. These goals prioritize the need to develop tourism on a scale that brings economic benefit to local communities while also committing the park authority to "control and monitor the activities of visitors. . .and to maintain rules to limit the impacts or changes produced by public use of its flora, fauna and ecosystems" [33]. However, the park has struggled to erect a system of surveillance and enforcement, despite the assistance of the National Armed Forces of Ecuador in the role of maritime police [37].

In practice, Machalilla National Park is a space in which the authorities attempt to administer and control the interactions between animals and humans (residents as well as tourists). In addition to humpback whales, tourists visiting the park try to see manta rays, sea turtles, and marine birds like the blue-footed booby. Hence, the park is a locus of biopolitical methods to regulate encounters between migratory animal populations and transient human populations.

3.3. Collecting Data on the Humpback Whale Population

For conservationists, the first important task is to define a wild population and its habitat. Ecuadorian NGOs have participated in the development of whale-watching since 1994, when the researchers affiliated with FEMM [Fundación Ecuatoriana para el Estudio de Mamíferos Marinos] cooperated with a fledgling group of whale-watch tour operators in the Machalilla National Park. The founders of FEMM, Fernando Félix and Ben Haase, had already carried out studies on lethal strandings of whales beginning in 1987 [40–42]; from 1995 onward, they carried out the first population studies of humpback whales in Ecuadorian waters [43–46]. The tourism operators collaborated by allowing the researchers to record their data while aboard the tourist vessels, which made the relationship mutually beneficial [45,46]. Félix noted that when whale-watching began in the early 1990s, it was the only form of nature-related tourism available on the mainland coast of Ecuador [47]. Ben Haase recalled, "Twenty-five years ago, all the attention was on the Galápagos, nobody knew anything about the [mainland] coast" [48].

Nevertheless, interest in the biodiversity of the Galápagos Marine Reserve did generate interest in whale conservation policies. In 1990, the reserve was declared a whale sanctuary, which was later extended to Ecuador's entire marine jurisdiction [49]. This was important because many regional populations of whales had been hunted to the verge of extinction by commercial whaling interests in the 19th and 20th centuries [50]. Although whaling was halted in 1986 by the International Whaling Commission, Japan and other member nations have continued to hunt whales by applying for a scientific whaling permit [6]. Ecuador's unilateral move to protect whales from targeted exploitation presaged the subsequent efforts to make whale conservation policies a conspicuous part of public discourse on marine conservation.

As a new generation of researchers emerged, additional NGOs contributed research. Notably, the Pacific Whale Foundation [PWF], directed by Cristina Castro and located in Puerto López, carried out studies in Machalilla National Park. In 2005, four organizations reported a collaboration to collect field data: FEMM, Fundación Natura, Yaqu-Pacha,

and the Pacific Whale Foundation [51]. Since 2004, Félix and Haase have continued their research through the nonprofit Museo de Ballenas, which maintains a database of 2000 whales [52]. In 2011, PWF and the Museo de Ballenas combined their databases to publish a study that included 1389 individual humpback whales [46]. As the tourism operators have cooperated with the researchers by offering the use of whale-watching boats for observing and photographing the whales, it has increased the capacity for data collection. In addition to facilitating research, the alliance between the scientists and the tourism operators also provided opportunities for raising public awareness of the value of whales and the urgency of conserving their habitat [53].

Ecuadorian NGOs affiliated with international conservation networks have carried out extensive work to categorize humpback whales as part of the natural patrimony and obligate the state to adopt whale conservation policies. The scientists who advocate for whale-watching as a market-based tool of conservation have documented their activities both in the Ecuadorian news media as well as in their scientific publications. Their tasks were twofold: first, to convince the Ecuadorian government that the humpback whale is an endangered subject in need of the state's protection; and second, to convince the government that the humpback whale is a reliable resource that appears regularly in the oceanic territories of Ecuador. This enabled the Ecuadorian state agencies to include the humpback in their calculations for economic and social planning and make the humpback whale central to the overall management of the coastal environment.

The Ecuadorian NGOs are networked into international organizations. While the research of FEMM was supported in the 1990s by the Whale and Dolphin Conservation Society [WDCS], PWF received support from its international affiliate. Both WDCS and PWF are among the NGOs that have been active in efforts to influence the policies of the International Whaling Commission [IWC] [54]. The Ecuadorian scientists have prepared and submitted numerous technical reports to the IWC, and they have served as delegates to the IWC meetings [55]. Through their activities of networking with colleagues in other Latin American countries, and with the goal of keeping the IWC moratorium in place, Ecuadorian NGOs have helped to create a Latin American anti-whaling lobby, known as the Buenos Aires Group [6].

In Ecuador, the link between whale-watching policies and international conflict over the whaling issue is expressed in the rhetoric of economic utility. For example, it was stated in the "Outline of the National Position" presented in 2010 by the delegates to the 62nd meeting of the International Whaling Commission that "Ecuador, in compliance with its environmental policies opposes the commercial hunting of whales. . .and favors the nonlethal use [of whales] through responsible whale-watching tourism as an alternative form of development for coastal communities" [56]. In 2019, the National Assembly's Parliamentary Group for Animal Welfare advocated for whale-watching, noting that 15 million dollars were earned nationwide through tourism related to whale-watching [57]. These arguments are based on the rational use of whales as a resource for tourist development.

However, other anti-whaling statements emphasized the rights of Nature, enshrined in the Ecuadorian Constitution of 2008 [58]. These include a public statement emitted by the Ministry of Environment and another by the Ecuadorian Ministry of Tourism, which reminded the public, "Within the constitutional framework of Ecuador, the hunting of whales is considered a violation of the defense of the rights of Nature. Our country recognizes the application of precautions and restrictions on activities that can lead to extinctions of species, the destruction of ecosystems, or the permanent alteration of natural cycles" [59]. Here, the language of rights displaces the language of economic utility.

Clearly, the knowledge produced by NGO-affiliated researchers is framed from the perspective that humpback whales are endangered at the international level as a result of past and current threats. Globally, the species may not be in danger since the IUCN has moved the humpback whale from the Red List category of "vulnerable" to "least concern" [60]. Nevertheless, the controversy over whaling enables Ecuadorian NGOs to categorize the humpback as a species in need of special protection. To convince the

Ecuadorian government that the humpback is worthy of protection, however, they have set out to document localized threats to the humpback. Furthermore, they have carried out research to document the reliability of the whales' migration patterns through Ecuadorian waters, providing proof that the whale is a "national" resource for development.

3.4. Setting Boundaries for Policies on Whale-Watching and Conservation

In addition to sharing their data for the analysis of conservation problems, the NGO-affiliated researchers provide data to support advocacy for conservation policies. They have collected and published data about threats to the whale population, such as interactions with fisheries [46,61,62] and ship strikes [63]. Interactions with fisheries occur when a whale encounters a fishing net, longline, or other gear that entangles the whale's fins, body, or tail, often leading to the eventual death of the animal [64]. The problem of cetacean interactions with fisheries has no clear solution since mitigation proposals such as closed seasons on fishing, restricted zones, and restrictions of fishing gear normally draw negative reactions in coastal communities where fishing is a crucial livelihood [65]. The researchers have used their data to estimate the number of whales entangled at 23–45 annually and call for improved surveillance and management [52,66]. Hence, research on fishery interactions represents the whales as threatened and leads to the argument that the government should take responsibility to mitigate the risks.

The author posed the question of cetacean interactions with fisheries during a brief interview with biologist Gustavo Iturralde, who at the time was Director of Regulations and Coastal Projects at the Ministry of the Environment [MAE]. His response was that the MAE could not intervene because not enough is known about the locations of the entanglements and the types of fishing gear involved in the whales' deaths [67]. He noted that any such entanglements that occur outside of the boundaries of the national parks and nature reserves are taking place outside of the MAE's jurisdiction. He also claimed that despite their undeniable scientific expertise, the conservation NGOs provide information that is inconsistent and of limited use to government planners and managers [67]. A different perspective was provided by marine biologist Fernando Félix, who suggested that the problem lies not with the fishing communities of Ecuador, but with the government's unwillingness to recognize the magnitude of the threat that fisheries represent for whales [47].

However, another major area of research for the NGOs has been the effects of whale-watching tourism on the humpback whales themselves. This research did capture the interest of government officials, as confirmed by Mr. Iturralde: "The main thing that the Ministry of the Environment wants [with whales]. . .is to regulate and control whale-watching activities" [67]. In 2002, a researcher in Machalilla National Park reported that tourist boats often surrounded the whales for an extended period of time [68]. A subsequent publication by another team confirmed that humpback whales in the park showed signs of disrupted behavior and other possible negative impacts of human contact [69].

The Ecuadorian government did support the ratification of the National Code of Regulations for Whale-Watching in Ecuador in 2014, incorporating the recommendations of the NGO-affiliated researchers [29]. The code is comprehensive, detailing the procedures for licensing tour operators, the types of vessels, the procedures of approach, the distance from the whales, the duration, and other aspects [49].

Here, it can be observed that whale conservation has followed a specific path of boundary-making. First, whale-watching as an activity has been determined to be feasible to regulate, and it has been earmarked as an activity suitable for the protected areas and national parks that fall under the jurisdiction of the Ministry of the Environment. In contrast, the harm to whales inflicted by fishing gear is deemed outside of regulation. This appears to be a result of the Ministry of the Environment's relative willingness to work with the NGOs, given that whale-watching is economically vital in the environs of the parks and protected areas. In contrast, the fisheries authority (Secretariat of Fishery Resources, Ministry of Agriculture, Livestock, and Fisheries) would view whale conservation as a threat or possible limitation on fisheries rather than as an opportunity. Second, the whale-

watching regulation is limited in its provision to include only cetacean species (whales and dolphins) and does not extend to other marine mammals. This boundary appears both arbitrary and counter-productive to NGO-based researchers like Ben Haase, who explained, "The decision to make Galápagos into a whale sanctuary was misguided. . .we said it should extend to all marine mammals" [48].

3.5. Connecting Whales to a Particular Territory

Overall, the most important research for conservation purposes has been the survey carried out to describe the population of humpback whales that migrate annually through Ecuador's coastal waters. The researchers were able to identify and record the presence of individual whales through the method of photoidentification [45,70]. The tail fluke displays pigmentation patterns unique to each whale and can be used like a "fingerprint" to identify the individual [71]. As each whale was photographed and identified, the researchers also classified it by sex and age category (adult, subadult, or calf). This provided a statistical estimate of the ratio of males to females, their age structure, and their health status. The researchers used a method called mark-recapture, a statistical procedure for the estimation of population size and population parameters.

Photoidentification led to the discovery that a proportion of the population of whales consistently visits Ecuador on its yearly migration. This has led some promoters of whale-watching to claim that there is an "Ecuadorian" population of whales that returns every year to mate and give birth to calves in the vicinity of Machalilla National Park. However, the situation is more complicated. There is no doubt that the "presence of humpback whales off the Ecuadorian coast is. . . a seasonal event with reproductive and calving purposes" [45], but many of the whales pass through the Ecuadorian waters as they head northward to Colombia, Panamá, and Costa Rica [70]. Nevertheless, studies carried out on migratory whales using satellite telemetry confirm that humpbacks use areas of the Ecuadorian coast for breeding and nursing calves [72]. Currently, it is thought that the Ecuadorian humpbacks are part of the southeast Pacific stock, which is estimated at 11,780 individuals [73].

Hence, the identification and monitoring of the whale population has reinforced the idea that the whales are a reliable resource for tourism, and the population of whales can be calculated as part of the Ministry of Tourism's strategy for the coastal region. The idea is supported by claims that humpback whales are migrants who faithfully return to a specific location in Ecuador year after year. For example, the Ministry of the Environment claimed that in "the Machalilla National Park, in the canton of Puerto López, in the province of Manabí. . .this place is known as the mating ground of this species, which crosses from the frozen waters of Antarctica to the warm Pacific waters. . . For the experts, this journey is part of the cetacean cycle of life which permits the normal reproduction of the species. However, for the romantics of Puerto López, it is a ritual of love which begins the gestation, that which will culminate in the journey of the following year, conceived in the seas of Ecuador" [74]. This discourse rhetorically assimilates the reproductive power of humpback whales to the biopower of the Ecuadorian nation. Hence, the advocates of whale-watching affirm that the humpback whales have an enduring connection to Ecuador, which the whales themselves pass down from generation to generation.

Here, it can be observed that whale conservation research has followed a specific path of boundary-making. First, conservationists have distinguished the national park and its boundaries as a special location for whale conservation since the jurisdiction makes it feasible to administer and regulate ecotourism activities. Next, they have categorized the humpback whales as Ecuadorian in nationality, a faithful population of migrant returnees. Finally, it should be noted that the research not only defines the whale as an Ecuadorian whale, but it also defines the Ecuadorian coastline as a location appropriate for ecotourism and conservation, to the preference or exclusion over other uses. For example, it was argued that aquaculture (fish farms) would be harmful for the whales and for the coastal habitat [75], as would offshore oil and gas drilling [76]. Barragán Paladines identified a

sociocultural transformation in Puerto López in which young adults came to view fishing as an inappropriate and outmoded livelihood, with preference given instead to tourism-related occupations [39]. In this manner, the boundaries imposed by NGO-led research may lead to biased public perceptions of the appropriate use of coastal habitats and resources [39].

Environmental governmentality requires not only knowledge for predicting numbers and the movements of the humpback whale population, since it also requires quantifying and monitoring the movements of humans who will come to see the whales. The former director of Machalilla National Park, Fernando Vera, explained that "we must control tourism" to maintain the species and the places that attract visitors [77]. In an interview with the author, Mr. Vera explained that it is important for the park to link whale-watching tourism to other nature-related attractions [78]. To this end, the park created a "Visitor Management System" to match each tourist with a nature-themed itinerary in the park [77]. Given that the number of tourists visiting the park has increased vertiginously from 517 in 1988 to 77,625 in 2019 [1], it is essential for the park administrators to control the spaces where the encounter between humans and nonhuman animals takes place so that the outcome of the encounter will not harm the animals. In essence, this is a practice of biopolitics.

Finally, it is important to note that NGO-affiliated scientists have devoted their own time to providing training for the whale-watch tour operators [79]. This represents a direct diffusion of knowledge from scientists to the handlers of human tourists, making it possible for the whale-human encounter to follow a routine procedure that prevents harm to the whales.

To summarize, Ecuadorian NGO-affiliated researchers have developed biopolitical technologies for classifying the whale population as one that is endangered and needs protection, identifying its individuals and tracking their movements, describing the population, and finally, practicing biopolitics by controlling the times and places where whales and humans can interact. Through these technologies, the whale is transformed into an animal worthy of conservation and protection by the Ecuadorian state.

3.6. Creating Personal Bonds with Individual Whales

Since 1998, the municipality of Puerto López has celebrated the Humpback Whale Festival each year in June to officially open the whale-watching season. The festival is a civic event that invites the participation of the public while also bringing together local officials (municipal, cantonal, and provincial), representatives of the national ministries, and tourism operators. The whale festival of Puerto López is so important to the community's hopes for prosperity and growth that it has been celebrated even during the COVID-19 pandemic, when tourists were necessarily absent [80]. As an event that fortifies the community identity of Puerto López, the festival serves to solidify the human community's identification with the whales. It has been suggested that the tradition will endure as long as the humpbacks continue their migrations [53].

In addition to celebrating the community, the festival serves to instill and promote an ethical stance toward humpback whales and toward nature in general. In this manner, the festival is a biopolitical institution that has disciplinary functions, instilling social norms and principles for the ethical manner in which to think about, look at, and interact with wild animals. The ethical messages of the festival are premised on the three aspects of knowledge produced by the Ecuadorian NGOs that study whales: (1) the idea that whales are endangered; (2) the idea that whales are connected to Ecuadorian territory and the national park; and (3) the idea that tourism is the most appropriate use for this environment. From these ideas, they derive an ethical stance toward whales that advances a specific model of human/nature interactions that occur in environmentally valued spaces, such as the national park.

The ethical model is performed by citizens and officials at the festival. For example, a high school student who participated in a pageant during the festival explained that he

wanted to make people more aware that everyone ought to respect marine species and their habitat [77]. A tour guide on the whale-watching tour said that he considers his work to be "ecological", and he is careful to follow all procedures necessary to safeguard the whales and their habitat [81]. A government official exhorted the local citizens not to discard rubbish in the sea and to take precautions against the improper use of fishing gear [74].

The ethical stance toward whales is justified by the scientific research methods based on the identification and tracking of individual whales. This individualization of the whale produces a metaphorical equivalence between the individuality of humans and the individuality of whales. It has been utilized to claim that humpback whales are individuals who can be named and known, just as human individuals can be named and known. Cristina Castro of the Pacific Whale Foundation is well known for having named a whale "Leonardo", after her father; she also named a whale "Isabel", in honor of a past Minister of the Environment who supported Ecuador's reentry as a member nation in the International Whaling Commission [82]. According to Castro, not every humpback whale is given a personal name, as it is "only those that are special, that return each year or have beautiful histories" [82].

Castro has helped to promulgate this practice through her work as an organizer of the annual whale festival in Puerto López. Since 2009, the festival has promoted the "baptism" and godparenthood of whales, a practice by which an individual or a corporation bestows a name and becomes the godparent of the whale. The goal is for the godparent to become "like an adoptive parent, who will look out for the whales and the care of their ecosystem" [83].

The extension of fictive kinship to whales in the name of conservation is based upon assumptions about the whale's individuality. Indeed, the assertion that each whale has a unique pattern on its tail fluke leads to the notion that "the tail is its. . .fingerprint or identity card" [84]. The whale's identity is therefore made official by its entry into a master database and the assignment of an identification number. According to Castro and Mena, "We are something like a Civil Registry for the humpback whales; we enroll them with their photos, we baptize them with names. . .and we investigate them during their entire lives, to simply know and understand a little more about them" [71].

This official identity registry has resulted in the imagination of the whales in another type of social relationship: Ecuadorian nationality or citizenship. Hence, Ángel Pincay, the municipal director of tourism for Puerto López, announced that the humpback whales are "proudly Manabitas" (citizens of Manabí province) since they breed and give birth in the waters of the Manabí coastline [83]. Biologist Cristina Castro has argued that "by nationalizing the whales that are born in our waters, these remain protected [from whaling] when they migrate to Antarctica for feeding during the summer months" [85]. The civic celebration of whale tourism in Puerto López is a venue for publicly imparting Ecuadorian nationality to the humpback whales, which will (perhaps) give them diplomatic immunity against the harpoons of Japanese whalers.

4. Discussion

The examples provided here illustrate that Ecuador's whale experts are not merely communicating information about whales; they also create knowledge about whales and promote specific conservation practices. Through their involvement in transnational advocacy networks, Ecuadorian whale experts have advanced the idea that whales are threatened and must have legal protection. Through research on whale-watching, they have shown the need for regulating the interactions between tourists and whales. Through photo identification, they have shown that humpback whales return to Ecuadorian territory annually. Their research findings have led to the institutionalization of an ethical stance toward whales.

Hence, in coastal Ecuador, the humpback whale as a flagship species is not merely a form of tourism propaganda; it is part of an effort to promote and popularize an ethical stance toward wildlife. The baptism of whales at the annual festival and the comparison

of the whale's tail to an identity card are practices that inculcate the idea that it is normal or natural for the government as well as local citizens to take steps to care for the whales. Through this stance, the whales are made into protagonists, or subjects of conservation, and humans (tourists, boat operators, and others) are obligated to treat them ethically. In this manner, the institutional policies and discourses of whale-watching and ecotourism transform the whale into an environmental subject.

Does the humpback whale, as a flagship species, lead to improved conservation? In interviews, Fernando Felix [47] and Ben Haase [48] indicated that the whale-watching regulation is only useful to the extent that it will be enforced by the authorities. In other words, they believe that conservation ultimately depends on the state's capacity to intervene and implement protective policies.

Thus, the persistent problem of the flagship species in conservation is to discover how to extend the subjective engagement with a specific object (the flagship species) to instill a wider commitment to coastal habitats and the environment overall. If environmental governmentality in practice operates through several distinctive modes, there are multiple ways to compel compliance, including intervention through the application of rules and penalties and the disciplinary mode, which operates through the inculcation of market-based norms [86]. If the flagship species represents a mode of governmentality that operates through the promulgation of norms, it may be insufficient without the intervention of enforcement mechanisms. The Ecuadorian case supports the idea that governmentality necessarily involves "multiple modes of conservation biopolitics that coexist" [87].

In response to the concern about ecotourism serving to commodify nature in a harmful manner, because it "cuts the threads that binds ecosystems together" [7], whale conservation in Ecuador cannot wholly refute this argument. Instead of extending protected status to all living things, humpback whales have been selected through boundary-making technologies of biopolitics, which categorize and separate the whales from other species. The practice of naming and baptizing individual whales affiliates the whales with humans, conceptually separating them from less charismatic species. The relationship is designed to oblige the human godparent to speak on behalf of the whale's right to exist and to receive the protection of the state. Similarly, the practice of nationalizing whales gives them a political relevance and subjecthood that are not granted to other species, which remain inanimate objects of policy rather than national subjects.

Nevertheless, Ecuador's whale-watching tourism gives a powerful illustration of a situation in which the future of human lives and communities is inexorably linked to the fate of non-human populations. Striving for economic development through wildlife conservation indicates that economic goals are inscribed within conservation goals. As Cristina Castro explained in an interview with the author, "It is not true that I want to conserve a beautiful animal simply because it is beautiful. It is because I want to conserve something that will [also] be of economic benefit for the people [of Ecuador]" [55]. In a published interview with Oswaldo Báez Tobar, she elaborated, "I don't believe in sustainable development, which mentions just the economy and the environment. I believe fully in sustainable human development, which is the path by which the environment, the economy, and human beings interact to help each other mutually. The proper management of nature can provide a better quality of life and improve the local economy, conserving these ecosystems" [88].

5. Conclusions

Whale-watching in Ecuador demonstrates that biopolitics gains its power from the instrumental nature of its ethical claim to care for nature and humans. The knowledge of whales developed by whale-watching advocates has served to separate the humpback whale from other natural species, portraying it as a species especially deserving of the right to be protected from harm. Conservationists have categorized the whale as threatened (by whaling), individually identifiable, and faithfully returning to a specific habitat in Ecuadorian coastal waters. These bases for carrying out research on humpback whales

have extended the power of Ecuadorian government agencies to utilize the whales as an economic resource while also calling for an ethical and benevolent relationship between humans and whales. In this ethical frame, the advocates of ecotourism have argued forthe most profitable way to save the whales and hence preferable to other uses of the coastline, such as fishing, aquaculture, or fossil fuel exploitation. When they assert the ethical nature of whale-watching tourism, backed up by the National Code of Regulations for Whale-Watching in Ecuador, the advocates hope to make whale-watching competitive so that it will prevent the more harmful industries from becoming established on the coast. In this manner, the "ethical" nature of whale-watching is instrumental, serving as a political and economic pathway to promote conservation in place of extractive industries that create more aggravated impacts on natural habitats.

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Exogenous, Endogenous, and Peripheral Actors: A Situational Analysis of Stakeholder Inclusion within Transboundary Water Governance

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Abstract: Transboundary water governance involves collaborative decision-making across geopolitical boundaries to manage shared water resources sustainably. While this approach integrates public, private, and community efforts, little scrutiny has been directed toward the involvement of non-institutionally affiliated stakeholders. This study critically examines stakeholder participation in Upper Klamath Basin water governance by investigating how deficiencies in stakeholder inclusion impede transboundary water management processes by favoring institutionally affiliated actors. Findings reveal the differential influence of "endogenous" (directly involved), "exogenous" (indirectly involved), and "peripheral" (limited engagement and influence) actors. While endogenous and exogenous actors have formal or informal ties to institutions, peripheral actors lack institutional affiliation(s), making it difficult for them to participate in and ultimately influence water governance decision-making processes. Their limited access to financial, natural, and social capital further restricts their engagement with governance efforts. This imbalance underscores challenges to equity and inclusion in transboundary water governance processes. Addressing the exclusion of peripheral actors from transboundary water governance requires that governance institutions prioritize equity and inclusivity, fostering transparency, incentivizing inclusive practices, and comparing engagement processes to enhance effectiveness and equity in transboundary water management.

