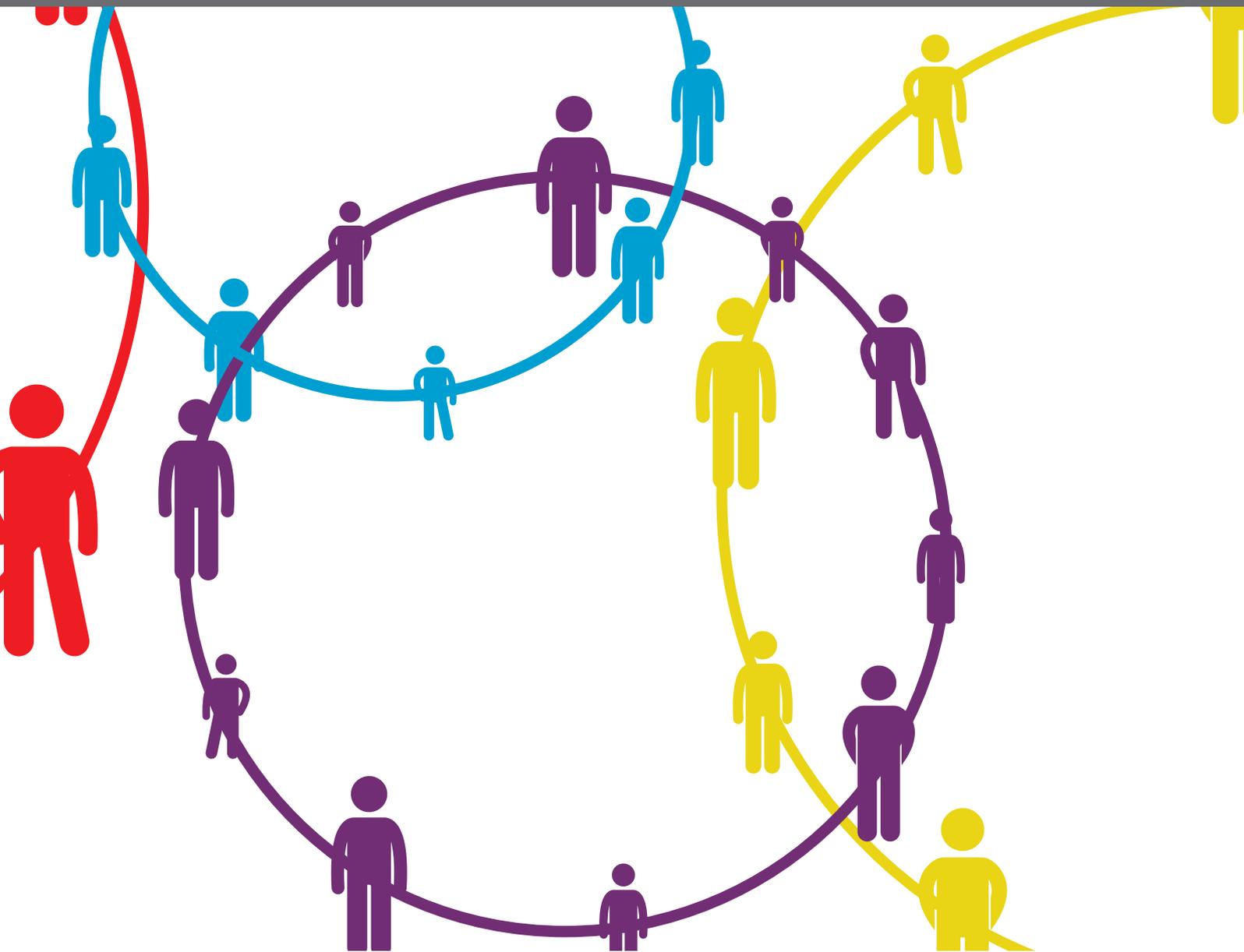


CLIMATE CHANGE AND SOCIETY

EDITED BY: Fátima Alves and Luísa Schmidt

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CLIMATE CHANGE AND SOCIETY

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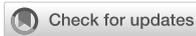
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Editorial: Climate change and society

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Editorial on the Research Topic Climate change and society

Climate change presents one of the greatest challenges of the 21st Century. It will massively affect human societies in complex and multiple ways. And it seems to be almost uncontrollable in the near future. Our knowledge of the chemistry and physics of climate change, its causes and its consequences for planetary systems, is far greater than our understanding of the societal changes it poses. Climate change results from a complex process of societal transformations, which we all need to understand to better cope with the challenges it presents. Climatic conditions play a significant role and interfere with people's lives in multiple ways. The causes are essentially known, based on unequivocal human action. All solutions also involve human decision and action. It is social and human action in both individual and social settings that are decisive for the future pathways of climate change and its disentanglement.