Keywords: collaborative governance; environmental decision-making; situational analysis; transboundary waters

1. Introduction

It is predicted that by 2050, the number of people living in river basins under severe water stress around the globe will reach 3.9 billion, totaling over 40 percent of the world's population [1]. Projections indicate a fivefold increase in the global land under "extreme drought" compared to 2020 [2], while water demand is expected to surge by 55 percent [3]. Given these projections, it is understandable why water and its governance remain an urgent theme in sustainability science [4–6]. This urgency stems from the need to navigate the complexities of adjudicated water rights [7], heightened competition among stakeholder groups with diverse and often conflicting interests [8], and the necessity of ensuring the human right to safe, clean, and affordable water [9] in an increasingly warming and meteorologically unpredictable planet [10].

Complicating the management of this increasingly fragile resource, water bodies are fluid; they do not follow, or are not easily confined to, artificial political boundaries. Globally, more than 310 river and lake basins are shared between at least two countries [11]. Of the 195 independent sovereign nations on Earth, 145 share at least one of these international bodies of water [11]. Interstate water bodies and irrigation infrastructure further complicate regional water management. For example, more than twenty river basins and nine federal irrigation projects cross state boundaries in the United States alone. Beyond freshwater systems, challenges in transboundary governance and management are also evident in saltwater bodies, such as bays and oceans [12–14], and groundwater reservoirs [15,16], as

well as frozen water sources like glaciers and snow packs [17,18]. Despite their hydrological differences, these diverse water systems share common issues related to transboundary jurisdictional complexities, environmental degradation, and competing resource demands, necessitating integrated approaches for effective management and sustainability. As transboundary entities, each of these systems boasts unique ecological, social, economic, and political challenges, leaving natural resource scholars and practitioners to ask: How do we best manage transboundary waters amid climate variability [4], growing political frustrations about resource allocation [19], and the pressing need to enhance resource resilience and sustainability [20,21]?

Over the last century, regional environmental management has been marked by technocratic decision-making processes wherein costly and extensive government-sponsored projects have been executed with minimal public input [22]. An example of such bureaucratic, "top-down" approaches to environmental management include the establishment and exertion of federally controlled laws and regulations on the extraction and use of regional water resources. Ongoing initiatives helmed by bureaucratic agencies are now making strides to scrutinize and remedy this historical trend, such as incorporating multi-stakeholder partnerships, decentralized governance structures, and community-based resource management. Through these initiatives, roles that government (state) actors previously dominated are increasingly categorized as activities carried out by more local, non-government (non-state) actors [23], including decision-making over natural resource use. This paradigm shift is often characterized as a move from *government* toward *governance*, emphasizing broader participation, collaboration, and shared responsibility among multiple stakeholders, including non-governmental actors and civil society organizations. In the shift, various "hybrid" forms of decision-making have emerged, in which state actors collaborate with non-state actors to manage common pool resources [24], which are natural assets like land, water, and the atmosphere. These common pool resources are shared among multiple users, characterized by rivalry in consumption and difficulty in excluding others from use. Examples include co-management, public–private partnerships, and social–private partnerships, all emphasizing collaboration between actors at different scales [25]. These efforts, ranging from local community forestry initiatives to international climate change mitigation projects, represent a turn toward more inclusive and participatory environmental decision-making approaches.

A growing body of social science literature stresses collaborative water governance as a promising strategy to tackle these issues [26–28]. Through the involvement of a diverse set of actors, collaborative governance has demonstrated its capacity to bring stakeholders together in collective forums to engage in consensus-oriented decision-making [29]. Some of the most well-known case studies investigating the collaborative governance of transboundary waters are highlighted in Wolf's analysis of water management and hydropolitics along the Jordan River [30], Wallis and Ison's investigation of institutional complexity within the management of Australia's Murray–Darling Basin [31], Sullivan et al.'s study of collaborative governance in the Colorado River Basin [32], and Simms et al.'s examination of First Nations' concerns with collaborative watershed management in British Columbia, Canada [33]. Despite the publication of case studies such as these, a notable gap persists in the critical assessment of participant equity and inclusion within stakeholder engagement processes and their resultant outcomes [34].

This article investigates how the limits of natural resource decision-making (e.g., deficient stakeholder inclusion) hinder transboundary water management processes by privileging the participation of actors affiliated with institutions. Section 2 outlines the challenges of transboundary water governance, arguing that collaborative governance can lead to more effective protection of the environment while simultaneously appealing to those seeking just means of resource management. Section 3 describes how the study's qualitative research design incorporates a situational analysis methodology to examine how stakeholders are involved in decision-making processes in transboundary water governance in the Upper Klamath Basin. Section 4 uses the situational analysis methodology's

conceptualizations of "decision-making arenas" and "social worlds" to illustrate the complex dynamics shaping transboundary water management in the Upper Klamath Basin. After identifying the presence of one decision-making arena and three groups of social worlds in this case, Section 4 examines them in four sub-sections: (1) the water governance arena, (2) endogenous social worlds, (3) exogenous social worlds, and (4) peripheral social worlds. These subsections delve into the nuances of power dynamics, stakeholder interactions, and the distribution of decision-making authority. Through this examination, it becomes evident that specific stakeholders wield disproportionate influence due to their affiliations with non-governmental organizations (NGOs) and state and federal institutions, perpetuating existing power differentials and impeding broader participation. Section 5 expands upon these findings to reveal how the collaborative stakeholder engagement process used in Upper Klamath Basin water governance inadvertently perpetuates power imbalances by favoring a select group of stakeholders. Within this structure, engagement processes prioritize groups and individuals associated with government bodies, agencies, service providers, and NGOs, effectively excluding individuals and communities who lack formal affiliation with institutions.

As a result, this selective approach not only marginalizes concerns and perspectives from institutionally unaffiliated parties but also perpetuates the dominance of privileged, institutionally affiliated stakeholders in water governance decision-making. Despite initiatives like the Bureau of Reclamation's Policy CMP 903, which seeks to broaden public involvement systematically, underlying power differentials remain unaddressed, thus reinforcing systemic inequities within the water governance system. These findings significantly contribute to the field by providing empirical insights into the complexities of stakeholder inclusion in water governance, particularly in the Upper Klamath Basin. By examining the challenges various stakeholder groups face and identifying systemic barriers to participation, this article fills a gap in the literature that often lacks data-driven analyses of engagement processes and outcomes in water resource management [35]. Moreover, the findings underscore the need for more comprehensive research on stakeholder engagement dynamics, including the role of power structures, institutional biases, and access to information, thereby enhancing our understanding of how to foster more equitable and inclusive decision-making processes in water governance contexts.

Recognizing the limitations of current stakeholder engagement practices, the sixth section concludes the article by emphasizing the need to reevaluate stakeholder engagement practices within transboundary water governance processes to achieve genuine inclusivity and address systemic barriers. This article contends that future research should critically examine stakeholder legitimacy—including how legitimacy is awarded—and explore strategies for enhancing representation and participation. Comparative studies across transboundary watersheds can identify common patterns, challenges, and best practices, informing more inclusive and effective engagement efforts to address complex water governance challenges. Ultimately, this process can foster accountability and promote sustainable solutions in water governance.

Drawing from environmental decision-making and management literature, environmental and natural resource sociology, and the science of stakeholder engagement, this article delves into the intricate landscape of stakeholder inclusion within collaborative governance processes. By synthesizing insights from these diverse fields, it sheds light on the expanding role of non-governmental actors in decision-making, emphasizing the importance of multi-stakeholder engagement in tackling complex environmental challenges. However, it also acknowledges persistent hurdles such as power disparities, unequal representation, and the risk of perpetuating inequalities within collaborative frameworks. Thus, it advocates for further empirical research to unravel the nuanced dynamics of power and inclusion in collaborative governance, aiming to foster social and environmental equity in decision-making processes.

2. Review of Relevant Literature

2.1. Stakeholder Engagement in Collaborative Environmental Governance

Collaborative governance is defined as "the processes and structures of public policy decision-making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private, and civic spheres" [36]. In this process, non-government parties, like environmental groups, private technical service providers and consultants, citizen groups, university affiliates, and residents, claim a more prominent management role in natural resource management, working in tandem with state agencies to oversee the management of natural resources. This form of collaborative resource governance is often characterized by multi-scalar, multi-stakeholder engagement. One can see such examples in the cases of catchment management in New Zealand [37], transboundary river basin management in the European Union [38], and the movement toward sustainable groundwater management in California [39].

In stakeholder engagement processes, institutions invite individuals or groups deemed "stakeholders" to actively participate in research, planning, and actions that directly impact their lives. However, defining precisely who qualifies as a "stakeholder" presents a complex challenge within environmental governance literature [40]. This debate arises partly from the difficulty in determining what constitutes a legitimate "stake" [40]. Those affected by the outcomes of environmental management decisions inherently possess an interest and, therefore, hold a stake in the process. Reed et al. [40] describe how various stakeholder theories propose differing definitions, ranging from narrower, more instrumental views, such as those that are essential for an organization's survival [41], to broader, more normative perspectives that include any entity affected by organizational performance [42,43]. Additionally, Checkland [44] suggests that individuals or groups who own a problem should also co-own the process to solve it. Coase [45], in his work on environmental pollution, categorized stakeholders as either polluters or victims, with victims encompassing those directly or indirectly impacted. Following the framework proposed by Eaton et al. [34], stakeholders are defined in this article as "those directly or indirectly affected by and potentially able to affect a decision" (p. 284).

Scholars working at the intersection between natural resource management and the science of stakeholder engagement claim that different actors can be classified based on their involvement and influence on a decision-making process. Based on his study of collaborative negotiation efforts in the Klamath Basin during the mid-2000s, McCool [46] argued that watershed stakeholders can be classified into two categories: endogenous and exogenous. Endogenous stakeholders are physically present at the water governance table and are actively involved in management decision-making. Though McCool did not clearly distinguish which stakeholder groups fit into each category, recent ethnographic research has found that endogenous stakeholders include individuals who are on boards of directors or serve as supervisors of drainage and irrigation districts or agricultural and natural resource non-governmental organizations (NGOs), elected officials, staff in state and federal agencies, irrigation managers, and representatives of tribal governments [47]. On the other hand, exogenous stakeholders are not directly involved in natural resource management but have the power to influence or interfere in such processes. These individuals include movers and shakers in the political world, including owners and operators of agricultural businesses, agricultural and environmental non-governmental organizations (NGOs), media reporters and publishers, academic researchers, and informal, non-institutionally affiliated groups.

2.2. Challenges and Opportunities for Stakeholder Engagement in Collaborative Environmental Governance

Advocates of engagement posit that empowering stakeholders to join in decision-making enables learning, builds relationships, strengthens capacities, and fosters the coordination required to address complex environmental problems [48,49]. Approaches aimed at building partnerships and shared understanding among stakeholders have shown

that actors who are actively involved in developing solutions to environmental problems are more inclined to accept and champion the decisions decided by the group, even if those decisions do not directly align with their own interests [29]. When used appropriately, these engagement outcomes reflect a broad range of knowledge and are more likely to be acceptable to all parties, with less potential for contestation compared to outcomes of non-collaborative decision-making [50,51].

Though stakeholder engagement offers advantages—in terms of acceptance and effectiveness in protecting the environment—compared to traditional bureaucratic decision-making [11,52], disadvantages remain. Collaborative approaches are grounded, to varying degrees, in the assumption that all actors can contribute to ultimate outcomes in meaningful ways [51]. In cases where stakeholders have relatively equal social capital, resources, and networks, this assumption may prove valid. However, in environmental governance, the kinds of actors that come together are rarely equal [53]. They can readily differ regarding access to information, financial resources, and decision-making power.

Collaborative environmental governance processes, as highlighted by Eaton et al. [34], encompass a diverse array of stakeholders, ranging from government actors fulfilling bureaucratic functions to political groups advancing specific agendas, lobbyists seeking political gains, non-government organizations (NGOs) pursuing organizational objectives, and citizens addressing personal concerns. Given the inherent differences among these stakeholder groups and their capacities, it becomes crucial to address potential challenges. Common criticisms of stakeholder-based governance efforts highlight that collaborative processes can inadvertently mirror existing power structures, potentially excluding stakeholders not already integrated into formal and informal natural resource management frameworks [54]. This historical distortion jeopardizes the potential of collaborative governance to enhance equality by neglecting individuals, organizations, and positions typically underrepresented in environmental and natural resource governance [55].

Moreover, the "tyrannical potential" of public participation in governance, as coined by Cooke and Kothari [56], underscores the risk of dominant stakeholders manipulating participatory processes to serve their interests. This manipulation can lead to the marginalization or silencing of less powerful groups or individuals, potentially undermining the democratic ideals of collaborative governance. To avoid such pitfalls, it is essential for organizers to critically assess and account for the existing power structures at play [57]. Without this critical awareness, collaborative governance processes may devolve into mere tokenism, where public participation forums become symbolic rather than substantive [58].

Power in collaboration and engagement is also tied to institutional privilege. In many cases, environmental governance is the responsibility of one specific stakeholder, often a government agency. Colvin et al. [59] describe how such a government agency's dual role of "rule adjudicator" and "privileged stakeholder" may perpetuate power imbalances through the alignment of their decision-making power with their participation in collaborative governance processes. It is through this progression that stakeholder engagement in governance processes may, in fact, reproduce inequalities. Specific to collaborative transboundary water governance, the engagement and communication dynamics between state- and institutionally affiliated stakeholders and other actors who are non-state and non-institutionally affiliated remain inadequately understood [60]. This raises concerns about the dynamics of power and control adversely affecting resource management and the fairness and sustainability of existing governance practices [61].

Nevertheless, the dynamics between institutionally affiliated and non-institutionally affiliated actors in collaborative governance processes have so far only received limited attention in empirical studies. More case studies of governance processes from diverse contexts are needed to build a more extensive understanding of how to meaningfully advance environmental outcomes and social equity through collaborative decision-making [62]. Answering this call, this article investigates a specific case of transboundary water governance to identify how stakeholders are involved in such processes. As Brisbois and de Loe [53] note, the empirical study of participant inclusion within environmental governance poses

inherent challenges due to power relations' dynamic and intricate nature. Operating at multiple levels, from local to global, and involving a diverse array of actors, power dynamics demand a nuanced yet circumspect analytical approach. Environmental decision-making, moreover, often features power structures that are not explicit or formalized, encompassing informal networks, cultural norms, and historical legacies [63]. For these reasons, this article sheds light on these complex dynamics to provide insights into navigating them effectively in collaborative environmental governance processes.

3. Study Context and Methods

This article is part of a larger project that provides an extensive empirical examination of water governance efforts in the Upper Klamath Basin, a transboundary watershed on the border of Oregon and California located within the broader Klamath Basin. While the broader project aimed to understand various aspects, including governance structures, stakeholder engagement dynamics, power dynamics, and the influence of regional secessionist movements, this article investigates how transboundary water governance processes engage stakeholders with differing power levels and incentives to participate. Specifically, this article aims to determine the following:

1. In what ways do institutional affiliations shape stakeholder participation in transboundary water governance within the Upper Klamath Basin?
2. What strategies can be implemented to promote greater inclusivity and equity in decision-making processes, particularly for stakeholders who are not formally affiliated with an institution?

To provide comprehensive answers to these questions, I employed Clarke's situational analysis methodology [64]. This approach involved in-depth qualitative fieldwork and analysis, including 28 interviews with 32 participants, attendance at 85 public meetings, and over 400 hours of in-person ethnographic fieldwork.

3.1. Background: The Upper Klamath Basin

Primary data for this research were collected in the Upper Klamath Basin (see Figure 1), a sub-watershed of the greater Klamath Basin (see Figure 2), which stretches over ten and a half million acres on the border of Southern Oregon and Northern California (USA). In this region, the debate over individual rights to water, the consequences of climate change and persistent drought, and the role of stakeholders in decision-making processes have played out prominently over three decades. Native American tribes, three endangered species, six federal wildlife refuges, and a federal irrigation project compete for regional water allocation. Conflict between these actors has been well-documented [47,65–67], with researchers often describing the region as a site of an ongoing "water war" characterized by "combat biology" [68], "macho law", and "dirty politics" [69].

Water in the Upper Klamath Basin is governed by a complex system of agencies, organizations, laws, and policies that are being actively litigated. The Klamath Tribes hold the most senior water rights in the Upper Klamath Basin; their priority dates simply reading "time immemorial". The Klamath Tribes' ability to claim any water rights has been complicated by their "irregular" status as a tribe with no reservation. After the Klamath Reservation was "essentially extinguished" by the Klamath Termination Act [67,70], the federal government sought to determine the Tribe's water rights. In United States v. Adair [71], the Ninth Circuit Court held that the Klamath Termination Act preserved pre-existing water rights, including the right to instream flows needed to meet treaty hunting and fishing obligations—those rights, the Court ruled, date to time immemorial. The Court further determined that the federal water rights guaranteed to the Klamath Tribes through Adair need not be registered within the State of Oregon and have, thus, never been quantified.

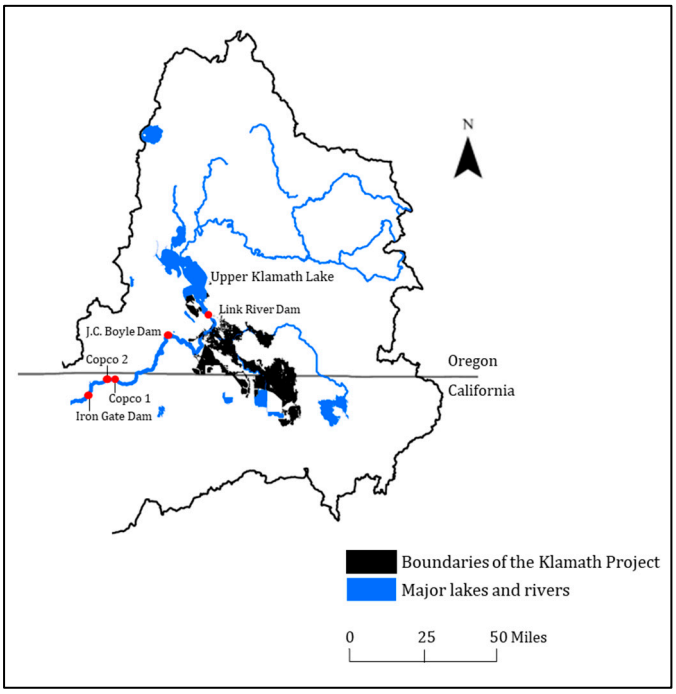

Figure 1. Map of the Upper Klamath Basin. Figure created in ArcGIS Pro 2.9.5. Cartography by the author. Data Sources: [72–75].

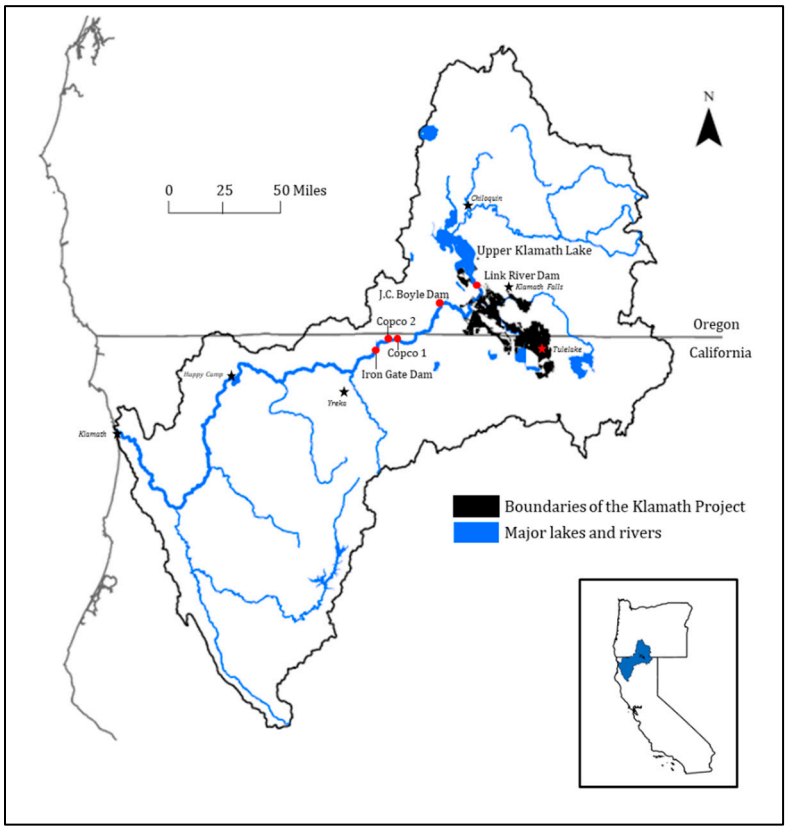

Figure 2. Map of the Klamath Basin. Figure created in ArcGIS Pro 2.9.5. Cartography by the author. Data Sources: [72–75].

An important element affected by water governance is irrigation in the Upper Klamath Basin. The Klamath Irrigation Project (henceforth, "the Klamath Project" or "the Project)

was initiated in 1905 as one of the first federal irrigation projects constructed by the U.S. Bureau of Reclamation (BOR) [47]. Today, the Klamath Project irrigation infrastructure serves approximately 230,000 acres and over 1400 agricultural operations. Production is primarily barley, alfalfa hay, and irrigated pasture, with smaller acreages devoted to higher-valued potatoes, onions, mint, and horseradish. In 2023, Klamath Project agricultural outputs were estimated to produce half a billion dollars annually in regional economic activity [76].

3.1.1. Key Agencies, Regulations, and Policies affecting Water Governance in the Upper Klamath Basin

Decision-making about the Klamath Project occurs at various levels, involving federal, regional, state, and local governments and agencies [47]. Currently, final decisions on irrigation management are exclusively made by federal agencies, including the U.S. Department of the Interior, with input and consultation from agencies such as the U.S. Bureau of Reclamation (BOR), the U.S. Environmental Protection Agency (EPA), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS).

Officially, the Bureau of Reclamation's Klamath Basin Area Office oversees the day-to-day operation and maintenance of the Klamath Project [47]. To meet oversight demands, the BOR contracts the services of local irrigation districts to carry out the day-to-day operation and maintenance demands (e.g., delivering water to Project patrons, removing debris from irrigation canals, and repairing Project infrastructure). The three largest of these districts are the Klamath Irrigation District (KID), the Klamath Drainage District (KDD), and the Tulelake Irrigation District (TID). All Project irrigation districts, including the smaller separate water user districts, are government entities formed under Oregon and California law. These contracts are carried out under the close eye of the BOR's Klamath Basin Area Office, the BOR's California–Great Basin Regional Office, the Bureau of Reclamation, and the Department of the Interior.

The Endangered Species Act (ESA)

In addition to these contracts, the Bureau of Reclamation must adhere to various federal laws, with a prominent focus on the Endangered Species Act (ESA). Originating in response to the environmental movements of the 1960s and 70s, the ESA stands as a cornerstone for protecting endangered and threatened species, encompassing fish, wildlife, and plants. Its impact on water allocation in the Klamath Basin gained prominence in 1988 with the listing of the c'waam (*Deltistes luxatus*) and koptu (*Chasmistes brevirostris*) as endangered species [77,78]. Commonly known as Lost River and shortnose suckers, these species bear immense cultural significance for the Klamath Tribes, supporting tribal fishing families and maintaining integral roles in cultural practices. Nevertheless, their survival is increasingly imperiled by drought, escalating temperatures, declining water levels, and deteriorating water quality [79]. Certain academic researchers and agency scientists contend that irrigation practices in the Upper Klamath Basin directly impact the habitat, migration patterns, and overall well-being of c'waam and koptu [80,81], sparking significant conflicts among the Upper Basin's agricultural, environmental, and tribal stakeholders.

Section 7, Biological Opinions (BiOps), and Interim Operations Plans (IOPs)

The ESA's Section 7 Policy [82] mandates collaboration among federal agencies to safeguard endangered and threatened species. As the agencies responsible for administering Section 7 in the Klamath Basin, NMFS and USFWS are tasked with undertaking assessments of water management practices to understand the potential effects on endangered species in the watershed. Following data collection and analysis, the agencies engage in a "meet and confer" process, where they discuss their findings and recommendations with "relevant stakeholders" [83], including representatives from local communities, environmental organizations, and government agencies. This dialogue encourages a broad exploration of the potential impacts and the development of tailored conservation measures. Subsequently,

the Bureau of Reclamation utilizes these recommendations to craft Interim Operations Plans (IOPs) for the Klamath Irrigation Project. These plans serve as guiding documents for federal water allocation decisions, ensuring that they align with the conservation goals outlined in the BiOps while also considering projected hydrological conditions and the needs of various stakeholders within the basin.

Implications of the Current IOP and Water Management Process

The current IOP regulating Klamath Project water allocation [83] has exacerbated contemporary tensions between stakeholder groups in the Upper Klamath Basin. Under its guidance, the Klamath Project served less than 15 percent of water demand in 2020 and 2022. It was shut down entirely in 2021, as allocation to irrigation interests was theorized to negatively impact endangered species during those years.

In early April 2022, the Bureau of Reclamation released its 2022 Operations Plan [84], which projected water allocation to the Klamath Project based on "current and projected hydrologic conditions." In this Plan, the BOR argued that "ongoing extreme drought conditions for the third consecutive year" were "preventing [. . .] Reclamation from operating the Project consistent with the conditions anticipated to occur for species listed as threatened or endangered under the Endangered Species Act" [84] as specified in the National Marine Fisheries Service 2019 BiOp [85] and the U.S. Fish and Wildlife Service 2020 BiOp [86]. Under conditions of the NMFS and USFWS BiOps, the BOR is required to "meet and confer" with both agencies "in the event that hydrologic conditions in Upper Klamath Lake and in the Klamath River are anticipated to fall outside the scope of certain 'boundary conditions' analyzed by the [agencies] in their respective BiOps" [86]. Coinciding with their "meet and confer" process with NMFS and USFWS, the Bureau of Reclamation simultaneously initiated a collaborative "public involvement" process concerning the 2022 Klamath Project Operations Plan (see Section 4.1.1). In other words, if rainfall and snow accumulation had been more consistent and of greater volume, the water needs of endangered species and the agricultural industry might have been satisfied. However, the water resources were insufficient, exacerbating debates over natural resource allocation and management priorities.

3.1.2. Significance of Investigating Power and Inclusion in Water Governance in the Klamath Basin

The Klamath Basin's complex set of contemporary water management and governance issues make this "situation" well-suited for investigating power and inclusion in multi-jurisdictional decision-making processes about the environment. Along with county, state, federal, tribal governments, and individual landowners, more than 60 formal parties are interested in the Basin's water governance decisions [47]. Published academic literature has examined the watershed in the context of relationships between agriculture and endangered species [87], environmental law and irrigation diversion [69], social-ecological restoration and large dam removal [67], and the economic effects of water conflict [65]. Scholars and decision-makers can benefit from examining the Klamath Basin "situation" to identify how collaborative governance processes either effectively or ineffectively engage stakeholders and the associated power- and equity-based implications and implications for environmental outcomes.

3.2. Research Methodology

Qualitative research methods are best suited for studies that aim to provide an in-depth understanding of the lived experiences of research participants [88]. The kinds of social problems best handled by such methods are ill-defined or poorly understood, deeply rooted, delicate or intangible, and sensitive to individual perspectives, cultural contexts, and subjective interpretations [89]. For example, in a multi-site case study examining the effectiveness of local blue economy practices in addressing the intertwined challenges of poverty and environmental degradation in coastal communities [90], qualitative methods

allowed researchers to explore the diverse perspectives of residents on the impacts of poverty, overfishing, pollution, and climate change on their livelihoods and well-being. Similarly, in research on Indigenous resource conservation in Colombia [91], qualitative approaches enabled researchers to uncover the cultural values, traditional knowledge, and social dynamics influencing ancestral practices for water and land management. These examples illustrate how qualitative research provides rich insights into the multifaceted challenges facing sustainable development and environmental management, offering nuanced understandings that quantitative methods alone may overlook.

The strengths of qualitative research also lie in the in-depth data analysis allowed by its methods. Researchers can delve into issues in detail and examine how phenomena are perceived, understood, and related to the individuals engaged in the data collection process [89]. This approach suitably complements more quantitative studies, which can ascertain prevalence, correlations, and statistical significance but not reveal underlying motivations or contextual nuances [89]. While quantitative methods provide valuable numerical data and statistical generalizability, qualitative research adds depth and richness to our understanding by exploring the intricacies of human behavior, perceptions, and experiences.

Given qualitative methods' capacity to delve into research participants' lived experiences and explore deeply rooted, delicate, and sensitive issues, their utilization in this study is apt for addressing the research questions outlined in Section 3. Qualitative methods offer a nuanced understanding of stakeholder engagement dynamics and provide valuable insights into strategies for improving inclusivity and equity in decision-making processes. Moreover, qualitative methods allow for thoroughly examining implicit power structures, necessitating empirical methods to uncover overt and covert social dynamics within a specific context [53].

Situational analysis, a qualitative analysis method established by Clarke [92] and further developed by Clarke [93] and Clarke, Washburn, and Friese [94], offers a robust framework for examining how affiliations and relationships shape processes and outcomes [95]. Researchers use visualization techniques to create unique visual representations akin to "systems maps" in other disciplines to convey complex situations and illustrate the interplay between various elements and actors (see [96] for examples of how systems maps have been applied in sustainability research). These visual representations offer insights into the interplay between multiple elements and actors within the context under study, aiding in comprehending diverse relationships and dynamics within the "situation". In this context, the term "situation" encompasses many elements and their varied relationships rather than being limited to a singular object or event [94].

Like other situational analyses (e.g., [97]), the larger research project that informed this article is rooted in the ontological assumption that human nature operates in a world where outcomes are strongly influenced by the struggle for and exercise of power. Aligning with this assumption, the situational analysis methodology provides a robust framework for exploring the complex interplay of power relations within social systems. By employing techniques such as social worlds/arenas mapping, researchers can systematically uncover and analyze power distribution, the negotiation of interests, and the exercise of control within specific contexts. Dudley et al. [97] first argued for situational analysis as a critical qualitative methodology to examine power and control in systems sustainability. This article builds upon their work by investigating how water governance processes engage stakeholders with differing power levels and incentives to participate.

Situational Analysis's Conceptualization of "Social Worlds" and "Arenas"

Within the situational analysis methodology, the process of mapping social worlds or arenas encourages researchers to define and describe the various groups of people involved and the places, whether physical or representational, where these groups interact. This methodology conceptualizes groups of actors as "social worlds" and identifies the spaces, whether tangible or abstract, as "arenas".

In the situational analysis methodology, "social worlds" refer to distinct groups of actors with varying sizes, each characterized by a collective identity and unique dynamics [94]. Within these social worlds, individual actors contribute to shared perspectives that shape both individual and collective identities. To identify social worlds within a "situation", a researcher must qualitatively code their data to distinguish what social worlds come together in a particular arena and why. During data analysis, the researcher asks themselves: "What are [individuals/organizations'] perspectives? What do they hope to achieve through collective action? What are their properties? What constraints, opportunities, and resources do they provide in that world?" [64]. Ultimately, the social worlds/arenas map visualizes how different actors engage with each other [64]. These perceptions undergird the commitments of the social world to collective action in the arenas in which they are involved.

Similarly, "arenas" bring together actors from diverse social worlds who unite to address a particular issue and are prepared to act within that framework. Within these arenas, representatives from various social worlds engage in debates, negotiations, and other interactions [64]. This mapping process aims to identify the organizational and institutional actors involved in the situation, examining which social worlds are concerned about specific issues and their intended actions. By unraveling the complexities of social worlds and their interconnections within arenas, this process sheds light on the unique roles of actor groups in shaping and influencing decision-making processes.

This article uses the social worlds/arenas mapping process to illustrate the complexities of stakeholder engagement within the Upper Klamath Basin's water governance arena. The social worlds/arenas mapping process directly addresses the research goals outlined in Section 3. Specifically, this methodology helps illuminate how institutional affiliations shape stakeholder participation in transboundary water governance within the Upper Klamath Basin. By categorizing actors into distinct social worlds and arenas, the mapping process provides a visual framework to analyze the complexities of stakeholder engagement and interactions within the water governance arena. Additionally, it facilitates a deeper understanding of how different stakeholder groups with varying power levels and incentives participate in decision-making processes. The social worlds/arenas mapping process serves as a valuable tool for achieving the objectives of this study by shedding light on the dynamics of stakeholder engagement and identifying strategies to promote greater inclusivity and equity in decision-making processes, thereby offering practical insights for policymakers and researchers interested in transboundary water governance within the Upper Klamath Basin.

Still, it is important to acknowledge the limitations of the situational analysis methodology, despite its valuable insights into institutional affiliations and organizational landscapes. In the context of environmental and natural resource social science, these limitations can significantly impact a study's findings. For instance, the reductionist representation of complex situations by SA may hinder the comprehensive understanding of environmental dynamics, potentially overlooking critical factors or interactions between actors. This could lead to incomplete insights into the intricate relationships between stakeholders and their impacts on decision-making processes. Additionally, SA's limited applicability in capturing temporal changes may restrict the study's ability to assess the evolving nature of environmental issues over time, potentially missing important trends or shifts in dynamics between human and non-human actors. Furthermore, the challenge of attributing specific discursive positions within SA may limit the depth of analysis regarding stakeholders' perspectives and interests, potentially resulting in oversimplified interpretations of complex environmental debates. While situational analysis methods may be more suitable for less complex environmental issues, this article demonstrates its utility in examining transboundary water governance processes, particularly in identifying less powerful actors, as suggested by Clarke [64].

3.3. Data Collection and Analysis

The findings presented in this specific article are based on data from observations of public meetings and events and semi-structured interviews conducted within the broader research project. Details regarding this data and their collection process can be found in Table 1.

Table 1. Sources of primary qualitative data used in this study.

Data Source	Total N	Timeframe Collected	Category of Event, Meeting, or Interview Participant		Remarks
			Event, Meeting, or Participant Type	Category N	
Observation of Public Meetings and Events	85	September 2021 to December 2022	Klamath Basin Improvement District Board of Directors Meeting	4	Over 400 hours spent observing 85 separate meetings and events with natural resource stakeholders representing more than 100 organizations, government agencies, businesses, tribal groups or families across the Klamath Basin
			Klamath Drainage District Board of Supervisors Meeting	12	
			Klamath Irrigation District Event or Board of Directors Meeting	15	
			Klamath Project Drought Response Agency Board of Directors Meeting	7	Observations conducted at online and in-person meetings and events; handwritten notes taken throughout the observation
			Klamath Water Users Association Event or Board of Directors Meeting	11	
			Tulelake Irrigation District Board of Directors Meeting	5	
			Local political group meeting or event	13	
			Other	18	
In-depth, Semi-structured interviews	32	March 2022 to December 2022	Elected county official	2	28 interviews conducted with 32 people involved in the Upper Klamath Basin's agricultural and natural resource governance
			Employee of a Klamath Project drainage or irrigation district	3	
			Employee of an agricultural or natural resource NGO	4	Participants had to be interested in Klamath Basin agricultural and natural resource governance and be aged 18 or older
			Employee of a county, state, or federal resource agency or service provider	10	
			Local news reporter	1	Participants recruited using a combination of purposive, convenience, and snowball sampling [98]
			Klamath Project patron who held an elected leadership position	5	Used a semi-structured instrument consisting of 27 open-ended questions organized into five categories: introduction, perceptions of and adaptations to water scarcity; participation in water governance organizations or processes; perspectives on water scarcity during the summer of 2021; and closing interviews ranged from 25 min to five hours, with an average length of one hour and six minutes
			Klamath Project patron who did not hold an elected leadership position	7	

Human subjects protection approval for this study was granted by the Pennsylvania State University Institutional Review Board (IRB) (Study IDs 00018640 and 00019030). Before observations of public meetings and events began, an observation protocol was developed, framed by the broader study's questions and objectives [47]. Before observational data collection, approval was requested from Pennsylvania State University's Institutional Review Board. Penn State IRB determined that data collection at public meetings did not "meet the definition of human subject research". As such, attendees at the public events and meetings observed in this study were not required to obtain verbal consent. Following the conclusion of each observation, all handwritten notes were digitized, participant identifiers were removed from the digitized file, and all interviewees were assigned gender-neutral pronouns and pseudonyms. For each interview participant, informed, verbal consent was obtained from all subjects using an IRB-approved verbal consent form as the consent guide. Before each interview, participants were provided with a detailed information sheet explaining the study's purpose, procedures, and potential implications. Following this, they had the opportunity to ask questions about the research and their participation in it. Verbal consent was obtained from each participant before their interview began. With a participant's verbal consent secured, their interview was audio recorded and transcribed verbatim using a transcription service. All personally identifiable information was redacted from each transcript before data analysis began. At the end of each interview, participants were given a paper copy of the lead author's contact information and contact information for Pennsylvania State University's Office for Research Protections should they have any questions or concerns about the study, their participation, and their data.

Data analysis followed the principles of situational analysis [64], involving initial coding of words, phrases, and sentences. Interviews underwent comprehensive review and coding, while observation notes were selectively coded for emergent themes. The NVivo 12 qualitative coding software facilitated code elaboration and categorization, while constant comparative analysis refined codes and categories [99]. The social worlds/arenas mapping process, a situational analysis tool described in Section "Situational Analysis's Conceptualization of 'Social Worlds' and 'Arenas' above, was employed for further data examination. To create the social worlds/arenas map, I condensed and synthesized the extensive interview notes into key themes and categories, identifying recurring patterns

and relationships among them [94]. These themes were visually represented and interconnected in the social worlds/arenas map, providing a comprehensive overview of the interconnected social systems and dynamics within the research context.

Creswell [100] describes many methods scholars can employ to promote the validity of qualitative studies and suggests that researchers utilize at least two. I engaged in peer review, debriefing, and member checking in this study. Member checking, a technique to enhance study accuracy, credibility, and validity, involved one-on-one clarification with participants post-formal interviews and sending verbatim transcripts for review and edits using Microsoft Word's "Track Changes" feature. While some scholars critique this method [101,102], it proved effective in verifying and enhancing data accuracy, confirming redactions, and allowing participants to provide additional insights to their initial statements. I also used methods articulated by Harvey [103] to check preliminarily analyzed data. Seven interview participants were recruited to partake in unrecorded one-on-one meetings held in December 2022 in the final weeks of my fieldwork. These meetings ranged from thirty minutes to two and a half hours and took place at the individuals' home or place of work. During this time, I shared a preliminary draft of Figure 3 and additional findings from the broader study of which this article is a part. Participants were asked if they recognized their own experiences within these themes and findings, and they were encouraged to raise any information that should be added or problematized in the preliminary findings. These member-checking processes were imperative for validating this study's findings.

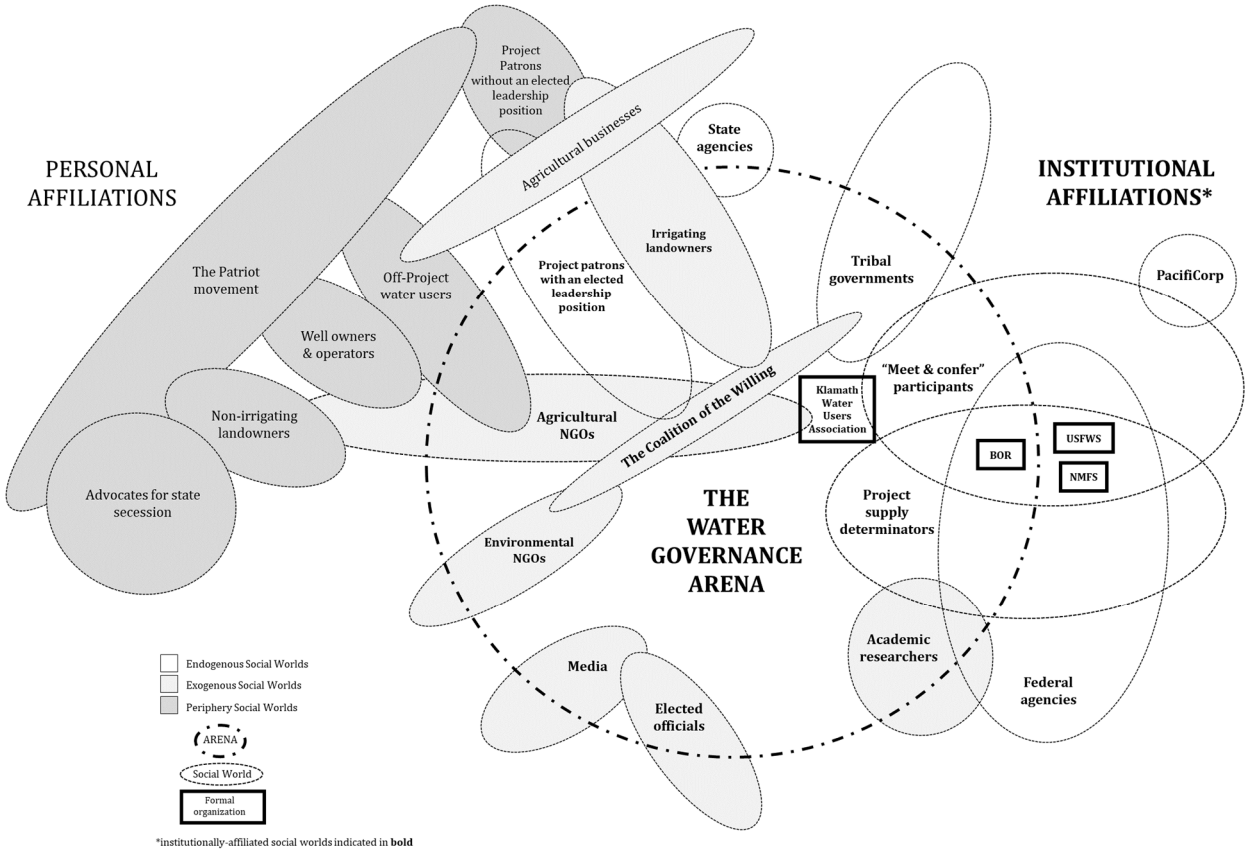

Figure 3. Social Worlds/Arenas Map of the Upper Klamath Basin Decision-Making Domain.

4. Findings

The findings outlined in this section offer insights into the involvement of stakeholders in the decision-making processes related to water governance in the Upper Klamath

Basin. These insights are derived from extensive field observations and semi-structured interviews described in Section 3.3. The social worlds/arenas map presented in Figure 3 serves as an interpretive tool, visually representing the complex dynamics of stakeholder participation in transboundary watershed governance, directly addressing the research questions outlined in Section 3. To create Figure 3, qualitative data from field observations and interviews were analyzed using coding techniques outlined in Section 3.3 to identify and differentiate social worlds based on their perspectives and interactions within specific arenas. This visualization illustrates how actors engage with each other and their roles in decision-making processes. By categorizing actors into distinct social worlds and arenas, this figure visually represents stakeholder interactions and power dynamics within the water governance arena, deepening our understanding of how institutional affiliations shape stakeholder participation. While acknowledging the inherent limitations of situational analysis methodology described in Section 3.1.2, it is essential to view Figure 3 as an interpretive visualization, offering a specific illustration of stakeholder dynamics within the Upper Klamath Basin decision-making domain. Despite its limitations, Figure 3 serves as a valuable tool for visualizing the complexities of stakeholder engagement within water governance processes in the Upper Klamath Basin, ultimately informing collaborative efforts toward sustainable management practices.

4.1. The Water Governance Arena

Following Clarke [64], the social worlds/arenas map presented in Figure 3 lays out "the arena" of participant actors within the Upper Klamath Basin decision-making domain. This domain has been interpreted for this study as comprising a singular decision-making center: "the water governance arena". Within this arena, different actors are grouped into "social worlds". These "social worlds" differ in their concern about how—and to whom—the Upper Klamath Basin's water is allocated. Within this domain are two broad classifications of actors: those with "institutional affiliations" and those with "personal affiliations". Here, I use the term "institutional affiliations" (bolded social worlds in Figure 3) to signal the administrative relationship(s) of the social worlds formally affiliated with a government, organization(s), company(ies), or state-sponsored agency(ies). Data from observations and interviews found that these social worlds are directly involved with or able to influence water governance decision-making in the Upper Klamath Basin. As revealed in Figure 3, the actors possessing the most institutional affiliations are located directly within the water governance arena circle.

"Personal affiliations", on the other hand (unbolded in Figure 3), are composed of non-institutionally affiliated social worlds. These worlds comprise actors who are not direct participants in government-led stakeholder engagement activities, nor are they privy to all information used to inform water governance decision-making processes. Examples of such actors include non-irrigating landowners, off-Project irrigators, and affiliates of political movements. Despite their non-institutional status, these actors significantly shape water governance dynamics. These non-institutionally affiliated social worlds typically operate independently from formal governance structures and may not directly engage with other stakeholders in the water governance arena. However, as detailed in Section 4.1.2, there are instances where certain social worlds straddle the personal–institutional boundary. For instance, "Agricultural NGOs", "Off-Project water users", and "Project patrons with an elected leadership position" maintain connections to institutionally affiliated stakeholders. These interactions challenge the status quo of water governance processes and outcomes in the Upper Klamath Basin. By leveraging their connections and strategic alliances with institutionally affiliated actors, some non-institutionally affiliated stakeholders can assert their interests and preferences, influencing water governance decisions despite their lack of formal institutional ties. This strategic maneuvering enables them to articulate their needs effectively and exert considerable influence over water governance processes, even within an institutional framework from which they are formally detached.

In Figure 3, I applied McCool's stakeholder involvement classification [46] to the actor groups in the Upper Klamath Basin context, aligning with the social worlds/arenas map analysis discussed in Section 3. McCool identifies two key stakeholder groups. Endogenous stakeholders are individuals, companies, governments, and organizations physically present at a governance table and actively involved in decision-making. On the other hand, exogenous stakeholders are not directly involved in this aspect of decision-making but have the power to influence or interfere in such decision-making processes. My analysis introduces a third group of stakeholders with neither endogenous nor exogenous status in the Upper Klamath Basin decision-making domain: peripheral stakeholders. As peripheral stakeholders, individuals and organizations may be interested in or affected by basin water governance processes and outcomes. However, they are neither physically present at the decision-making table nor have the requisite capacity to influence or interfere with such processes. Categorizing social worlds as endogenous, exogenous, or peripheral illuminates the spatial dynamics between actors and unveils the varying degrees of influence and involvement in decision-making processes. This delineation underscores the stark division in participation and influence among different social worlds within the water governance arena. Examining these power dynamics is crucial for recognizing how institutional affiliations may shape access to decision-making processes and how non-institutional actors strategically navigate their influence within the governance framework.

The analysis of social worlds and their affiliations, as depicted in Figure 3, provides a comprehensive overview of stakeholder dynamics within the Upper Klamath Basin water governance arena. By delineating actors into institutional and personal affiliations, the article highlights the varying degrees of involvement and influence among different stakeholder groups. These affiliations, aligned with McCool's stakeholder involvement classification [46], underscore the spatial dynamics of participation and power within the governance landscape. Understanding these power dynamics is essential for comprehending how decision-making processes are shaped and influenced by different actors within the water governance arena. Moving forward, the subsequent subsections will delve into the specific roles and interactions of endogenous, exogenous, and peripheral stakeholders, further elucidating the complexities of stakeholder involvement and influence in the Upper Klamath Basin context.

4.1.1. Endogenous Social Worlds

Data analysis revealed a direct correlation between a social world's classification as "endogenous" and the outcomes of a newly implemented "public involvement" policy by the Bureau of Reclamation in the spring of 2022. The Bureau of Reclamation's Policy CMP P03 Public Involvement in Reclamation Activities [104] authorizes, though does not mandate, "the systematic [provision of] opportunities for affected publics to be informed about the issues; as appropriate, participate in the definition of the problem, objectives, and possible solutions, and have their views documented and considered in Reclamation's decision-making processes" [104]. In determining the Klamath Project's 2022 Operation Plan, the Bureau of Reclamation followed Policy CMP P03 by

> *collaborat[ing] with stakeholders including the Klamath Basin Tribes (Yurok, Hoopa Valley, Karuk, Klamath, Quartz Valley tribes, and Resighini Rancheria), the Klamath Water Users Association, Project irrigation and drainage districts, the Services [NMFS and USFWS], Oregon Water Resources Department, the Bureau of Indian Affairs, PacifiCorp, and leadership from the Department of the Interior and the Department of Commerce* [84].

As highlighted in the quote, the list of participants in the "public involvement" process was made public by the Bureau of Reclamation. However, since these engagement efforts were not open to public participation or observation, the agendas and contents of these meetings remained undisclosed, as did their ultimate impact on transboundary water governance outcomes. The implementation of policies like the Bureau of Reclamation's Policy CMP P03 ostensibly aimed to foster increased inclusivity and transparency.

However, the efficacy of such measures remains uncertain, particularly when crucial discussions occur behind closed doors. This ambiguity underscores the importance of transparency and public access to decision-making processes, especially in matters as vital as water governance.

4.1.2. Exogenous Social Worlds

Distinguishing themselves from their endogenous counterparts, the actors included within exogenous social worlds remained outside the direct sphere of decision-making processes. While their absence from official documentation of state-mandated policies or public involvement in decision-making was notable, their latent influence on these processes was significant. This influence, however, operated covertly, demanding observation to discern how these social worlds subtly shaped outcomes without formal engagement. Figure 3 outlines exogenous social worlds, depicted in the second-lightest shade of gray, which exhibit varying degrees of influence on the water governance arena of the Upper Klamath Basin. These entities assert considerable sway over decision-making processes through overt and covert means.

The overt influence of exogenous social worlds on the water governance arena is exemplified by interactions involving "Irrigating landowners", "Project patrons without an elected leadership position", "Project patrons with an elected position", "Agricultural businesses", and "Agricultural NGOs". Despite their non-inclusion in formal decision-making circles, these actors, endowed with significant financial, natural, and social capital, wielded influence over outcomes through their connections and interactions with institutionally affiliated endogenous social worlds. As articulated by numerous interviewees, a prevalent form of overt influence was the perceived dominance exerted by a few landowners. These influential families, deeply entrenched in various boards and committees, were perceived to wield disproportionate power, effectively steering the direction of the Klamath Project. This sentiment underscored broader frustrations regarding the concentration of influence among a privileged few, perpetuating perceptions of exclusion and inequality within the community.

Furthermore, divisions between large and small agricultural operations underscored disparities in lobbying power and political access. A select few exogenous actors, comprising agricultural businesses, NGOs, and Project patrons with elected leadership positions, leveraged their financial and political clout to sway decision-makers at high levels of government, thereby shaping policy outcomes to their advantage. The division between large and small agricultural operations was also observed in the ability of a select few exogenous social worlds ("Agricultural businesses", "Agricultural NGOs", and "Irrigating landowners") with financial capital and political connections to lobby influential decision-makers like high-ranking cabinet members in the Department of the Interior, members of Congress, and agricultural support services. Through this process, some members of social worlds could use financial capital and political connections to individuals within the water governance arena to affect decision-making processes and outcomes in the Upper Klamath Basin decision-making domain.

At the same time, the exclusion of specific social worlds from the water governance arena was also discussed in the context of the intentional exclusion of political actors from the water governance arena (i.e., those affiliated with "The Patriot movement" and "Advocates for state secession"). This deliberate exclusion reflected broader tensions within the community regarding the appropriate boundaries of participation and the perceived legitimacy of certain voices in decision-making processes. The resistance to including these groups suggested a more profound struggle over representation, power dynamics, and the perceived alignment of interests with broader community goals. Such exclusions risked further polarization and alienation within the community, potentially undermining efforts to foster inclusive and collaborative governance structures.

While examples of overt influence were easily identified through observations of public meetings, examples of exogenous social worlds' covert influence arose from in-depth

interview data. One specific form of exogenous social worlds' covert influence on the Upper Klamath Basin decision-making domain was the potential impact of informal "clandestine stakeholder meetings" on Upper Klamath Basin water governance. These "clandestine meetings" were described by multiple interviewees, all of whom explained how meetings were held in non-public settings and typically involved stakeholders from agricultural and natural resource NGOs, drainage and irrigation districts, county resource agencies, Tribal governments, and others holding formal leadership positions within the Klamath Basin. Some participants in Upper Klamath Basin water governance expressed frustration with these forms of "clandestine stakeholder engagement", with some fearing that the conversations that occurred may "favor particular landowners" and "incite increased frustration with other community members who think that decisions are made behind their backs" (fieldnotes, 9/14/22). These private gatherings raised concerns regarding transparency and accountability, heightening apprehensions among community members regarding decision-making processes conducted behind closed doors.

4.1.3. Peripherial Social Worlds

Unlike endogenous and exogenous, peripheral actors are typically not institutionally affiliated and, thus, have limited financial, technical, and social resources, making it difficult for them to exert any noticeable influence or force on decision-making. Their relationships relied on personal connections to gain information on happenings within the Upper Klamath Basin decision-making domain. This limitation was not because peripheral stakeholders were quiescent, but because of their restricted access to financial, natural, and social capital. In essence, peripheral stakeholders were not "in the arena", so they could not effectively engage or impact the decision-making processes.

Peripherial stakeholders' lack of land, time, money, and information directly correlated with their inability to actively participate in decision-making processes or exert measurable influence over other stakeholders involved in the Upper Klamath Basin decision-making arena. One clear example is visible in the comparison between the capacity of Klamath Project patrons without an elected leadership position (a peripheral social world) and Klamath Project patrons with an elected leadership position (an endogenous social world).

As outlined in Section 3.1.1, the Klamath Project irrigation allocation decision-making process is under the control of the federal government. The Bureau of Reclamation contends that it fosters engagement between itself and various stakeholder groups in the Klamath Basin. However, during the spring of 2022, the BOR only extended invitations for participation in the "public involvement" process to formally recognized group members. To be involved, a member of the agricultural community within the Klamath Project must hold an elected leadership position on one of its boards of directors or supervisors. Such positions can be obtained within drainage and irrigation district boards, the Klamath Project Drought Response Agency board, or the Klamath Water Users Association board. Individuals may also hold leadership roles in other agricultural or environmental non-governmental organizations (NGOs). Holding these leadership positions enhances access to information, enables the expansion of social and political networks, and amplifies the capacity for one's voice to be influential in decision-making processes. This is exemplified by the common occurrence of individuals holding multiple leadership roles, and by families with extensive land holdings having a more significant presence in Klamath Project agricultural leadership compared to those with smaller land holdings. For example, one family who operated on roughly 15,000 acres in the Upper Klamath Basin was represented in leadership positions in the Klamath Basin Improvement District, the Klamath Drainage District, the Klamath Drought Response Agency, the Klamath Water Users Association (KWUA), the KWUA public relations committee, and the Tulelake Irrigation District board of directors. Here, we see how land ownership correlated with opportunities for leadership roles and increased influence in decision-making processes within the Klamath Project.

Likewise, even if an actor held an elected leadership position, they often struggled to participate given the status of their agricultural operation. Compared to large operators,

Klamath Project patrons with small operations saw themselves as possessing less time to attend water governance meetings—an issue of unequal capacity. Because they could not be present in these conversations, they believed they had less access to information than other colleagues in the "Irrigating landowners" social world.

Moreover, because peripheral stakeholders lacked institutional affiliations, their social worlds did not have access to the same information and knowledge as institutionally affiliated endogenous and exogenous groups. Endogenous groups could access inside information because they were directly involved in the water governance process. Those in the exogenous social world typically gained access to inside information through informal networks, personal connections, and by actively seeking out information from various sources outside of formal institutions. Since they lacked institutional affiliations, they were not bound by the restrictions or protocols that may limit access to information within formal organizations. Instead, they relied on personal relationships, informal channels of communication, and their own initiative to gather insights and knowledge. This flexibility allowed them to access a broader range of perspectives and information sources, although it may also have meant they had to work harder to establish credibility within formal governance structures. Peripheral actors, on the other hand, often relied on more indirect or limited channels to obtain information. Without direct involvement in formal governance processes or established networks, they may have relied on public reports, media coverage, or information disseminated by more central actors. Additionally, they might have gathered insights through interactions with individuals who have closer ties to formal institutions or through participation in public forums and meetings. However, their access to inside information was typically less direct and comprehensive compared to endogenous and exogenous groups. This limited access could further reinforce their status as peripheral stakeholders and may have contributed to their perceived lack of legitimacy within the water governance arena.

This analysis found that the water governance arena disproportionately favored more powerful and "legitimate" endogenous and exogenous groups, reinforcing their dominance in decision-making. Consequent to their location on the figurative margins of the water governance arena, peripheral stakeholders were notably absent from the "public involvement" process exercised by the Bureau of Reclamation in the spring of 2022. This reality underscored the exclusionary nature of ostensibly "collaborative" and "publicly-involved" decision-making efforts. The question of whether characteristics defined peripheral stakeholders, leading to their exclusion from decision-making, or whether exclusion from decision-making rendered them peripheral, is complex. While characteristics such as lack of institutional affiliations and limited access to inside information contributed to their peripheral status, it was also the exclusion from decision-making processes that further solidified their marginalization within the water governance framework. This exclusionary dynamic perpetuated the dominance of more powerful groups and reinforced the marginalization of peripheral stakeholders, creating a self-reinforcing cycle of exclusion and marginalization within the water governance system.

5. Discussion

In cases of transboundary natural resource governance, such as in the Upper Klamath Basin, decision-making processes typically include a diverse array of actors, including governments fulfilling bureaucratic obligations, political groups advancing their agendas, lobbyists seeking political advantages, NGOs pursuing organizational goals, and concerned citizens addressing political issues. However, multiple actors involved in decision-making processes rarely possess equal opportunities to influence governance outcomes [54]. In the context of collaborative water governance, this inequity is problematic because it can perpetuate already existing disparities in resource access, exacerbate environmental degradation, and undermine the legitimacy of governance structures. A common criticism of engagement-based governance efforts is that they can mirror existing power structures in society and exclude potential stakeholders who were not already part of the existing

structure [54]. This exclusionary trend can further exacerbate inequities within collaborative governance efforts by sidelining individuals, organizations, and perspectives typically underrepresented in environmental and natural resource governance [55]. Studies on transboundary water governance consistently attribute influence and power dynamics to the governance processes' institutional organization, stakeholder interactions, resource distribution mechanisms, and the socio-political contexts of specific natural resource governance settings [105–108]. This study expands our understanding of transboundary water governance by demonstrating how an actor's ability to shape water governance processes and outcomes is also intertwined with their institutional affiliations, their perceived legitimacy, and their capacity to participate in collaborative decision-making processes.

5.1. Privilege Associated with Institutional Affiliation(s)

In the Upper Klamath Basin's decision-making arena, clear examples of privilege emerged. As highlighted in Section 4.1.1, the water governance process there heavily favored institutionally affiliated stakeholders, reinforcing existing power dynamics and excluding those not already part of the established framework. This bias was evident in the prioritization of endogenous government entities, agencies, service providers, and specifically chosen NGOs, effectively sidelining individuals and groups without formal affiliations. This selective approach perpetuated inequalities by granting exclusive decision-making access to a limited group of actors. As discussed in Section 2.2, scholars like Colvin et al. [59] have noted how actors with dual roles, like rule adjudicators and privileged stakeholders, can deepen power imbalances by leveraging their institutional ties within collaborative processes. Therefore, the analysis of the Upper Klamath Basin's water governance reveals a replication of inequities, deviating from inclusive practices and aligning with criticisms of mirrored power structures and exclusionary tendencies.

The Bureau of Reclamation's application of Policy CMP 903 [104] within the Upper Klamath Basin decision-making domain was one attempt toward more inclusive and participatory approaches to transboundary water governance. However, despite CMP 903's embrace of increased collaboration and "public involvement", the situational analysis presented above found that the policy in execution only elevated the perspectives of state- and institutionally affiliated endogenous social worlds within the Upper Klamath Basin's decision-making domain. Under Policy CMP 903 [104], the BOR is authorized to "systematically provide opportunities for affected publics to be informed about the issues; as appropriate, participate in the definition of the problem, objectives, and possible solutions, and have their views documented and considered in Reclamation's decision-making processes" [104]. This systematic engagement is a methodical effort that differs from public relations, information sharing, educational campaigns, and shared decision-making between collaborators on an equal playing field.

Because the BOR is not required to engage the whole public in their decision-making processes, they can methodically invite specific government representatives, agencies, service providers, and non-governmental organizations to the decision-making table. By involving an intentionally selected, small number of government representatives, state and federal agencies, and a select few non-governmental representatives to participate in the water governance arena, Reclamation gave the appearance that collaborative decision-making was occurring. However, this "public involvement" was only a symbolic effort toward participant inclusion, as significant divides (visible in Figure 3) remained between the types of social worlds directly located within the water governance arena. Ultimately, actors affiliated with formal institutions like the DOI and the Bureau of Reclamation had more influence.

In addition to the limitations of stakeholder inclusion posed by Policy CMP 903, differences in the capacity of stakeholder groups within social worlds also restricted stakeholders' ability to participate in and ultimately exert influence upon the Upper Klamath Basin's decision-making domain. As demonstrated in Figure 3, non-institutionally affiliated worlds typically did not operate within the water governance arena. Nevertheless, a select few

social worlds—those possessing increased financial, natural, and social capacity straddled the personal–institutional divide. This ability to access the water governance arena was the most significant difference between exogenous and peripheral social worlds.

Stakeholders' unequal capacities to participate in collaborative decision-making processes was directly related to the resources (visible or invisible) that they possessed [53]; social, cultural, financial, built, and natural capital were all elements that influenced an individual's ability (i.e., capacity) to engage in environmental governance. As discussed in Section 4.1.3, differences in available capital and personal capacity were the main factors distinguishing exogenous, endogenous, and peripheral social worlds and ultimately influencing an individual's ability to participate in transboundary water governance processes.

5.2. Potential Effects of Perceived Legitimacy

This study's findings underscore the complexities surrounding the perceived legitimacy of stakeholder groups and their participation in engagement processes. As discussed in Section 2.1, the environmental governance literature grapples with defining stakeholders, reflecting a fundamental challenge in determining who should be involved in decision-making processes. While those affected by environmental management decisions inherently hold a "stake" in the outcomes, access to governance arenas often requires institutional affiliation, as evidenced in this situational analysis. The study reveals that merely holding a stake in decision outcomes is insufficient; stakeholders must also possess the interest, power, and capacity to actively participate in water governance processes.

Section 4.1 underscores the hierarchical nature of participation within these social worlds, where actors with perceived legitimacy, typically institutionally affiliated stakeholders, wielded significant influence. This dominance often marginalized less recognized groups, exacerbating power imbalances and compromising the inclusivity of governance processes. The complications arising from perceived legitimacy underscored the importance of addressing biases and ensuring fair representation within social worlds. Without clear criteria for legitimacy, decision-making outcomes may reflect the interests of a select few rather than the broader community. As such, efforts to promote transparency and inclusivity in governance structures must include robust mechanisms for evaluating and addressing perceptions of legitimacy among stakeholder groups. Through these measures, water governance processes can better reflect the diverse interests and needs of all stakeholders involved.

Friedman and Miles [109] maintain that the literature often assumes stakeholder legitimacy without clearly defining the criteria distinguishing legitimate from illegitimate stakeholders. Similarly, Friedman and Miles [110] emphasize the importance of legitimacy as a basis for influence, highlighting the ongoing need for clarity on what constitutes legitimate stakeholder involvement. The subjective nature of identifying legitimate stakeholders, often done ad hoc, poses challenges as it can marginalize certain groups, bias process outcomes, and undermine long-term support for collaborative efforts. Nevertheless, it is important to acknowledge differing perspectives on the relationship between perceived legitimacy and stakeholder involvement. Some scholars argue that overly stringent criteria for legitimacy may inadvertently exclude certain voices and perspectives from decision-making processes, hindering inclusivity [111–113]. Others maintain that the dynamic nature of "legitimacy" means that stakeholders' perceived legitimacy may evolve [114]. These perspectives highlight the need for flexibility and ongoing dialogue to ensure that governance structures remain responsive to all stakeholders' diverse needs and interests. Thus, while addressing biases and ensuring fair representation are crucial, it is also essential to recognize the nuances and complexities inherent in defining and evaluating stakeholder legitimacy. Future studies on power, equity, and inclusion in water governance must further explore the legitimacy of stakeholder groups within decision-making processes. A comprehensive evaluation of endogenous, exogenous, and peripheral stakeholders offers a promising avenue to delve deeper into the underlying dynamics of representation and participation. Through such analyses, researchers and practitioners can enhance our under-

standing of stakeholder dynamics and inform strategies for fostering more inclusive and effective governance structures.

5.3. Influence of Available Capital and Personal Capacity

This study has also found that disparities in available capital and personal capacity are the primary factors distinguishing exogenous, endogenous, and peripheral social worlds, thereby influencing participation in transboundary water governance processes. This finding underscores the urgent need for proactive measures to address the marginalization experienced by those in peripheral social worlds. The situational analysis methodology employed in this study offers a potent tool for identifying and visualizing the relationships and dynamics of marginalization within stakeholder groups. Through an appreciative inquiry lens, it becomes evident that government agencies or their engagement consultants should embark on comprehensive stakeholder mapping initiatives. These processes pinpoint potentially marginalized groups and unravel the intricate dynamics perpetuating their exclusion. In light of critiques offered by scholars like Alexander et al. [115], Forrester et al. [116], and Mercer-Mapstone et al. [117] on typical stakeholder mapping practices, there is an opportunity to refine these methodologies. By adopting more nuanced approaches that consider the socio-cultural, financial, and environmental dimensions of capital, stakeholders' capacities and their potential for marginalization can be more accurately assessed. This refined stakeholder mapping can serve as a crucial tool for recognizing and addressing the root causes of marginalization, contributing to more inclusive and effective transboundary water governance processes.

6. Conclusions

This article's examination of stakeholder inclusion in Upper Klamath Basin water governance revealed multiple challenges for equitable and inclusive engagement processes. Despite collaborative decision-making's professed goal of inclusiveness, prevailing power structures often perpetuated exclusionary practices, sidelining specific stakeholder groups. These findings significantly contribute to the field by providing empirical insights into the complexities of stakeholder inclusion in water governance, particularly in the Upper Klamath Basin. By examining the challenges various stakeholder groups faced and identifying systemic barriers to participation, this article fills a gap in the literature that often lacks data-driven analyses of engagement processes and outcomes in water resource management [35].

As described in Section 4.1.1, the Upper Klamath Basin's water governance process prioritized the involvement and opinions of institutionally affiliated stakeholders, selectively involving government representatives, agencies, service providers, and NGOs over people not affiliated with a formally organized and recognized group. While initiatives like the Bureau of Reclamation's Policy CMP 903 take essential steps to increase public involvement in natural resource decision-making by providing "systematic opportunities" for public participation, the selective invitation of stakeholders to be involved in these systematic processes failed to address underlying issues related to power imbalances, institutional biases, and historical marginalization. This oversight can ultimately reinforce inequities in the water governance process, perpetuating the dominance of privileged stakeholders and sidelining the perspectives of marginalized communities. Consequently, rather than genuinely addressing power differentials, implementing policies like CMP 903 tended to perpetuate existing inequities, maintaining the status quo of decision-making authority. This approach created the illusion of comprehensive collaboration while failing to bridge the significant divides between different social worlds within the basin, emphasizing the superficial nature of inclusion efforts that must address the root causes of exclusion and marginalization.

Moreover, the findings underscored the need for more comprehensive research on stakeholder engagement dynamics, including the role of power structures, institutional biases, and access to information, thereby enhancing our understanding of how to foster

more equitable and inclusive decision-making processes in water governance contexts. As detailed in Sections 4.1.2 and 4.1.3, differences in stakeholder capacity played a significant role in exacerbating disparities in stakeholder engagement, with some groups having greater resources and influence over the Upper Klamath Basin's water governance process. This disparity, evident through the presence of endogenous, exogenous, and peripheral social worlds, highlighted systemic barriers to participation in engagement processes. Stakeholders with greater resources and institutional ties—like those from exogenous and endogenous social worlds—wielded disproportionate influence, while peripheral groups remained marginalized and largely removed from engagement processes.

The complications related to the perceived legitimacy of stakeholder groups significantly exacerbated these challenges. Findings in Section 4.1.3 highlight how a key challenge to peripheral actors' ability to be involved in governance decision-making processes was their perceived legitimacy by the institutions responsible for coordinating the collaboration effort. Suppose a specific group or individual is not deemed "legitimate" by the actor(s) or organization(s) leading the engagement effort. In that case, they may face exclusion from critical discussions and decision-making processes, further perpetuating their marginalization. Because stakeholders are often identified and selected to participate in engagement processes on an ad hoc basis, determining which stakeholders are "legitimate" remains subjective, leaving room for bias and overlooking the voices of those who may hold valuable perspectives. This subjectivity can marginalize groups, bias process outcomes, and jeopardize long-term viability and support for future collaborative processes. Ultimately, stakeholders' affiliation with institutions often determines their access to the decision-making arena, marginalizing those without institutional ties and undermining the legitimacy of collaborative processes.

Finally, findings presented in Section 4.1.3 also highlighted the critical role of access to reliable information and avenues for participation in shaping stakeholders' perceptions and involvement in engagement processes like those outlined in Policy CMP 903. Peripheral stakeholders, lacking institutional affiliations, faced significant barriers to accessing comprehensive information compared to endogenous and exogenous groups. While endogenous stakeholders benefitted from direct involvement in water governance and access to inside information, exogenous groups relied on informal networks. In contrast, peripheral actors often resorted to indirect channels, such as public reports and media coverage, reinforcing their peripheral status and perceived lack of legitimacy within the water governance arena.

Addressing this cycle of peripheral group exclusion from stakeholder engagement efforts requires that water governance institutions critically evaluate participant equity in stakeholder engagement processes and maintain a genuine commitment to inclusivity. There are several specific strategies practitioners can take to meet these requirements. First, all water governance decision-making authorities (including federal decision-makers like the Bureau of Reclamation) should engage in proactive, transparent bureaucracy [118] and make publicly available information about how their agencies and organizations make decisions and what policies and regulations undergird these decision-making processes. Increased transparency, though not an avenue for all groups to have a ticket into a decision-making arena, may allow peripheral stakeholders to peer through the stands and catch a glimpse of who is involved in the decision-making process.

Second, engagement processes should be incentivized within transboundary water governance structures. In the case of the Upper Klamath Basin, engagement processes employed by the Bureau of Reclamation encouraged the intentional exclusion of non-institutionally affiliated parties. This hierarchical, bureaucratic system is problematic because it hinders the development of holistic, sustainable solutions that adequately address the diverse needs and concerns of all stakeholders. To foster genuine collaboration and inclusivity, local, state, regional, and federal government authorities are encouraged to create a system of voluntary engagement that promotes the participation of peripheral stakeholder groups traditionally excluded from governance processes. Though these groups may not have formal control over water allocation, regional residents—no matter

how peripheral—are still "affected publics" and should have the opportunity to know, at a minimum, who is making decisions, what information is being used to make those decisions, and have a chance to ask questions, raise concerns, and give praise. By incentivizing and prioritizing inclusive engagement, transboundary water governance structures can better address the complex challenges facing transboundary watersheds like the Upper Klamath Basin and ensure the long-term sustainability of water resources for all stakeholders involved.

Moreover, creating opportunities for meaningful dialogue and shared decision-making among diverse stakeholders is essential for building trust and fostering inclusive governance practices. Therefore, efforts should facilitate inclusive forums where all voices are heard, valued, and considered in decision-making. This may involve implementing structured consultation, consensus-building, and conflict resolution processes and providing resources and support to ensure meaningful participation from all stakeholders, regardless of their level of influence or representation. Ultimately, by embracing transparency, trust-building, and inclusive decision-making, water governance authorities can work towards dismantling barriers to engagement and creating more equitable and sustainable outcomes for all stakeholders involved.

Future research in stakeholder engagement and water governance would benefit from continued empirical investigation into the processes and outcomes of stakeholder engagement in water resource management. For instance, a recent systematic review of peer-reviewed publications on stakeholder engagement in water resource management [35] found that the peer-reviewed literature has limited data-driven studies of engagement processes and outcomes. More than half of the articles included in the systematic review's sample were case studies where community or stakeholder engagement played some role in an examination of stakeholder engagement in water resource management, but engagement processes or outcomes were not meaningful objects of inquiry within the publication [35]. For scholars to improve the practice, effectiveness, and outcomes of engagement, detailed empirical data such as stakeholder demographics, engagement methods, and outcomes must be included in the evaluation process.

In the specific case study of water governance in the Upper Klamath Basin, there is a pressing need for more comprehensive research. By delving deeper into motivations for stakeholder engagement and exploring the factors influencing agency decisions regarding inclusion, we can potentially transform the current state of water governance. Specifically, understanding how agencies like the Bureau of Reclamation determine whom to include in engagement processes, define and identify "affected publics," and justify their decisions regarding stakeholder participation can lead to significant improvements. Through empirical studies and data gathering on these aspects, we can better understand the underlying dynamics of stakeholder engagement in water governance contexts and identify opportunities for improving stakeholder engagement's inclusivity, transparency, and effectiveness. Understanding and documenting these decision-making processes are essential for fostering accountability and improving inclusivity in water governance.

Additionally, future research should compare engagement processes in the Upper Klamath Basin to those in similar transboundary watersheds in the western United States like the Colorado [119] and Columbia River Basins [120]. Researchers can identify common patterns, challenges, and best practices related to engagement, inclusion, and stakeholder participation by comparing practices across different cases of transboundary water governance. Examining the presence and dynamics of endogenous, exogenous, and peripheral stakeholder groups in these various contexts can provide valuable insights into the effectiveness and equity of engagement efforts. Overall, future research endeavors should shed light on the decision-making behind stakeholder inclusion, comparing engagement processes across regions and assessing the inclusivity and effectiveness of these processes in addressing complex water governance challenges. Through such efforts, sustainable solutions reflecting diverse perspectives can be achieved in a truly equitable and inclusive decision-making environment.

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Article

Moving beyond the Framing Impasse in the Aral Sea Delta: Vernacular Knowledge of Salinization and Its Potential for Social Learning towards Sustainability

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Abstract: The Food and Agriculture Organization estimates that close to 9% of the world's soils are affected by salinity. The purpose of this article is to discuss qualitative social science findings on alternative ways of conceptualizing salinization in Kazakhstan and how these findings could be leveraged for transformative knowledge towards sustainability. We highlight dimensions of land degradation that are doubly obscured: the under-represented issue of salinization, and vernacular knowledge on salinization. The article draws on qualitative data collection methods, including eighteen months of participant observation, workshop transcripts and archival records. Three research findings are presented. First, there is an analysis of the framing of environmental issues common among policymakers in the region. Second, these frameworks are contrasted with novel data on how local farming communities understand and deal with salinization. These two research results enable extrapolating a third finding: how such locally based knowledge could be harnessed towards solving salinization issues. Beyond the specific issue of salinization, the results of this research suggest potentially valuable design principles relating to specific ways that the environmental knowledge of expert farmers and scientific experts could be paired. In the case of Central Asia, models based on the local culture can be adapted, such as hosting and apprenticeship relationships. This example suggests transferable lessons on how to forge social learning towards sustainability that start from imperfect local tools (bottom-up) rather than from internationally promoted but socially distant blueprints (top-down).

Keywords: social learning; soil salinity; traditional ecological knowledge; framing catastrophes

1. Problem

Society faces multiple environmental crises, many of which are related to climate change [1]. While environmental degradation is often well understood, some forms of agricultural land and habitat loss receive significantly more attention than others. Salinization, for example, is a widespread problem, with massive ramifications for environmental health and human food security [2]. The Food and Agriculture Organization estimates that close to 9% of the world's soils are affected by salinity. The cost of this expanding form of land degradation in irrigated areas is calculated at USD 27.3 billion per year [3] (this estimate does not include positive and negative environmental externalities, which are notoriously hard to quantify and often not taken into account.). The causes are well known, yet compared to more charismatic issues such as rainforest loss or desertification, this form of anthropogenic soil infertility receives little attention.

In the area of Kazakhstan's Aral Sea delta, saline soils are a major concern for rural communities dependent on shifting agriculture, pastoralism and migrant remittances. However, national and international policymakers frame the shrinking sea as the only major ecological catastrophe. Given this disjuncture in the weighting of environmental

crises, this article asks: how can decision-makers take into account local concerns? How can both local and formal scientific forms of knowledge on—and adaptations to—salinization be drawn on to solve the crisis? What does engaging this particular issue and place suggest about how to deal with other pressing catastrophes?

2. Perspective

This article presents three research findings on the problem: first, an analysis of the framing of environmental issues common among policymakers in the region. Second, these frameworks are contrasted with novel data on how local farming communities understand and deal with salinization. Third, the article discusses the effects of the disconnect in framing salinization and suggests how local agriculturalists' expertise on salinization could be productively engaged. This analysis and discussion highlight dimensions that are doubly obscured: the under-represented issue of salinization, and vernacular knowledge on salinization that has yet to be leveraged sufficiently to attain greater sustainability.

In providing a nuanced understanding of how these different stakeholders in Kazakhstan articulate and navigate ecological challenges, the authors develop suggestions for locally realizable modes of incorporating local knowledge systems into state management systems. A general case for integrating lay and 'expert' forms of environmental knowledge has long been made and is widely affirmed as a goal [4–7]. However, how to achieve these aspirations is a much more difficult issue, one that is taken up here with a particular case study and a set of generalized propositions from the case. Drawing on the authors' transdisciplinary experience of realizing such alternative modes in the Syr Darya River delta, this paper argues for creatively drawing on less-than-perfect, historically established models of interacting and learning. Two concrete models for Central Asia are suggested: hosting relations and craft apprenticeship (known as 'ustat-shakirt' relations). Both are widely recognized in the region and could serve as the basis of communication and social learning models. This format could be adapted to bridge the expert-lay knowledge divide on salinization and other agricultural issues. This paper concludes with transferable lessons on how to forge social learning towards sustainability from 'imperfect' local tools rather than merely relying on internationally recognizable, top-down blueprints.

3. Methodology

3.1. Qualitative Scholarship

This study takes a qualitative social science approach to an agricultural arena, where much research is from the applied and natural sciences. Qualitative social science generally pursues different research goals, which can complement the goals of research in agricultural and environmental science. It also employs different forms of validating and assessing research than the quantitative and experimental sciences. Qualitative social science approaches are suitable for pursuing questions on complex human behavior, societal values and contexts [8], where the system boundaries typically drawn in scientific studies are hard to define or remain permeable and flexible, such as villagers changing which crops they plant or which hamlet they live in, in response to rainfall or heat.

For the field of sustainability, qualitative methods can, for example, analyze the motivations, beliefs, and experiences that drive environmental behaviors and policy decisions (see [9–11] for good examples). Data collection methods can include a variety of interview styles, focus groups, participant observation and content analysis. These methodologies allow researchers to gather rich, contextual data and gain a detailed understanding of complex phenomena. A number of data collection strategies are often combined to allow for triangulation and to enrich the kind of holistic understanding that is the goal of this approach. The research design for this article included eighteen months of participant observation, which involved living and participating in agricultural labor in the villages being studied; observing practices, discussing challenges with planting and harvesting, etc.; and the analysis of workshop transcripts and archival records.

In the discipline of social anthropology, participant observation is the core method: this methodology requires immersion of the researcher in a wide variety of day-to-day activities of research participants, usually over an extended period of time. While the approach often draws on a small sample size, it is uniquely able to document verbal as well as behavioral evidence, variance over time and between contexts (for a good example on sustainable energy, see [12]). The potential breadth of material coming from a larger sample size and the opportunity for statistical significance is sacrificed in exchange for depth of understanding of the mechanisms affecting daily life and decisions.

The bulk of participant observation data for this study is supplied by Aibek Samakov, who conducted eighteen months of fieldwork between 2016 and 2017, as well as several follow-up visits. He covered fourteen villages, engaging in everyday livelihood activities and conducting 101 semi-structured interviews. This effort was supplemented by analyzing policy and public communication records in four Kazakhstani archives (in the Russian language), covering data from 1938 to 1975 (timeframe based on limited archival holdings). Together with Aibek Samakov and Mohira Suyarkulova, Jeanne Féaux de la Croix ran a transdisciplinary workshop format with farmers and policymakers in the river delta (on this methodology, see Section 3.2).

Both the nature of qualitative research questions and forms of data collection require different forms of analytical assessment than the typical scientific or quantitative criteria of replicability, reliability and validity applied to experiments or numerical data analysis [13]. First, the criterion of reliability in qualitative research is measured by the trustworthiness of the research process. We employed detailed field notes, including documenting decision-making processes by farmers and researchers to provide evidence of dependability. Second, the criterion of replicability is replaced by the criteria of transparency in the research process. Researchers provide detailed descriptions of the methods and limitations of data collection and interpretation. For example, it is important to note that since Aibek Samakov is a man in his late 20s, local norms of gender segregation and work practices resulted in the majority of his interlocutors being adult men. Specifying research conditions in this way allows other researchers to assess the process and evaluate the findings in context. Third, in qualitative research, techniques to enhance validity include what are called 'thick descriptions', which provide detailed accounts of the context and participants' perspectives. Additionally, 'member checking' provides a systematic means for participants to review and confirm findings [14]. In this study, both procedures were used regularly to help ensure that interpretations accurately represent participants' experiences and views.

In sum, these methods allow for a comparison of different forms of salinization knowledge used by key stakeholders—farmers, scientists and government officials—and an assessment of their advantages and drawbacks. In addition to established qualitative methods, the analysis draws on theories of transdisciplinarity and social learning to demonstrate how the different forms of knowledge encountered could be fruitfully engaged in the pursuit of sustainable land management.

3.2. Concepts of Transdisciplinarity, Social Learning and Vernacular Knowledge

Across the spectrum of qualitative and quantitative sciences, transdisciplinarity defines a particular approach to research methods and goals. ,It is understood here as the co-production of knowledge by scientists working with non-scientists, on relatively equal terms. At best, such collaborative research teams become a self-informing and self-reflexive collective that has a transformative effect on their surroundings [15,16]. Attempts to combine empirical research, theorization and social impact are not new in all fields and settings. Current collaborative, transdisciplinary and social learning approaches emphasize the advantages of science in a range of settings, particularly in relation to environmental challenges. These applications include the ability to harness multiple perspectives for the resolution of complex problems [17,18].

The research drawn on here is partially transdisciplinary in nature, while the thrust of the article's argument embraces and goes beyond transdisciplinarity into a more all-

encompassing vision of 'social learning'. Like many places and issues in the world, the possibility for transdisciplinary working modes to address environmental degradation and agricultural policies in Kazakhstan is constrained by freedom of speech and precautionary principles of research. Even in the most auspicious socio-political settings, fully equal sharing of the research process and enactment of transdisciplinary ideals is a rarity. While the field data discussed here were not generated as full co-production of knowledge in the deepest sense of transdisciplinarity, the broader group research project did employ a transdisciplinary approach where possible, including work in the Syr Darya delta with local farmers and policymakers. We argue that the well-developed ideals of transdisciplinarity can be powerfully connected to the idea of 'social learning' as a useful way to approach transformative science and policy. The idea of social learning points to a broader, collective learning process among communities, experts and governments [19–22]. It builds on transdisciplinarity by setting a more ambitious goal. Social learning means moving relatively passive knowing into the use of knowledge ias(collective) doing. Information in this mode becomes the junior cousin of knowledge, which comes into full existence as 'knowing-in-action', which no single stakeholder or form of expertise can adequately reflect [23]. Full knowledge then means the ability to make use of different kinds of knowing and then act on our collective understanding to transform ways of living and working. Needless to say, stimulating such social learning represents a complex ambition [24].

Because of the broad scope and variations in global social and environmental conditions and issues, transdisciplinary methods and the social learning goal need to be creatively adapted to gain local traction, to communicate successfully and to create a sense of ownership. While basic principles may be widely validated, detailed blueprints for these processes are unlikely to work well. This context-dependent approach is needed whether international non-government policy units hope to engage businesses producing agricultural inputs or whether elected government representatives want to persuade local farmers to adopt particular farming practices. All of these actors must practice tactics of translation and reframing to approximate the language and relate to the interests of particular stakeholders. The research described here presents vernacular farming knowledge and coping practices to demonstrate the intricacy and applicability of this expertise. We then suggest adapting an 'Indigenous' mode of communication and understanding of apprenticeship.

Traditional farming systems still cover 10 million ha worldwide [25]. The role of traditional agricultural knowledge in designing more sustainable agricultural systems is now widely recognized [26,27]. Traditional ecological knowledge (TEK) is useful in terms of providing not merely information but a form of understanding that is complementary to scientific knowledge [28]. The separation between official and vernacular (partially traditional) knowledge is often very permeable, as scholars frequently learn from locals (a role that is rarely acknowledged) at various moments of knowledge production [29]. As outlined here, in the Syr Darya delta, farmers rely greatly on local experiential knowledge as a practical, personal and community resource [30]. Below, this article first introduces the Kazakhstani case study and then presents data on official and vernacular knowledge of salinization. Finally, the article concludes with an evaluation of these knowledge forms and identification of ways that vernacular knowledge could contribute to sustainability goals.

4. Findings

4.1. Framing Salinization and Other Disasters in the Aral Sea Region

Just as some environmental issues receive more attention than others, some regions receive more attention than others, or are characterized by 'flagship problems'. Such is the case with the melting ice in the Arctic, the desertification in the Sahel zone, or the destruction of the Amazon. (For an example of how flagship species such as whales can be used to argue for broader conservation measures, see ([31] in this Special Issue). Soils—and their microbial inhabitants—seem to have difficulty gaining imaginative traction in this way, compared to perhaps more 'charismatic' settings, such as aquatic life. Sitting at

the crossroads of 'great powers' such as China, Russia, Iran and South Asia, Central Asia remains an environmentally understudied region. Post-Soviet Central Asia is world-famous, however, for one environmental disaster zone: the Aral Sea (Figure 1). Trying to stop this inland sea from drying up, by ensuring its river feeders are not overused, has been the focus of hundreds of policy initiatives and documents—to little avail. One closely connected catastrophe that receives far less attention but may have equal or even greater import for people in the Aral region, is that of salinized soil. As discussed below, in Kazakhstan's Aral Sea delta, salinization is considered the major concern by rural communities dependent on shifting agriculture, pastoralism and migrant remittances. However, national and international policymakers frame the shrinking sea as the only major ecological catastrophe, largely ignoring local concerns, knowledge and adaptations around this more particular form of slow violence.

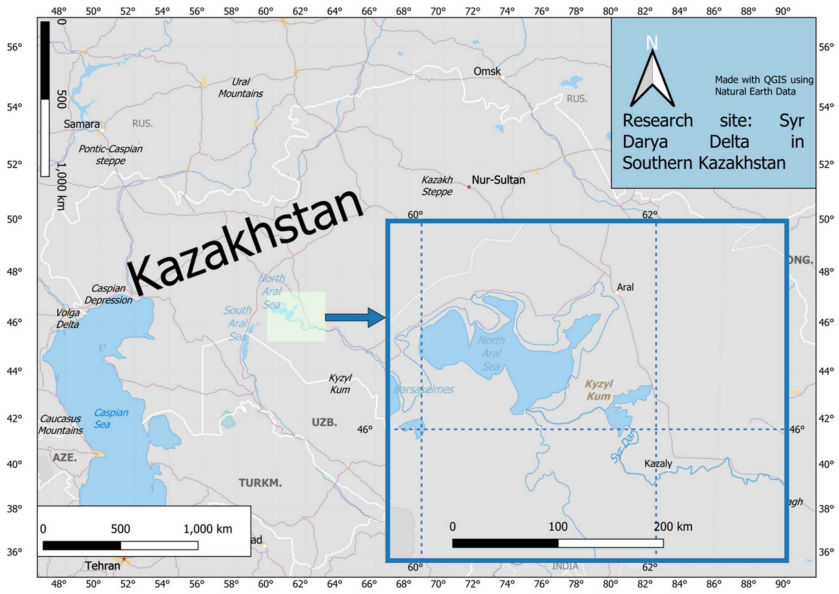

Figure 1. Case study site: Syr Darya Delta in southern Kazakhstan. ©Aibek Samakov 2024.

Soil salinity adversely affects more than 20% of global irrigated agriculture areas [32], predominantly in arid and semiarid regions. Soil salinity is documented in more than 100 countries and poses major challenges to agriculture in India, Pakistan (Indus and Ganges basins), China (the Yellow River Basin), the Middle East (the Euphrates basin), Egypt (Nile basin), Australia (Murray-Darling Basin) and many other countries, such as Iran, Thailand, Argentina, and Russia [3]. The salinization challenge affects more than 800 million hectares of land globally, in other words, nearly 6% of the world's total land area [33]. Climate change is likely to further exacerbate soil salinity and overall land degradation in Kazakhstan ([34,35]).

4.1.1. Case Study Setting

Delta inhabitants live in an area officially designated by law since 1992 as a Zone of Ecological Catastrophe. This designation acknowledges the deterioration of the local environment, high mortality rates and harsh social-ecological conditions. While in this law, the drying up of the Aral Sea is mentioned as a concrete problem, salinization is not explicitly mentioned [36]. It is, however, a major issue in the region and for Kazakhstan as a whole: around 60% of its land (1,619,584 km^2, an area several times the area of Germany) has been classed as degraded, including 57% of croplands, 21% of forested areas and 38% of grasslands [34]. The main drivers of land degradation are wind and water erosion, salinization, water-logging and industrial pollution of soils [37].

Primary salinization refers to the natural accumulation of salts in soil and water, while secondary salinization is caused by human activities, such as irrigation or mining. If

groundwater levels are altered by human activity, salts in the soil can become dissolved in groundwater and may rise to the surface, where the water evaporates and leaves behind a salt-laden crust [38,39]. These salts then interfere with the water and nutrient balance and uptake in plants, effectively making soil increasingly infertile [40,41]. The delta district Kazaly classifies 64.3% of its area as moderately salinized, 22.6% as 'slightly salinized', and 13.1% as 'extremely' [42].

Adjoining the northern shore of the remnants of the Aral Sea, the Kazaly district is quite ethnically homogenous, with over 99% of the population identifying as Kazakh (2019 census). The area is an important railroad hub for Central Asia, providing most of the available wage jobs in the district. Alongside local shops, other wage jobs are limited to rice-growing corporations, government offices, and services like schools and the post office. Labor migration to big cities or the oil and gas fields of western Kazakhstan is ubiquitous [43,44]). The majority of households have at least one family member working as a migrant. Many households also depend on government pensions provided to elderly family members.

The local rice-growing corporations are privately-owned businesses that rent village and government land to grow rice. As of 2016, there were eight such rice-growing companies—the larger ones also keep dairy cattle. The yields of the rice corporations make up most of the official agricultural output of the district and are supported by governmental subsidies. Some of the local villagers are employed by these rice-growing companies as irrigators, tractor drivers, and managers. However, the number of people employed in each village is not substantial. For example, the company, RZA Agro, cultivated alfalfa in Alga village and in 2018 employed about 20–30 locals out of more than 1000 villagers.

Most villagers try to get a wage job and complement it with herding, gardening, reed mowing, and fishing. These livelihoods are often subsistence-oriented, with only a fraction of produce being sold for money. Such combinations of livelihoods are somewhat typical in all rural areas of Kazakhstan [45]. Because dealing with salinization is so crucial, local farming communities in the Syr Darya River delta have developed their own classification system of soil salinity. This system is used to evaluate and choose shifting cultivation sites that are managed as a commons. Before turning to a detailed analysis of these forms of local salinization expertise, a content analysis of government environmental problem framing in the area is presented and its effects are examined.

4.1.2. Science and Policymaking Frameworks

The language of Kazakhstan's 1992 Law on the Zone of Ecological Catastrophe, as well as international institutions such as the International Fund for Saving Aral Sea [46], foregrounds the need to sustainably share the limited water resources of Syr Darya and Amu Darya Rivers. In other words, water scarcity and overuse, resulting in the near total destruction of the Aral Sea are the main frameworks for identifying environmental degradation in the study area. As a consequence, soil salinity issues in the Syr Darya Delta have often been communicated as a water scarcity issue. This framing has been established despite the fact that salinity has long been one of the major challenges for agriculture in Central Asia and has been mentioned in government reports on the area from at least the 1940s onwards.

In fact, supplying more irrigation water can exacerbate soil salinization. Firstly, diverting water from the river for irrigation raises groundwater levels, which is one of the main catalysts of soil salinization. Second, the Syr Darya's river water is polluted with a high concentration of dissolved salts and fertilizers originating from agricultural discharges upstream [47]. Thirdly, water diversions for irrigation further contribute to the drying of the Aral Sea and the accrual of salt on the former seabed, which is then blown onto surrounding fields ([48–50]). Lastly, leaching—as one of the prime methods of alleviating salinization in the short term—exacerbates the problem in the medium- and long-term. Leaching means flooding fields to wash away surface salt and is used both by small-scale

farmers and larger rice-growing corporations. This method both raises the groundwater level and washes salt to fields further downriver.

In response to these issues since Soviet times, agricultural scientists have urged improving the irrigation and drainage infrastructure, adopting water-saving irrigation techniques, strictly adhering to crop rotation, and using chemical remediation approaches such as applying calcium, zinc or gypsum [51,52]. Agricultural scientists have more recently also recommended phytoremediation approaches, such as planting salt-resistant plants and shrubs and certain tree species that can serve as biological pumps to lower elevated groundwater levels in waterlogged areas [36,52].

A number of specialists recognize the wicked problem of salinization being both exacerbated by and begging for more irrigation water. However, regional policymakers and water experts do not often consider the connection between the goal of supplying more irrigation water and exacerbating soil salinity in the delta. It is usually implied that if the water issues are resolved, then soil salinity issues will be resolved as well. Moreover, INGOs, scholars and governments typically tend to see solutions for river water issues on a transboundary scale [53,54]. They thus focus on growing an integrated water resource management approach across the region [55]. These approaches may indeed be beneficial. However, such a water-supply-centric framing of environmental degradation, with a strong preference for transboundary solutions, often effectively excludes local communities in the Syr Darya Delta and elsewhere as agents in the conversation. This approach also ignores the more sustainable, small-scale practices and expertise that local agriculturalists have, in fact, already developed to cope with salinization.

The following section provides data from the Kazaly district to reveal how local perceptions and classifications contrast with the scientific and management-oriented narratives of soil salinity. Then, the question is addressed of how these diverging forms of knowledge could be effectively related to support more sustainable agricultural and natural resource management practices.

4.2. Vernacular Typologies of Soil Salinity and Coping Mechanisms

As depicted above, scales of expertise and framing are not unified and already diverge in the policy and science arena. Data obtained through participant observation and interviews by Aibek Samakov in 2017–2018 show that there is some overlap in how the salinization problem is understood and acted upon between government agencies and local farmers (for a more complete documentation of sources and research processes, see [56]).

Local farmer observers agree that the drying up of the Aral Sea has greatly exacerbated the soil salinity problem. They comment that soil salinity gradually increased during the Soviet period, with a slight decline after the collapse of the Soviet Union, when a lot of agricultural land was abandoned and could recuperate. At the same time, local agriculturalists also have quite a distinct understanding that departs from all official concepts and framings. For example, scholars and governments talk about soil salinity in terms of the percentage of salts in soils and use such labels as 'mildly saline', 'moderately saline', 'extremely saline' and 'salinization and sodification', (e.g., Na or K-based soil salinity or salinization versus sodification [39]).

In contrast, delta communities use their own local typology of soil salinity that distinguishes between 'white' and 'black' salinity. Differentiating types of salt is a key criterion to communicate which plot is suitable for cultivation and which one is not. This distinction is particularly vital in the Syr Darya Delta, where local communities and rice corporations use shifting agriculture, i.e., the cultivators move from one plot to another every few years. Assessments of soil salinity levels are performed by local gardeners and rice-corporation agronomists (who are usually also local villagers).

There are layers to the meanings of 'black' and 'white' salt that deserve attention because they articulate a sophisticated means of coping with land degradation. On the most superficial level, farmers discuss a visual difference between areas affected by 'white salinity' and 'black salt'. Some areas have patches with a thin layer of salt on them, and

these areas are called 'white' areas because the top shines white. Other areas, which are muddy and dark in color or have a hard dark crust on the surface, are identified as 'black salt' areas. This typology is, however, not based solely on a simple visual marker: as discussed below, the assessment is more complex. In everyday communication, the distinction between white and black salinity may also refer to the severity of salinity, rather than the color of crust. If an area has a really thick layer of white-colored salt on it, it is called a 'black salinity' area, even though it may shine white (Figure 2).

Figure 2. Area affected by 'Black Salt', judged unusable for shifting agriculture. Urkendeu, 2016. ©Aibek Samakov.

While it is extremely difficult to find a plot completely unaffected by soil salinity in the river delta, the body of Traditional Ecological Knowledge (TEK) on black and white soil salinity allows farmers to select the least affected plots for cultivation, thus investing less effort and resources to secure the harvest. Delta farmers do not cultivate areas affected by black salinity, as it is seen to be a waste of time. Often locals communicate this idea by saying 'plants can grow on white salt and nothing can grow on black salt'. The statement about 'nothing' growing on the black salt is not always literal; quite a few such plots have salinity-tolerant vegetation, such as Anabasis salsa, Bergenia, Aeluropus lagopoides, and Dodartia orientalis. These plants act as phytoremediation agents and eventually reduce black salinity. If an area appears to have soil salinity but hosts such plant species as camel thorn (Alhagi) and/or licorice, that area is considered to be 'white', which means that one can manage to secure a harvest there. Thus, 'nothing grows on black salt' means rather that 'we cannot grow any crops there'. In other words, the 'black' and 'white' salt distinction may also mean that the area affected by 'white' salinity is still manageable for crops (Figure 3), whereas the areas plagued by 'black salinity' are not.

Since visually telling whether a particular plot is affected by black salinity can be tricky (see Figures 2 and 3), local gardeners and rice cultivators have developed a few strategies to determine the soil salinity of the areas. For example, gardeners water the area in question or visit a particular plot immediately after rainfall. If the plot turns muddy and develops a glittery surface, it means that it is salinized. The gardeners claim that the glitter comes from salt crystals reflecting the sunlight, which can be noticed by an experienced eye. Another strategy is to observe the prospective plot at dawn or sunset in autumn. The areas affected by black salinity "puke out" water or moisture, meaning that some areas of land secrete water (i.e., water comes from beneath the soil and makes it wet) on its surface, whereas the land around it stays dry. "Puking" water is a clear sign that the area has hidden black salt and will not be suitable for growing crops.

A look at this categorizing scheme in more detail reveals more about what makes black salinity unmanageable and white salinity manageable for farmers. Their assessment is related to how a particular type of salinity affects the plants. 'White' salinity is only present in the soil top layer, often forming a visible powder-like layer and sometimes a crust (Figure 3). 'White salt' is often the salt and dust residue from the former Aral seabed brought by winds. Hence, it can be physically removed by a hoe or leached with sufficient amounts of water to make it suitable for cultivation. In farmers' understanding, white

salinity is only dangerous at the beginning of a plant's growth cycle, because constant contact with salt affects the plant's stem and leaves and impedes water intake. Delta farmers say that 'white' salinity 'burns' newly emerging sprouts. If a farmer manages to get rid of this layer of salinity on the surface (e.g., by leaching or physically removing it with a hoe), then plants can grow normally there. When the plants grow bigger and their stems thicken, surface-level salt (salinity) has little effect on them, and white salinity is no longer considered dangerous for plants. To manage salinization on such viable plots, currently, the rice corporations and local farmers employ only a few soil salinity reduction methods, such as leaching, and choosing salt-resistant crops, such as melons.

Figure 3. A plot affected by 'white salt' after being plowed and leached. One can still see the salt residue on the edges of the irrigation ditch. Urkendeu, 2016. ©Aibek Samakov.

On the other hand, what makes the 'black' salt unmanageable is that it is mixed with soil on all levels; it cannot be physically removed. According to locals, the excess of salt in the soil traps moisture and impedes the water intake by plant roots, leading to crop failure. Black salinity originates from rising groundwater levels when highly mineralized groundwater seeps to the surface. Thus, excessive irrigation and/or continued leaching of white salinity areas can create or exacerbate black salinity. In other words, a more generous water supply can easily exacerbate the problem in the medium- and long-term.

These management approaches by farmers reflect examples of the complex body of local soil knowledge related to soil salinity. Evolved in a harsh environment where almost all areas of land are affected by soil salinity to a varying degree [51], the local classification of white and black salinity serves the purpose of avoiding the worst affected land and cultivating plots on which the salinity-type and level are manageable.

In conclusion, the fieldwork data on vernacular typologies and coping mechanisms demonstrates an active body of knowledge on secondary salinization. Like the characterizations of sodification by agricultural scientists, this locally-based insight is a differentiated and complex body of knowledge. It is characteristically different from agricultural science knowledge in several aspects. First, it has not been formally tested or documented to date. The vernacular scheme includes some understanding of both the origin of salinization and its effects, though this understanding is not as thorough as the scientific remit on searching for causes allows for. Second, a major difference to the classifications used by soil scientists is that the differentiation of 'black' and 'white' salt takes into account locally available coping practices ('white' salt can be managed, 'black' cannot). Third, these characterizations provide more action-oriented and applicable forms of assessment than government soil scientists can currently provide for small-scale farmers. Fourth, the vernacular salinization vocabulary also points to the problem of leaching as a short-term solution, which scientific

classifications in themselves do not highlight. The next section discusses techniques for relating this vernacular knowledge-in-practice to broader government and international policies on land degradation.

5. Discussion: Social Learning Techniques for Pairing Understandings of Salinization

In 2017–2018, Kazakhstan recognized the importance of halting land degradation and developed a national plan for achieving Land Degradation Neutrality (LDN), which stipulates that 'the Republic of Kazakhstan strives to achieve land degradation neutrality by 2030'. (Kazakhstan has set its LDN Targets in 2017 and 2018. URL: https://www.unccd.int/our-work-impact/country-profiles/kazakhstan. Accessed on 3 October 2024). Land Degradation Neutrality, or LDN in short, is a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remains stable or increases within specified temporal and spatial scales and ecosystems. It focuses on conserving, sustainably managing, and restoring land in the context of land use planning and aims at counterbalancing the expected loss of productive land with the recovery of degraded areas. UNCCD, URL: https://www.unccd.int/actions/achieving-land-degradation-neutrality. Accessed on 3 October 2024. Kazakhstan's promise to undertake major research on soil quality has, to date, not yielded any visible results). Soil salinization, drought and uneven use of pastures are some of the issues this policy seeks to address. The government intends to implement an array of measures, such as the inclusion of fallow and abandoned lands in their assessments, the creation of woody and shrub plantations to protect the land from water and wind erosion, investment in irrigation infrastructure, and commissioning soil quality research on 30 million hectares of agricultural land. Much of the policy emphasis is on carbon sequestration, a current flagship issue of the UN Climate Change Convention. Just as soil salinity is viewed and communicated through a water-centric lens in the case of the Syr Darya Delta, in climate policy, soil salinity is currently overshadowed by the issue of carbon sequestration.

At this level of abstraction, and when salinization—so important to farmers—is just one minor factor among many, what options exist to stimulate productive social learning among the array of stakeholders involved? How could the successfully applied experiential knowledge of farmers be integrated with other bodies of knowledge—or at least be considered on an equal footing? The first steps are to a) highlight the importance of the salinization issue and b) document vernacular knowledge-in-practice of agriculturalists as a valid alternative framework for working with saline soils—as is offered in this article.

There are many attempts to integrate traditional ecological or vernacular knowledge into 'normal' environmental science. For the Kazakhstani context, a different strategy is more promising. Attempting a smooth integration of vernacular knowledge within scientific frameworks can easily result simply in its subsumption into more powerful paradigms and voices. One alternative possibility is to make use of the North American Indigenous concept of 'two-eyed seeing' [57]. Two-eyed seeing means holding two forms of knowledge in mind when considering a problem, for example, the vernacular and the scientific understanding of salinization. Rather like farmers often do themselves, scientists and policymakers could pair several ways of understanding the problem and seek means to creatively relate them to each other to put these understandings to work.

Two concrete examples follow that demonstrate situated opportunities for this kind of social learning. The first is an unusual event that the authors experienced first-hand: a moment of refuting authoritative forms of knowledge. The second is a suggestion drawing on Central Asian life-worlds relevant to farmers and government officials alike. Both examples are proposed for further testing.

5.1. Observed Example: Vernacular Knowledge Sharing with Water and Agricultural Policymakers

In 2018, the authors hosted a workshop for water policymakers. The setting was unconventional since our hosts were the local farming households of a delta village. The content was also unconventional for Kazakhstan. Rather than demonstrating technical

expertise, e.g., on drip irrigation, participants went out to learn methods such as reed-harvesting from locals. The workshop organizing team had tried very hard to avoid framing the visit as a moment for outside experts to teach farmers how to do things better. That is not to say that scientific expertise and policy information would not be useful. Rather, the reason for de-emphasizing this direction of knowledge sharing was simply that it has often been conducted in a very rough-shod manner in the region and that opportunities for the inverse direction of knowledge exchange are extremely scarce.

Despite the stated goals of the workshop, one group of participants insisted on drawing up recommendations for the farming community. This insistence proved unexpectedly useful for the farmers, but not in the way imagined by visiting policymakers. After presenting their recommendations and discussing the advantage of particular government subsidies, workshop participants were faced with their village hosts' responses. The local farmers made clear that they knew of these government subsidies, and they carefully explained why the subsidies and marketing strategies recommended by development agencies did not work for them.

Considering the strength of authority and deference patterns towards policymakers in the region, this workshop moment provided a highly unusual opportunity for farmers to share their perspectives. It is very unlikely that they would have been able to voice these objections and counter-positions with anything like such frankness in a government office. This kind of rare and precious communicative moment was enabled by the farmers' role as authoritative hosts amid their own house guests (the policymakers). This fortuitous moment could only happen at the juncture of enacting (a) established Qazaqstani host–guest relations and (b) local expert knowledge.

5.2. Extrapolating from the Case Study: Using Cultural Repertoires for Social Learning

While the workshop design that the authors enacted by no means guarantees such social learning moments, it does open gaps for going beyond conventional modes of hierarchical (knowledge) relations. There are myriad ways in which one might scaffold such opportunities, whether drawing on widely recognized Soviet models of education in the region, or other cultural repertoires that can intersect in recognizable ways with local or global science and policy communities.

A second model is the Central Asian apprenticeship to craftspeople. The relationship between a master (usta) and disciple (shakirt) holds widespread resonance. It applies equally to relatively prestigious crafts, such as pottery [58,59], with long guild pedigrees in urban Central Asia, as well as more rural pursuits, such as building yurts. An apprenticeship is also recognized in more female domains of expertise, such as making patterned felt carpets [60], as well as the spheres of spiritual and religious learning.

The idea of an apprenticeship travels well across Central Asian sections of society, is recognizable globally, and confers a measure of value and prestige to 'masters' and the learning process. The title of 'usta' inspires a measure of respect and recognition, something that local farmers who are already lending their expertise on salt to subsistence and rice production in the delta, could benefit from. A program of awarding recognition and pairing learner–policymakers or learner–scientists and master–farmers could go a long way toward enabling the kind of pairing of environmental knowledge envisioned above. For example, adding the white/black salt perspective could shift policies centered on expanding water supply to addressing the practice of leaching, which contributes to both water scarcity and soil deterioration. Conversely, since farmers are already experienced in a limited way in phytoremediation (recognizing wild, salt-resistant plants that improve soil, growing salt-resistant crops), newer scientific phytoremediation methods, such as the introduction of particular shrubs (see Section 3.1), would likely be appreciated in this population.

Together, these modes of social learning include diverse elements, such as Kazakhstani social norms of hosting as well as apprenticeship practices. The spaces that are chosen to foster social learning may significantly affect outcomes, as demonstrated by the example of the unconventional social context for the workshop described above. The two suggestions

on hosting and crafting relations are not intended as the all-out solution for social learning on soil degradation and water scarcity in the region. Rather, they are proposed as promising ideas that have traction with our interlocutors and thus should be tested more broadly and in other settings.

6. Conclusions

This article illustrates the importance of framing sustainability-related issues by analyzing dimensions of land deterioration that are doubly obscured: the under-represented issue of salinization and vernacular knowledge on salinization. The case of soil salinization in the Syr Darya Delta and Aral Sea demonstrates how vernacular and scientific knowledge about the same issue (e.g., soil salinity) may exist in parallel without much interaction and cross-pollination.

These findings show, first, that the water-supply-centric and Aral-Sea-centric policies and the focus on carbon-sequestration in Kazakhstan's LDN targets place less emphasis on soil salinization, which is of highest concern to the local communities. Second, this article introduces new data on how local farming communities understand and deal with salinization. The scientific novelty of the results lies in the documentation of local agricultural knowledge. There is also an extrapolation of how this knowledge could be harnessed towards solving salinization issues.

Highlighting these valid local concerns could enhance scientific authority on salinization and, for example, generate more funding and programming attention to this major, yet neglected, issue. Thus, pairing forms of knowledge may contribute to future target setting in the context of national, regional or global sustainability goals. Moreover, addressing farmers' most immediate concerns with salinization, rather than the shrinking Aral Sea, could also be a much stronger motivational argument for enrolling farming populations in sustainability initiatives, such as LDN targets. This kind of consideration and process is surely a crucial element of social learning, which includes reframing and alternative acts of communication, such as giving more voice to local participants in a workshop with government policymakers.

Drawing on findings in the literature on social learning and transformative knowledge, it seems evident that pairing these two bodies of knowledge, as opposed to integrating one into another, can create grounds for social learning. Moreover, such pairing of several ways of understanding the problem can help in addressing pre-existing power relations and issues of data/knowledge sovereignty. Providing a nuanced understanding of how these different stakeholders in Kazakhstan articulate and navigate ecological challenges enables us to develop suggestions for locally realizable modes of social learning, connecting vernacular and formal knowledge systems on salinization. Further research is needed on how to operationalize social learning opportunities that require reducing social distance and balancing out social hierarchies. These elements are both locally specific, as well as potentially translatable into other settings in international development and science policy. These findings put forward new research avenues on retooling scientific and policymaking forms of knowledge production towards more citizen-centric methods that can stimulate sustainability action.

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Architecture for Complexity: Speculative Design as Enabler of Engagement in Co-Designing Post-Mining Futures in the Hunter Valley

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Abstract: The imminent closure of seventeen mining sites in the Wonnarua Nation in Australia's Hunter Valley over the next two decades has significant social, cultural, and economic implications. Transitioning to a post-mining future requires integrating rehabilitation efforts with socio-cultural and economic considerations. Speculative design and co-design approaches involving stakeholders from local communities, industry, and government offer alternative solutions for this complex scenario. This paper examines how architects can engage effectively in such transitions by using mixed-methods research, which includes in-class analysis, synthesis and design observation, and qualitative data from student interviews involved in a master's degree at the architectural design studio exploring the future of a major coal mine in Australia. In contrast to the conventions of assessing "before" and "after" conditions that propose a singular answer to the research, this paper describes the innovative testing of these wicked problems in the setting of the creative design studio. Anticipating the potential for multi-stakeholder co-design processes, the outcomes of this research extend beyond local perspectives. The overarching project, of which this experiment is a key part, aims to identify valuable opportunities for landscape rehabilitation in the Hunter Valley and help to articulate a scalable and replicable process that can be applied to address the environmental challenges faced in other Australian regions. This in-class approach presented the opportunity to rethink and reframe the methods used by reflecting on the interview feedback from students. This can enable students to actively engage in design-based responses to impending mine closure and promote inclusive planning in post-mining landscapes.

Keywords: architecture pedagogies; speculative design; regional urbanism and planning; sustainability; Hunter Valley; Australia

1. Introduction

In the current state of climate breakdown in which many unpredictable and multidimensional impacts threaten the futures of regional areas, energy transition emerges as a critical issue confronting communities that will define adaptation strategies at local, national, and global scales [1]. Australia has an extensive history of coal extraction, particularly in New South Wales (NSW), where it played a pivotal role in financing the development of towns and infrastructure throughout the twentieth century [2]. The positive image of coal in New South Wales (NSW) was until recently prevalent in the social, cultural, economic [3], and political discourse [4]. However, there is a growing momentum in Australia towards transitioning to cleaner energy futures [2].

In the context of declining coal extraction and consumption, the Hunter Valley in NSW is undergoing a transformative process, presenting significant challenges to the region's

future development. Home to some of Australia's largest coal mines, which supply coal to the world's largest and most efficient coal export facility at the Port of Newcastle, the Hunter Valley witnessed dramatic growth during Australia's mining investment boom in the 2010s. However, seventeen mines are projected to close over the next two decades, resulting in profound social, cultural, and economic impacts [5]. Initiatives proposed to address this transition from a coal-dominated region to a post-mining future have been considered inadequate, as they fail to recognise that the transformation entails more than just rebuilding the economy [6,7].

As coal mining regions transition away from fossil fuels towards an uncertain future, there is an urgent need for alternative approaches that meaningfully engage communities, empowering them to design their future while integrating sustainable initiatives [7]. Local community organisation Hunter Renewal advocates for a transition process that involves restoring and rehabilitating landscapes while addressing the diverse needs and concerns of nearby communities through inclusive and participatory approaches [6]. Furthermore, diverse case studies and researchers have highlighted the importance of multidisciplinary, spatial planning, and governance approaches to address energy transition and design clean energy futures [8–10].

This paper explores the role of architects in navigating the complex transitions of such regions. Rather than focusing on specific desired futures or testing overall programs for stakeholder engagement, it examines how professional architects and architecture students can offer valuable insights, particularly through visualising multiple future scenarios. It does so by analysing a specific architectural design studio that employs speculative design processes. This design studio, an integral component of an architectural master's degree, synthesises research, communication, theory, technology, and construction skills in a specific design project, offering a dedicated pedagogical space for testing complex scenarios for future architects.

The research is situated within the context of regional urbanism, investigating rural planning issues that encapsulate challenges such as achieving meaningful stakeholder engagement and representing community voices to ensure fair and collective welfare [11]. In rural Australia, insufficient stakeholder engagement has been identified as a factor weakening the social fabric, exacerbated by the vast geographical distances and the disproportionate focus on large cities like Sydney and Newcastle in NSW [12]. Given the challenges in reaching and addressing local communities and their specific concerns, there is a risk of tokenistic participatory actions limited to consultations or even manipulation of local interests rather than genuine engagement and active participation in decision-making processes [13]. Therefore, this paper aims to provide alternatives for co-designing futures for the Hunter region through active stakeholder engagement to understand their diverse needs and to seek alternatives [13] to address complex issues arising in the transition towards a post-mining future for the region. The proposed method for co-designing the Hunter region considers using tools for visualising speculative scenarios proposed by students at the University of Newcastle as a point of departure for discussions to revitalise their region.

This paper focuses on the following research question: What can be the architect's role in addressing the complexities of transition in the Hunter region? To examine this question, this paper combines research and in-class experiences in developing future visions of a clean energy and sustainable future for the Hunter region, Australia, by engaging architecture master's students in an interdisciplinary design process focused on inclusive and participatory planning combined with speculative and integrated design approaches. The inclusion of students' perspectives in which they retrospectively reflect on their experience in the proposed in-class experiment for creating a co-design framework are also considered in identifying key areas for improvement of this pedagogical experiment.

2. Theoretical Framework

2.1. Speculative Design and Transition Design

The transition from a strong coal industry presence in the economic, social, and environmental structures of the Hunter Valley to a post-mining and renewable energy future creates a complex context that benefits from having a range of alternative approaches to visualising possible scenarios for the future. This scenario of unpredictable futures refers to the wicked problems confronting multiple stakeholders with conflicting agendas that often straddle disciplinary boundaries [14]. Unlike traditional design approaches that are linear and decontextualised to simplify the problems and are based on predictable scenarios [15], addressing wicked problems requires an understanding of ill-defined issues that exist at multiple scales, are interconnected and interdependent, and are in permanent evolution [14,16]. Consequently, any intervention aiming to solve wicked problems can have unpredictable ramifications [14], requiring transdisciplinary approaches and fostering innovation, engagement, and novel modes of collaboration, including participatory and co-design practices in service and social innovation [17].

Addressing wicked problems frequently clashes with solutions within existing realities, as it limits the opportunities for solutions. Speculative design asks questions about the future and aims to expand critical practices and represent alternative or yet-to-exist realities [18,19] towards diverse visions of possible future scenarios [18]. As a process, it employs creative tools to propose radical options that foster a greater sense of imaginative freedom [19]. These tools are harnessed to stimulate the imagination and propose innovative design concepts. An example of this approach in the Hunter Valley is that rather than only testing out alternative energy sources used previously and locally such as solar power and wind turbines, one could speculate on how biomass fuel production, for example, might not only produce energy but also reinvigorate the local agriculture industries that would feed it.

Current approaches of speculative design and transition Design observe stakeholder relations as a form of "connective tissue" within a wicked problem. This is necessary to understand the nature of the issue at hand, such as roots and consequences, and barriers to solutions [14]. For example, the Australian Public Service Commission [20] acknowledges that wicked problems are often "imperfectly understood", and involvement and discussion among all relevant stakeholders are necessary to properly understand their complexity. Baumann, Stokes, Bar, and Caldwell [19] explored a methodology using "what if" questions to define parameters and support brainstorming, where participants determine the concepts and design outcomes. For instance, in the context of this study, the following questions might emerge: What if the Upper Hunter Valley became an educational hub for clean energy engineering and design, and could that open up new partnerships between government and industry? What if we could harness the heat produced from hydrogen production plants to produce destination hot springs for swimming and leisure? Thus, stakeholders can navigate between possible, plausible, and probable futures based on the existing conditions and possible trends [21,22].

Exploring and addressing the wicked problem of the future in the Hunter Valley through speculative design and transition design enable the potential of these yet-to-exist scenarios to become a medium for raising awareness, examining and provoking actions, opening discussions, stimulating the proposal of alternatives [23], and engaging diverse stakeholders and communities. That, in turn, enables shaping preferred futures through a participative co-design process. This paper observes the opportunities of co-design approaches, their entanglement with various stakeholders, and the capacities of co-design processes to create change at social, economic, and political scales [24].

2.2. Co-Design and Community Participation

The prevailing discourse on community engagement in decision-making underscores the necessity for co-creation processes involving citizens and stakeholders to enhance the legitimacy of decisions and planning directions [25]. Co-design emerges as a pivotal approach

in fostering trust among communities and stakeholders, particularly in addressing policy knowledge gaps and delivery challenges that public organizations may encounter while also aligning with the needs and aspirations of target groups over time [25]. Co-design entails a set of principles and practices aimed at understanding problems and generating solutions through the active involvement of various participants [26]. However, poorly designed co-design strategies can inadvertently undermine engagement opportunities, erode trust, exacerbate feelings of marginalisation, restrict access to decision-making, and underscore existing power and structural inequalities [25,27].

Evans and Terrey [25] claim that co-design implies understanding and learning through three iterative stages in the learning process and requires engagement and re-engagement between engagement practitioners/facilitators, researchers, and citizens. The stages defined by Evans and Terrey [25] are (1) discovery and insight; (2) prototyping; and (3) evaluating and scaling of co-design interventions.

Participation is at the core of the co-design process, and understanding how that engagement is implemented is crucial. Academic and practice-based scholarship have explored models of engagement and diverse engagement purposes. For instance, Arnstein [13], in a well-known "ladder of community participation", proposes eight levels of participation. On this ladder, three levels are closely linked with the extent of power given to engaged communities in the decision-making process. While community engagement can lead to citizen control and empowerment at the top of Arnstein's ladder, some forms of tokenistic approaches include placation, consultation and informing. At the bottom, two nonparticipation approaches, or illegitimate "participation", might even lead to manipulation to fulfil government or private interests. That is the challenge for architects seeking to engage in co-design, making that engagement non-tokenistic, an objective that doubtlessly makes the architects' tasks more complex and more time-consuming.

Blomkamp [26] claims that in the public sector, co-design is referred to as a more effective, democratic, or innovative alternative to conventional approaches for community participation and engagement, service design, and policy development. However, the perceptions from practitioners might differ, as co-design may carry a high political component, which can affect the power relations in decisions that might affect the target groups [25]. Legacy [27] warns about the risks of politicisation in the co-design process, as it might be subject to complex funding arrangements and engagement of the private sector and commercial tendering processes. Nonetheless, the possible controversies and issues that might emerge in implementing co-design strategies hold great promise for policy [26].

Governmental organisations and policymakers are encouraged to explore the adoption and integration of co-design practices, given their potential to generate innovative ideas, foster cooperation among stakeholders, rebuild trust between citizens and public officials, and catalyse transformative impacts on participants' agency and well-being [26]. In regions undergoing energy transition, such as the Hunter Valley, communities often feel overlooked in decision-making processes. Authentic co-design practices offer the opportunity for these communities to leverage their knowledge and commitment in shaping the region's future. Such participation not only respects the inhabitants and workers in these areas but also lays the foundation for strong, sustainable regional development.

3. Materials and Methods

3.1. Approach to the Research

This paper examines the potential for enabling architects to help address complex issues for energy transition in the Hunter Valley by assessing in-class experiences of students and educators of the integration of speculative design, while considering opportunities for engagement of local stakeholders through co-designing strategies. This study is grounded on the premise that the goals of innovative research aimed at addressing wicked problems should focus on "fertility-seeking" instead of being driven by truth-seeking [28]. Nickles [28] argues that future developments and opportunities should be evaluated through *heuristic appraisal*, emphasising the potential fertility of contributions to advancing innova-

tive research through experimental design. Thus, this study explores scenarios beyond the representation of reality and implies a systematic application of idealisation, simplification, iteration, approximation, and abstraction [29]. The transformations for designing scenarios for energy transition imply changes that challenge current understandings by revealing new areas of enquiry—i.e., exploration of what might be possible—in contrast to the evaluation of empirical knowledge and problem-solving within existing perspectives that have limitations, with an aim to illustrate scenarios that could otherwise seem unimaginable [28]. The scenarios generated here are not simply optional futures for the Hunter Valley but also imply an engagement tool for students, teachers, and practitioners of architecture in scenario generation for other regions. In other words, the focus is not just on what the Hunter Valley can become but also on how postgraduate architecture students can be active actors in a participatory process emerging in response to the challenges and opportunities presented by energy transition.

3.2. Research Design

In Australia, environmental land use planning is primarily governed by individual state governments, each following its own territorial spatial planning policies, systems, and legislation [30]. In New South Wales, the Environmental Planning and Assessment Act of 1979, along with subsequent amendments [31], marked a shift toward greater environmental protection and accountability. These changes also aimed to enhance collaboration between state and local governments and increase public involvement in the planning process. However, despite these amendments, many communities perceive land use planning as a top-down and bureaucratic process lacking transparency, especially in its interactions with key industries.

Community engagement often involves one-way presentations by representatives of industry, consultancies, or government or, at best, focus groups [32]. This research, however, focuses on testing generative engagement among various stakeholder interests in shaping future design solutions. The experimental project, which is central to this research, uses co-design strategies to integrate multiple frameworks into the design process from its inception through development. Pedagogically, this approach differs from traditional architecture design processes, which typically emphasise individual creativity and the interests of the designer in conceiving and developing a project.

This paper combines two components: (1) current knowledge and pedagogical approaches in designing and planning for energy transition, considering the multiple issues and complexities, and (2) analysis of the master's in architecture studio, in particular the design stream titled, "Don't Be Afraid: Care and Courage in Climate Restoration, Reparation and Re-composition".

The first component is based on a literature review. Peer review and grey literature were identified through online searching focusing on the following search terms or keywords: mine closure, energy transition, energy transition in Australia, mine closure in Australia, energy transition in the Hunter Valley, mine closure in the Hunter Valley, planning for energy transition, spatial and energy planning, inclusive planning, and participatory planning. The sources selected were analysed through traditional literature review, also known as narrative or non-systematic literature review [12]. The narrative synthesis implies an interpretative technique to describe similarities, dissimilarities, and complementarities among the analysed studies [13,14].

The second component is based on mixed methods combining participant observation and qualitative data obtained through interviews conducted with students who participated in the architecture design stream exploring possibilities for a post-mining future in the Hunter Valley.

3.3. Participant Selection and Data Collection

Primary data collection adhered to protocols established by the Human Ethics Committee at the University of Newcastle, with project ethics approved under Ethics Number

H-2023-0309. This paper is based on the first component of a larger research project, which will also promote the engagement of local stakeholders such as communities, government, and other relevant actors involved in the discussions and planning of the future of the Hunter Valley. Five students enrolled in the Master of Architecture studio during semester 1, 2023, were recruited to participate in semi-structured interviews to capture an in-depth understanding of their experiences and perceptions during the studio design process. The aim was to learn from students about the challenges they faced during the studio and opportunities for improvement considering the uniqueness of the teaching experiment and the complexity of the problem addressed. The interviews were conducted during the following semester after the completion of the design studio during semester 2, 2023. Thus, students provided a retrospective perspective and were able to detach from the stresses of the semester's teaching and minimise the potential bias in their perceptions. The participating students were of the median age of a Master of Architecture student, between mid-20s and mid-30s, provided gender diversity, and were inclusive of both local and international students. The qualitative semi-structured interviews included sections such as (a) general student information, (b) motivations to enrol in the master design studio and specifically in the stream the authors have developed, (c) perceptions of the studio process and their journey as students, and (d) takeaways from the studio work.

3.4. Scope and Limitations

This study focused on analysing the design process of creating alternative proposals for the future of the Hunter Valley produced during the Master of Architecture design studio completed during the first semester of 2023. The interviews with students were conducted upon completing the design studio in semester 2, 2023. Therefore, this study collects retrospective qualitative data. Despite the short period of time since the completion of the research and the interviews, less than six months, there might be some concerns about the objectivity of the data collected regarding events in the past and people's tendency to reconstruct the past in light of present circumstances [33,34].

This paper outlines the initial stage of a larger project aiming to engage local people in the co-design and planning of the Hunter Valley. The outcomes of the design studio are observed as a tool for starting the co-design conversations, which are expected to facilitate dialogue among stakeholders. Therefore, the effectiveness of the proposed scenarios as enablers for co-design has not yet been tested. Additionally, technical specifications of the scenarios for the post-mining futures drafted by students are beyond the scope of this study.

The analysis of qualitative data from five interviews provided the necessary in-depth information due to the breadth of projects that present a suite of five different and unique approaches, based on complex human issues rather than generalisations [35], to how an architect may operate productively in this kind of scenario.

3.5. The Architecture Design Studio

The architecture design studio is the centre of an architecture degree and provides dedicated time and space for the exploration of the many components that make up any built environment design project. While there has been continued critical discourse around the rigidity in the pedagogical process of the architectural design studio, especially in the design critique process [36], it retains the bulk of contact hours and content for architectural degrees globally. Additionally, an important characteristic of architecture design studios is the emphasis on iteration as a design strategy, embracing a process of discovery in which the failures and successes become recurrent feedback in the design process [37,38]. An iterative process enables students to solve complex issues define architectural problems themselves [28] and supports students' self-reflection on their work in a process of reflective practice towards solving these problems [37].

At the University of Newcastle, a full-time load per semester is 40 credit points, of which 30 are taken up by the design Studio. Studio groups of 20 students work with a tutor over the course of an academic semester, usually 12–14 weeks, to develop speculative

design projects around specific scenarios and sites. In total, during the semester, they are expected to work 360–420 h on their projects, including 91 h face to face with academic staff.

In this way, the design studio provides an ideal space for future architects to experiment and resolve complex issues related to post-coal regional planning. It provides a unique learning environment for students to address the multifaceted scenarios that have been discussed in relation to energy transition and regional urbanism. While the spatial development project is the work of many academic disciplines such as environmental sciences, engineering, construction management, and town planning, architectural design supplies tools for facilitating conversations across the many disciplines toward alternative spatial outcomes. The primary tool is visualisations, both diagrammatic and representational, that allow multiple stakeholders to see key issues and data in relation to each other and to envision and thereby make tangible what a different world may look and feel like.

4. Exploring the Role of Architects in Designing for Transition

This section focuses on the exploration of architects' roles in proposing scenarios for natural and social environments in transition through a design studio. It engages architecture students as future designing and planning professionals and trials how their contributions can operate productively in proposing solutions to such complex contexts.

The tools used by the students included the development of activities and pedagogical approaches to address wicked problems, focusing on strategies such as speculative design, design for transition design, and co-design during the implementation of an architecture design studio.

4.1. Transition in the Hunter Region Towards a Post-Mining Future

The Hunter Valley is Australia's largest regional economy and is significantly dependent on primary industries, such as mining, as the region holds nearly 40% of New South Wales coal deposits [5]. However, the decline of the coal industry in the Hunter region means that 17 mining sites will cease operations in the next two decades, with the earliest, BHP's giant Mount Arthur complex, forecast to close in 2025 [6]. Consequently, over 130,000 hectares of land will be available for new uses, including over 50,000 hectares of buffer lands and more than 25 massive voids created for open-cut coal extraction across the Hunter Valley [39].

In the recent book *The Superpower Transformation* edited by best-selling Australian energy economist Ross Garnaut, Susannah Powell describes the jobs and direct investment that will come from developing zero-emissions industrial products as the "renaissance of rural and regional Australia" [40]. Whether this is renewable energy production, manufacturing of zero-carbon metals, carbon sequestration opportunities, or biomass production and processing, Powell emphasises the opportunity for revitalisation and growth, particularly for traditional coal regions that already have existing industrial infrastructure. With these new industries come new workers and communities. The demand for housing as well as investment in key services and amenities, transport, and infrastructure all provide opportunities for economic activity and development. The alternative to this has been played out in many post-coal regions such as in Wales in the UK and parts of the Appalachians in the US, where the lack of economic investment has led to despoiled landscapes and abandoned mines that have contributed to extreme economic disadvantage and failing townships.

Interestingly, in the context of the Hunter Valley, the estimates from the Lock the Gate Alliance [5] point out that land restoration can contribute about $200 million to the Hunter economy, creating new jobs and positioning the region as a world leader in regenerative industries. Hunter Renewal, a local initiative subsidiary of Lock the Gate, is observing and analysing the energy transition in the region and serving as a platform for collaboration and engagement. Hunter Renewal claims that the post-mining transition cannot be based solely on economic development grounds, which has been the trend so far [6]. For instance, in the *Hunter Regional Plan 2041*, the NSW government focused on diversifying industry and employment in the region to face mine closures [41]. However, Hunter Renewal [6] claims

that coordination based on government-industry meetings cannot achieve the full potential for redevelopment of the region and that this process requires the regular engagement of local communities and other relevant stakeholders.

4.2. Accepting the Challenge: Designing for Transition in the Hunter Valley

The structure of the Master of Architecture degree at the University of Newcastle allows for multiple project streams in which students vote to participate in particular areas of practice-led research. In February 2023, a master's stream titled "Don't be Afraid: Restoration, Reparation and Re-Composition for a Post-Coal Future" was proposed and run by the authors, and Hunter Renewal's report, *After the coal rush, the clean-up: A community blueprint to restore the Hunter*" [6], was the primary briefing document for students.

The design studio also incorporated a key element, which is care for Country, leaning on the Connecting with Country Framework [42], which aims to "respond to changes and new directions in planning policy relating to Aboriginal culture and heritage, including place-led design approaches". The term "Country" relates to the Aboriginal visions of the world as "nation, cultural group and region that First Nations people belong to, find healing from and will return to" and the understanding and caring for the wellbeing of the Country and its interconnections with present and future systems [42]. Thus, it is crucial to develop strategies to assist Aboriginal and non-Aboriginal communities in sharing knowledge of First Nations sites and places of shared cultural and heritage significance, respecting and protecting sensitive sites, and strengthening culture [42,43]. In a severely affected landscape context, care for Country has become a key issue in understanding and analysing issues for healing the site towards restoration, reparation, and re-composition. This form of inclusion is made complicated by historical marginalisation and trauma experienced by Aboriginal communities, such as genocide, abduction of children, segregation, discrimination, and the more recent denial of a Voice to Parliament for Australia's First Nations people (Aboriginal people and Torres Strait Islanders).

4.2.1. Studio Design Process

The design studio looked at the multidimensional nature of the problem of this site through analysing socio-economic issues through the demographics of jobs, income, and population along with mapping local industries. The studio endeavoured to understand liveability factors, ecological zones, and corridors to understand past and existing biodiversity in the region, opportunities for growth, and the many aspects that make up this complex place. This research provided the basis for extrapolating and speculating on new spatial and environmental opportunities.

The various stages of the design studio are presented in Figure 1 through which one can see how the speculative design process operated within the studio teaching process. The initial stage included data collection and critical analysis through understanding the many issues related to the site and the context of the theme selected in the stream. This parallels the sort of data gathering that a professional architect would do in relation to a possible commission or other professional engagement. The outcome from this initial stage was a dossier that summarises the most relevant information and that served as the basis for the following stages. While this kind of report is often outsourced in real-world scenarios, ensuring that design outcomes are driven by analysis and data is a key part of master's level architectural teaching.

The second stage focused on the schematic design phase, a similar stage to a conventional architectural project in which the architect develops a rough set of drawings that outline the design project from which feedback from the client can be obtained and budget estimates can be made. In this stage, due to the large scale and complex brief, students were divided into smaller groups to promote closer discussion and collaboration that could lead to more specific design proposals.

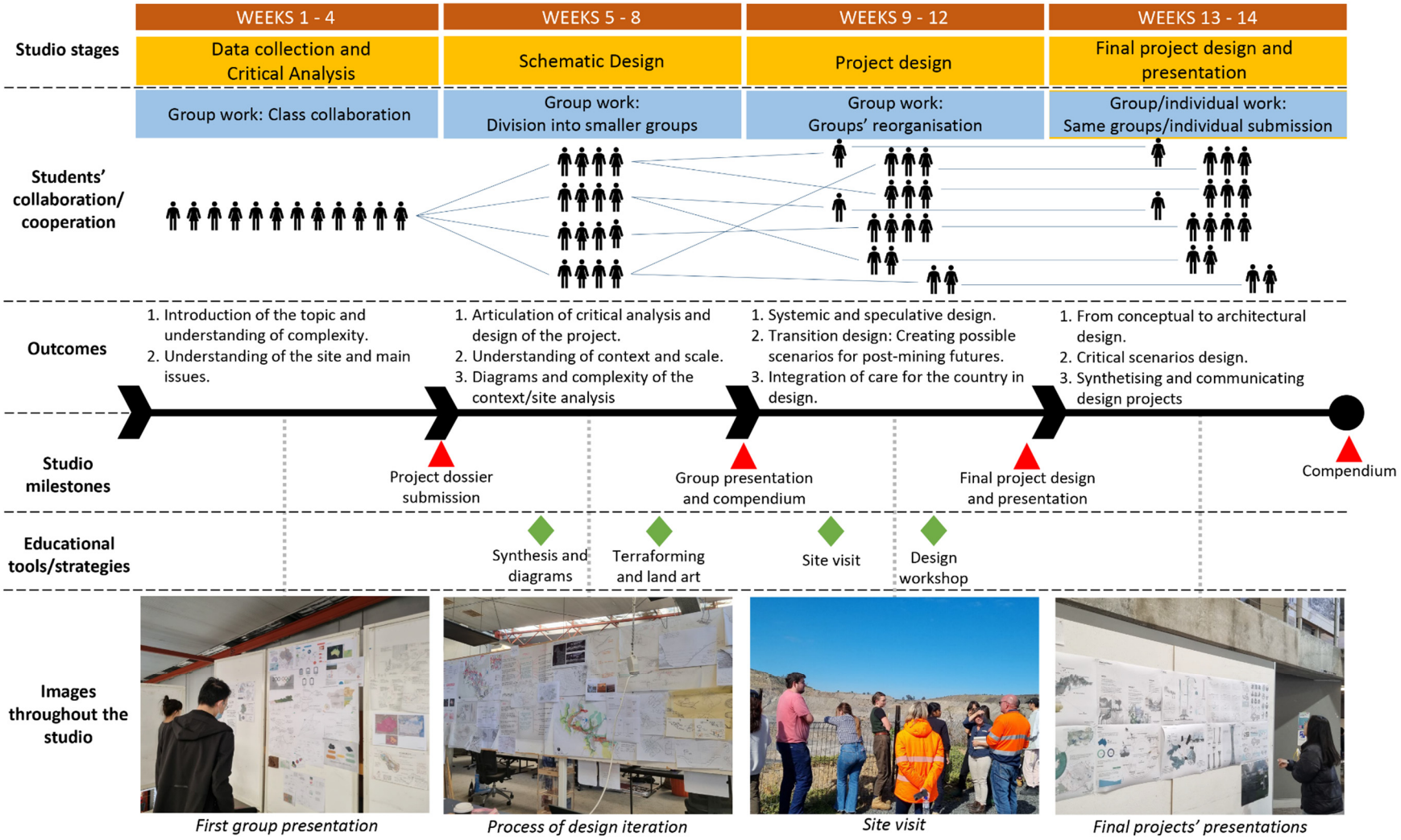

Figure 1. Schedule and design process. Source: Authors.

This stage included synthesising the information and trends through the development of diagrams as visual tools for architectural analysis. Furthermore, concepts such as terraforming were introduced to students to address the massive mining interventions in the landscape, minimising the risks of further pollution and toxicity of the soils and defining the limitations for architectural interventions. Precedent projects from formal and experimental land art were also analysed and discussed in the studio, as the specificity of large-scale sites such as mining areas are often dismissed or misunderstood since it is unusual to propose design projects in such large dimensions [44,45]. These elements, again, resemble processes for professional involvement in an architecture firm.

For the third stage, project design, the student groups were reorganised based on their affinities. Group sizes varied from two to four students, and some students decided to continue the design process individually. In this stage, students incorporated architectural elements of land design and rural planning and development to resolve the project and propose some clear spatial outcomes for the region.

During this stage, students were able to visit the site, as the coordination with stakeholders and representatives of mining operators required specific permission due to the nature of the industry and the public concerns and controversies (see [46,47]). Students were able to perceive the scale and local conditions that impacted the elaboration of planning and architectural design in their own projects.

Additionally, an in-class design workshop was conducted to facilitate the rapid design of the site and students' groups interaction with their peers to improve the quality of their project design.

The final project design included the resolved presentation of students' projects, presented in Figure 2, to the class and a panel of professionals and representatives of organisations working with local communities in the Hunter Valley. Students presented their projects as groups and received feedback through critical comments that supported further design development. Following the presentation, students had two weeks to submit their final design projects via individual compendiums summarising the stages of analysis and design throughout the studio. While the first stage of groupwork and research, followed by schematic design and development, followed a typical design project brief for an architect, the compendium that came at the end emphasised the educational process that students were going through, where analysis and reflection on the process was as important as the final design product presented prior.

4.2.2. Design Challenges:

What emerged as the key challenges students faced during this studio can be understood as the same real-world blockages faced by the local community, businesses, and government decision-makers when confronted with a region shifting to a post-coal future—complexity, scale, and care for Country. The first two factors refer to the amount and difficulty of working in these kinds of extractive regional contexts [38], thinking through challenges and opportunities at the mammoth scales in which mining operates, and the extreme impact on environmental systems and permanent landscape destruction.

Two visual mediums were employed to engage complexity and scale—(1) the mapping of the most crucial issues in the present and possibilities for the future and (2) diagramming the correlations among different aspects analysed that helped students address the complexities of the project. The working architects' ability to understand, create, and utilise these two mediums in a professional context give them considerable agency in supporting co-design processes.

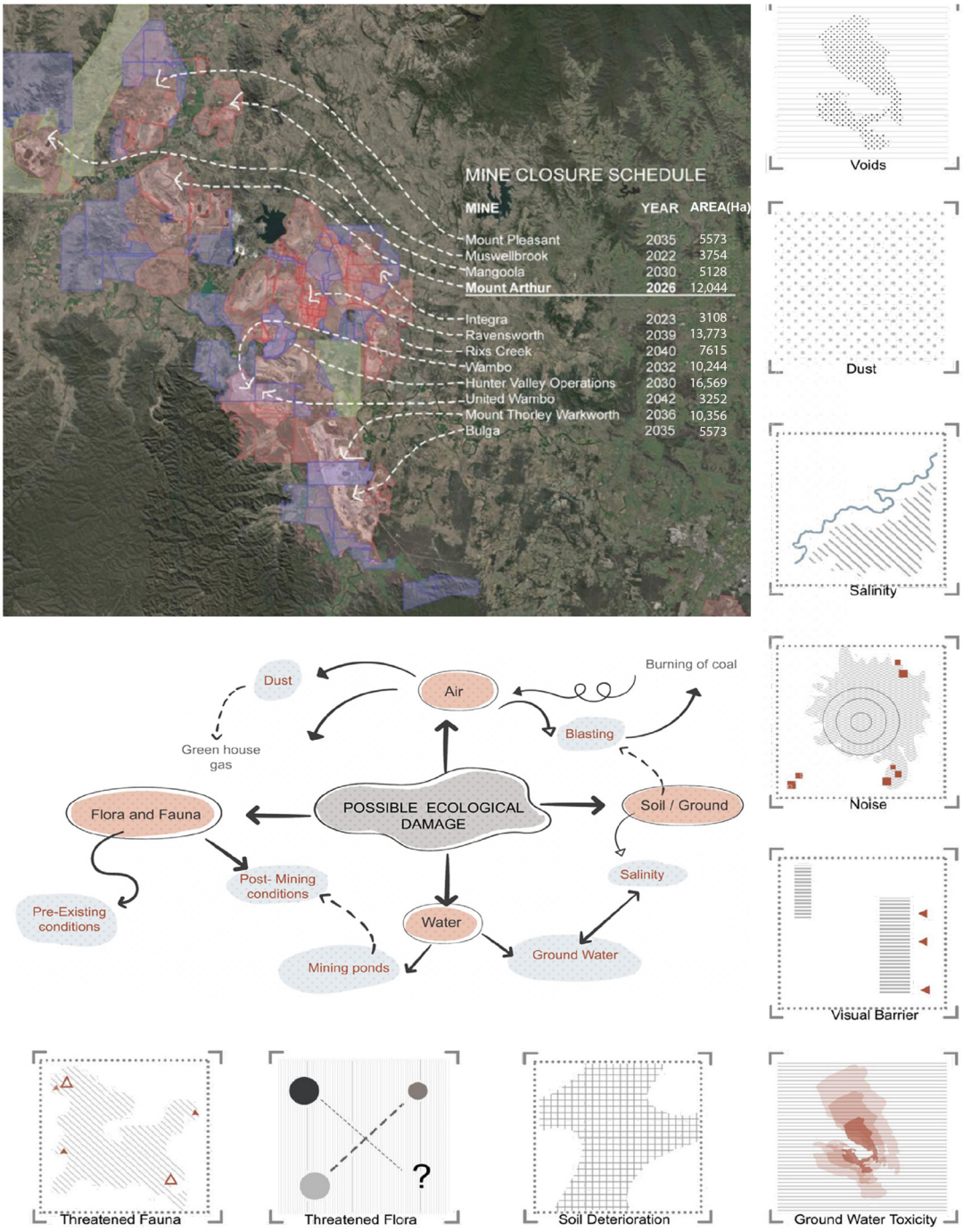

Figure 2. Mapping and diagramming of main issues in Mount Arthur. Source: NP, MRD.

a. Complexity and Diagramming

The design studio began by tackling the issue of complexity through research. Holding the diverse issues of the Hunter Valley, which are often entangled and antagonistic, were very challenging for students. The students' close analysis of the Hunter Valley included amassing data spanning demographics through understanding community priorities and concerns and information around vegetation. Alongside this, they were developing an understanding of the role of energy production in the region and the options around new energy technologies and innovation. In looking at the contemporary situation of the Hunter Valley, the following concerns emerged, including the impact of the transition of mine closure; existing voids, vegetation, habitat loss, groundwater pollution, topography,

soil conditions, the Muswellbrook and Hunter local communities, carbon emissions, air quality, transportation, heritage, policy and legislation, scale, and climate change, as seen in Figure 2.

The students' sense of responsibility greatly amplified this perception. One student mentioned that "despite being a local and knowing the area, I felt that there were many things that I haven't considered before. I feel that I need to learn more and do my best for me, my community, and my children" (Student 3, Female).

The diagram was used as an important design tool to navigate the large amounts of information collected and discern what was important to the design project. Diagrams reveal or propose an underlying conceptual organisation of the multiple aspects of the physical environment [48]. Thus, diagramming became a way of holding the data of the studio in manageable and tangibly visible ways, revealing and building hierarchies and relations among information [49]. More importantly, diagramming was a way of revealing new approaches forward through the relationship between sometimes discontinuous information. As architectural theorist Stan Allen [50] states, the diagram is a visual assemblage between activity and form. It is a generative tool in bringing information and spaces together.

Diagrams produced by students included information on health issues in the region, pollution, jobs and income, housing, and education. It also included analysis of larger climactic issues—alternative energy production technologies and anthropogenically modified atmospheric, soil, and water issues. Diagramming allowed one group to realise that with the decision to prioritise environment and job security in the region, they needed to focus on food production and water security. Another group concluded that economic security, climate change, and education could lead to a different way that energy production could operate in the region—not only as industry driven but also as education and community driven. In this way, hybrid programs were developed between sometimes unlikely disciplines and industries, innovating the way that these relations could service the region and operate across this large site.

b. Scale

It also became apparent that the other key challenge for students was scale, an issue unique to the context of extractive landscapes. The massive scale and degree of alteration in extractive landscapes negates normative prescriptions of design and requires a humbler recognition of physical and fiscal limits [51]. Open-cut mining has created vast, toxic terrains that necessitate innovative approaches to restoration and rehabilitation. Environmental approvals post closure demand that the site is brought back to its original state; however, how this is interpreted remains a contentious issue. While rehabilitation of buffer zones that surround the voids is often presented as exemplars of what is possible post closure, the mine pits are the real problem.

At Mt. Arthur, the main pit spans 7 km in length and at its deepest is 250 m in depth. The size only began to become really apparent when one student overlayed, at scale, the mine site upon the city of Sydney, through which students realised that the pit alone would take up the entire city centre. With this realisation that the pit needed to be understood at an urban scale rather than a building scale, the students' proposals for programs and projects became more expansive and complex. Students' perceptions highlight the complexity of large-scale environments for designing and the uncertainty that it caused in finding appropriate approaches to deal with them. As one student mentioned, "Observing the complexities and to be asked to approach the scale it is hard, and it was an experiment and struggling to understand and try to get answers where there were no answers" (Student 1, Female).

Scale was tackled initially by the students through mapping. Cartographic systems allow for the data to land on the site. The scale of the Hunter Valley as a region as well as the scale of the voids themselves were challenges for architecture students used to dealing with the scale of a building. Students mapped information on biodiversity corridors, water systems, and catchment zones, overlaying these on top of topographic conditions, existing populations, heritage zones, and infrastructure and transport systems. Like the diagram,

these maps were a process of research and discernment, a communication device, and a way of revealing new opportunities for the projects.

c. Care for Country

Care for Country was the third key challenge that became clear through this process. Students worked hard to embed Aboriginal and Torres Strait Islander world views and perspectives in emergent design processes through meaningful and respectful engagement with culture, country, and community. Aboriginal world views were also understood to incorporate long-term approaches to environmental sustainability, transforming the traditional human-centred design approach to one of custodianship and ecological relations. These challenges map to those currently facing the architectural profession in Australia as it struggles to develop meaningful protocols for indigenous engagement in the built environment.

Students had a lecture series of Aboriginal practitioners and allies in the built environment. They also had access to two expert Aboriginal consultants throughout the semester who provided valuable insights and feedback, assisting students to authentically engage with First Nations knowledges, practices, and understandings of Country within their projects. Students acknowledged the crucial role of these consultants in their development of their projects, especially when these are the core of the concepts and their designs. As one student mentioned, "Having our Aboriginal staff to consult about many concepts and understanding of their way of see the world was important, although it would have been good to have the perceptions of local Aboriginal people in Mount Arthur or nearby areas" (Student 2, Male).

However, students also acknowledged that despite the advantage of the conversations and assistance from the Indigenous consultants, the understanding of particular concerns regarding dramatically altered landscapes like Mount Arthur required interaction with local Aboriginal communities, which, unfortunately, was limited in this studio, combined also with personal experiences of local students who have witnessed the landscape deterioration and the review of relevant literature on Aboriginal knowledge and principles.

While the 2021 changes in the Architects Accreditation Council of Australia [52] now demand competency from all graduates in architectural master's degrees in Indigenous knowledge and practices, how this element is integrated and engaged in architectural teaching is both diverse and novel. That means that educators and students are required to explore and assess together the most relevant aspects for their projects. This requirement created additional layers of complexity and contradiction in how the design outcomes would unfold and properly portray the situation and concerns of directly affected communities during and after the extractive industries cease in the area.

Additionally, international students struggled with understanding Australian Aboriginal cultures, as they were unfamiliar with local socio-economic and cultural issues that challenge the country's development, requiring additional effort. Despite these difficulties, these students acknowledged the value of incorporating care for Country, which could impact their future student and professional development. A student mentioned, "As an international student I struggle thinking on how I can incorporate Caring for the Country into architecture and the help from our Aboriginal consultants made a huge difference and I believe I will carry that experience for my own professional future" (Student 4, Female).

4.2.3. Outcomes

Following the initial analysis and theoretical design process, students started to propose speculative architectural outcomes based on the potential scenarios proposed in previous stages. The emphasis was not on solutions to the many issues of the region but to speculate on what students felt were key opportunities for this site. Figure 3 presents some of the architectural designs produced by students, which demonstrate a wide range of approaches and priorities addressed through students' projects.

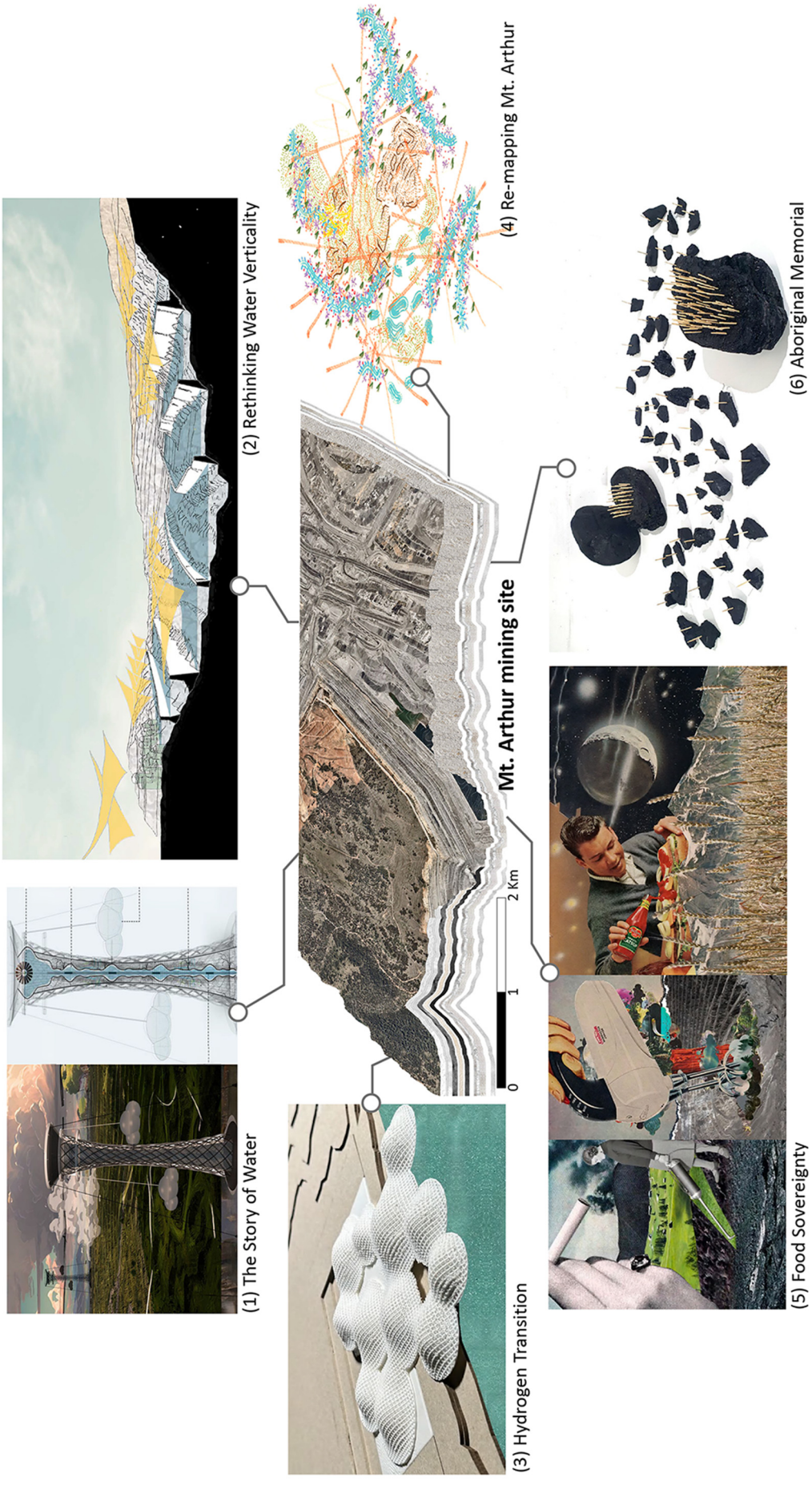

Figure 3. Students' design projects. Source: Authors, based on students' works at the architecture masters' studio.

For instance, designs (1) and (2) used water as a concept for their designs, as their creators decided through their research that the issue of water in the already drought-affected region, which would steadily worsen through climate change, made it the core driver of their designs. Students iteratively explored how water could be harnessed and harvested through architectural and engineering technologies. Design (1) includes towers to capture water from the fog and use it to restore the natural environment and limited interventions that were planned in the rest of the site, acknowledging that the landscape had already suffered massive alterations and needed to heal. Design (2) is the product of a personal reflection of a local student who sees the site as spaces for retreat and spiritual reflection using water as a sensorial element. This perspective took water as a historic, metaphoric, and sensorial material, embedded in local Indigenous thinking, in which landscape remediation could be tied to human healing through a design project.

Designs (3) and (5) focused on alternative economic industries for the region, transitioning from the coal mining industry to clean energy and food production. Design (3) proposes transitioning to hydrogen production, considering the character of the area and the community-developed image as part of the energy production chain. Design (4) proposes facilities for food production and the recovery of productive land. Interestingly, students use artwork to present their projects.

Finally, designs (4) and (6) propose projects that are centred on care for Country and are attempts to reflect First Nations communities' visions of the world. Design (4) considers decolonising the understanding of the site through re-mapping Mount Arthur and proposing a collective process of observing the important sites, elements, and others in the area that would guide future planning and designing initiatives. Design (6) proposes an Aboriginal Memorial as a tribute to First Nations communities, their hardships, and their hopes for the healing of the land and restoration of the natural landscape in harmony with Aboriginal concepts that guide the structure of space, time, and the universe.

5. Discussion: Enablers for Co-Design and Educating for Engagement

5.1. Architecture for Co-Design

The architecture design studio process led to an in-depth analysis of the Hunter Valley's current situation, specifically at the site of Mount Arthur. The integration of site analysis, examination of current trends and issues, and contemporary community feedback enabled the conceptual definition of possible, plausible, and probable futures through the design of scenarios that encompass the challenges and opportunities in extractive regional zones (see Figure 4). The final design outcomes revealed a variety of speculative architectural designs that translated conceptual scenarios into visual tools to be used in co-design, which Blomkamp [26] highlights as the key for co-design. Thus, effective communication through media, images, mapping, and other visualisation tools are essential for citizen participation in participatory planning [26,53].

However, visualisations alone are unlikely to promote participatory planning and stakeholders' engagement, leading to a collective design of preferred futures, as seen in Figure 4. Al-Kodmany [53] claims that a series of strategies are crucial to bridge the gap between "experts" and local residents. Developing empathy, active listening, and sensitivity to diversity and various cultural styles encourages open communication in an environment of neutrality, tolerance, and mutual trust [53]. Furthermore, enabling transparent and trustable strategies for a community's engagement is critical to provide them with real power to impact the outcome of the participation process and avoid empty rituals of participation [13]. In this context, visual elements can also create a common language for communication and a focus for discussions between diverse groups and individuals within communities, raising awareness and, at least temporarily, putting aside particular interests and concerns [53].

The engagement with care for Country brought students into the complexity of this field and gave them an understanding of the importance of finding ways to authentically build that into their designs. This manifested in different ways in each project, showing the

diversity of approaches needed when integrating Aboriginal content and approaches. Different methods were engaged throughout the design process, from the conceptual starting point of their brief that looked at the Wonnarua Nation history and stories of the region through practical engagement methods with community, but all students explicitly ensured that their designs worked with care for Country in a particular way. For some students, that indigenous engagement centred on the integration of indigenous stakeholders into the ownership structures of the hydrogen plant; for others, it meant the use and celebration of indigenous medicinal and food knowledge; and for one group, it meant forgoing all built work and focusing on a process that would activate community conversations about what the site could be first. While all of these projects sat within the speculative realm of design practice, collectively they present a suite of potential forms of meaningful engagement with Country.

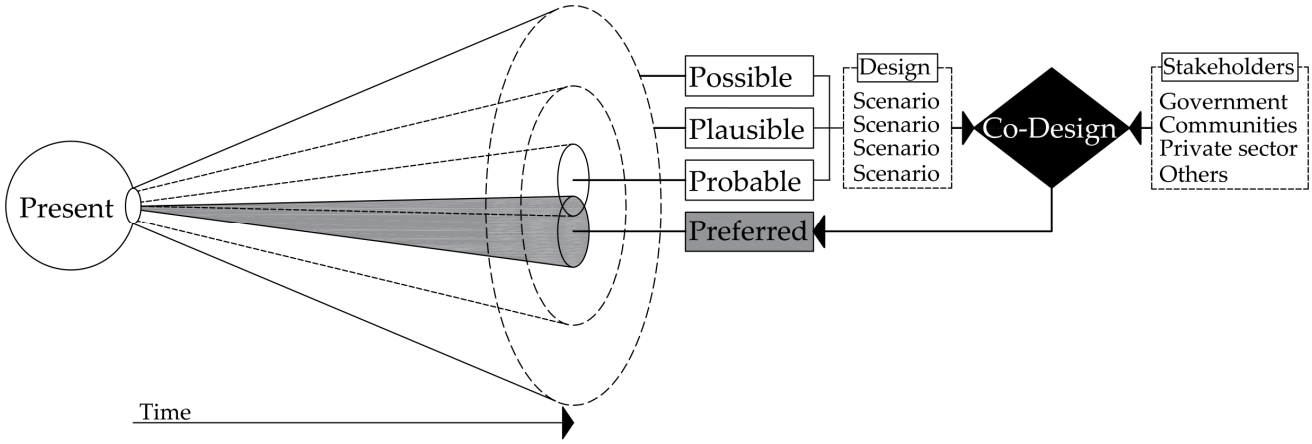

Figure 4. Process of Participatory Speculative Design. Source: Authors, based on [21,22].

The speculative design studio could thus be seen as standing out as a vital platform for students, nurturing their analytical skills and empowering them to navigate intricate contexts. In doing so, it prepares students for working collaboratively and productively in designing regional futures. The curriculum can be understood to have supported the development of the critical thinking that architects would require in this setting, equipping students with the capacity to construct scenarios, deepening their comprehension of architects' multifaceted roles in planning and design. This exercise did not reveal to students specifically what a good design *response* to energy transition looks like. Rather, it revealed elements of what a good co-design *process* looks like.

A distinctive quality of the studio outcomes was a commitment to having the architecture profession address the imperative of healing natural environments. Going beyond conventional boundaries, the work integrated considerations of socio-economic interests, along with incorporating First Nations concepts and values into students' education and their future professional practice. This holistic approach underscores the need to guide students through a context of transition and adaptation, wherein architects shoulder the responsibility of acknowledging, connecting, and harmonising diverse elements via a design approach rather than through a more narrowly technocratic approach of "problem-solving". Adding another layer of significance, students were presented with the opportunity to share their meticulously crafted architectural projects with local communities, which helps community stakeholders to learn and respond to what engagement with architects might bring.

Envisioned as visual tools for co-design, the student projects—and future architect engagement—could act as catalysts for further community engagement via their ability to manifest alternative spatial futures. The impact is not confined to academia, as it fosters a profound sense of professional responsibility among students that should carry into their professional practice. In interviews, a unanimous sentiment emerges among participating students—a deep satisfaction stemming from the realisation that their projects actively

facilitate community participation in the crucial planning processes for the remediation and restoration of Mount Arthur. This reciprocal exchange enriches the students' learning experience and establishes a tangible link between their academic pursuits, their profession, and the broader imperative of environmental and social stewardship.

This study is situated in a specific context, a coal mining region facing energy transition with its own colonial history and a suite of economic prospects influenced by Australia's place in world trade and world politics. Some might argue that that limits the replicability of the experiment conducted here. However, the heuristics employed—a systematic application of idealisation, simplification, iteration, approximation, and abstraction—are replicable to architectural education programmes and replicable and adaptable to local conditions in different regions of the world. Any attempt to apply these heuristics will start and end with parameters characteristic of the regions, populations, and professionals in training where they are applied.

5.2. Learning for Future Teaching

Analysing the students' perspectives about their experiences during the pedagogical experiment conducted during the master's design studio provided important insights for improvement of the approach of the studio in providing opportunities for engagement of various stakeholders beyond the classroom. Three key areas were identified that are related to the students' challenges presented in the previous section:

a. Communication of complex ideas

In architecture, diagrams are essential for effectively communicating complex information. They help manage and visualize extensive data, making it accessible to a broader audience, including community members and policymakers. In the case of the studio focusing on the Hunter Valley, students found diagrams integral to navigating issues like demographics, vegetation, and energy production, revealing relationships and facilitating new insights for thinking on the future of the region in a post-mining scenario. This approach enabled clear communication of priorities such as food and water security and innovative energy methods, fostering interdisciplinary collaboration and informed decision-making. Diagrams thus bridge the gap between technical expertise and public understanding, enhancing engagement and inclusivity in architectural projects.

b. Reconsidering scale in architecture

In architecture, the consideration of scale is crucial, especially when dealing with large scales and vast areas of land. Traditional architectural design often focuses on smaller, more manageable scales, such as individual buildings or small urban areas. However, in the context of extractive landscapes, the massive scale and degree of alteration present unique challenges that necessitate a shift in perspective that students found particularly challenging. Understanding these scales necessitates contextualising them within familiar urban environments, as well as using mapping tools to overlay data on biodiversity, water systems, and infrastructure. These tools help reveal new design opportunities and address the complex challenges posed by such large-scale environments that might be more relevant in rural design and planning.

c. Developing culturally sensitive approaches and incorporating Indigenous principles

Incorporating Aboriginal and Torres Strait Islander perspectives, referred to as care for Country, is important in designing and planning, especially for disrupted landscapes, as it emphasises long-term sustainability and custodianship over traditional human-centred designs. Australia's architectural profession is developing protocols for Aboriginal engagement, requiring students to demonstrate competencies promoting culturally sensitive responses and respect for Indigenous knowledge. Students were also required to propose initiatives that avoided impersonating Aboriginal imagery and that reflected understanding of the limitations of being outsiders to these First Nations communities. Considering that direct engagement with local Aboriginal communities is often complex and difficult to

manage in many Australian sites, the engagement of Aboriginal consultants that the studio modelled was recognised as an invaluable asset.

6. Conclusions

This research marks the initial phase of a broader effort to support positive transitions in regional Australia by working across disciplines to design informed, inclusive, and sustainable ways forward. It explores the role of architects in this process—including visual and design elements and planning strategies, in consonance with the analysis of the current and possible scenarios that are often missing—by way of a complex regional site undergoing energy transition and its accompanying social and spatial transformation. Using a heuristic and iterative process within the Master of Architecture design studio, the study enabled a non-linear discovery process to understand the complexities of the problem and promoted students' critical design thinking. Students' projects at the end of the studio will enable interdisciplinary dialogue for a public exhibition and panel discussion in the Upper Hunter Valley in 2024, engaging diverse stakeholders, including local communities, First Nations groups, industry representatives, and governmental bodies.

The methodological design experiment considered contextualising speculative design in the initial phase of a comprehensive co-design framework, which means that participant stakeholders—e.g., community members, business operators, local government representatives—in future project phases can embark on an exploratory trajectory, interrogating "what if" scenarios emerging from discussions about the students' projects. This methodological foundation proposes a nuanced understanding of potential future trajectories, positioning the students' final project outputs as advocacy tools to facilitate collective, contextually attuned alternatives. By not just offering theoretical frameworks or text-heavy reports but also spatially visualising what alternative scenarios could look and feel like, the projects' co-design process and outputs have the capacity to mobilise stakeholder engagement in ways that one-way presentations or focus groups cannot.

Therefore, the exhibition and discussion are expected to become vehicles for community engagement. While not expecting to provide a single solution for this locality to the problem of transition to post-mining planning, these events are expected to provide a platform for collective and generative thinking, helping to define multiple possibilities, priorities, and future alternatives for discussion and participation. The anticipated outcomes are expected to strategically address immediate environmental exigencies (such as threats to streams from mine runoff after heavy rains) and attend to the spatial, socio-cultural, and economic dimensions intrinsic in post-mining regional landscapes in the Hunter Valley. The transition process opens opportunities for rethinking and establishing alternative livelihood opportunities, job transition and re-skilling, and connection to place and reinforce the sense of belonging and community.

This research paper illustrates elements of an adaptable, scalable, and replicable process that can play an important part in community-focused, comprehensive, and sustainable responses to environmental transition challenges in Australia and other regions globally. Through critical analysis of the process and interviews with students, the study also evidences some of the key issues for these complex projects and how they may be better tested pedagogically in architecture design studios. Testing and evaluating outcomes of this methodological tool in a variety of settings can provide valuable lessons for constructing a robust methodological framework to integrate speculative design, co-design, and participatory approaches, highlighting the value that a visually based profession like architecture can offer.

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