There is also a factor of climate injustice that must be addressed. The nations that contributed most to the problem are often those that experience more limited and manageable consequences while those who contributed the least are often the most affected, vulnerable and unprepared. With climate change, the risk of conflicts, disasters and internal displacement increases so exacerbate existing inequalities and poverty. This presents a moral conundrum of the highest order.

At the ecological level, the destruction or disintegration of nature/nurture is more visible, with strong impacts on the availability and reduction of natural resources. In terms of social systems, climate change breaks down social organization, housing, the food system, generates migration, increases economic losses, hunger and public health breakdowns. In a more invisible way, climate change destroys cultural belonging and individual and collective identities. In addition to these expected impacts in the most diverse social, cultural, economic and environmental sectors, human health has emerged as an important area of considerable alarm. Although not frequently mentioned or targeted as a key political concern, it is expected that the impact of climate change on human health will be severe, both in the proliferation and incidence of diseases. Moreover, climate change will have extensive implications to human wellbeing, which will reflect on social structures and ways of life.

Though the impact of changes in these biophysical systems is widely recognized, as it is increasingly in economies, at a social and cultural level and when most needed, there is still a long way to go. This situation adds to the complexity of the challenges of the climate emergency, insofar as it introduces contextual, territorial diversities and social-cultural diversities of the people who inhabit those territories, and with that, social inequalities.

For a long time, the importance of a paradigm shift has been widely recognized, in which societies face the paradox of continuing to deepen the well-documented socio-ecological crisis whilst it is imperative to alleviate it. We seek, but we do not find, leadership from the world's rulers. The need for transformative change is an imperative from which we can no longer escape. The alternative is catastrophe or action on top of it.

The aim of this Research Topic is to highlight and share knowledge on the social, economic, political and cultural implications of climate change, as well as reflect upon the required transformations in policy, governance and social-cultural strategies to accelerate mitigation, adaptation and prevention. To understand the multiple dimensions of climate change and their interdependencies, we need to bring together a multitude of sciences, knowledges, powers, and decision-makers.

The social sciences and sociology play a central role in analyzing the effects of human activities on natural systems. Social Sciences can scrutinize those phenomena and relations that, within human societies, produce social structures and ways of thinking and judging that ultimately undermine the integrity of the environment.

This Research Topic provides an overview of social sciences, and also multidisciplinary literature and research on climate change and socio-ecological challenges, facilitating the identification of key areas for further research and development. The articles included in this Research Topic address a variety of themes seeking to clarify the need to understand and act on climate change. They question forms of knowing and the understanding of the senses and meanings, perceptions, and the role of social and cultural factors in their construction. Thus, this Research Topic extends to the knowledge of perceptions, to the need to convey meaningful voice to the voiceless, whether children, women, or any other minorities, in order to highlight the processes of good governance and citizen participation, and to ensure supportive involvement in environmental decisions. These are prerequisites of the ecological transition requiring transformative changes at structures' and subjects' levels. The aforementioned Research Topic includes 9 articles (organized) as follows:

Kythreotis et al. analyse "Citizen Social Science for More Integrative and Effective Climate Action: A Science-Policy Perspective," highlighting the challenges to States and policies to keep the temperature below 2°C, focusing on the role of citizens and citizen agency in changing behaviors. The authors

seek to elevate "Citizen Social Science (CSS) to a new level across governments as an advanced collaborative approach to accelerating climate action and policies that moves beyond conventional citizen science and participatory approaches." In this context, citizens become the central actors in driving climate policy change.

Romero-Lankao and Gnatz, link adaptation to climate change with SDG and the New Urban Agenda. The article "Risk Inequality and the Food-Energy-Water (FEW) Nexus: A Study of 43 City Adaptation Plans" suggests relating inequality in climate risk to urban populations. The authors "examine whether and how adaptation plans from C40 member cities address inequality in risk, by planning actions to reduce hazard exposure or tackling the drivers of social vulnerability." In general, their findings express that the "FEW-nexus thinking is not yet embedded in narrative understandings of risk and planned adaptation actions, within the adaptation plans" they have studied.

In their essay, Aldeia and Alves discuss the limits of mainstream environmental sociology as a field capable of fostering how we understand and deal with contemporary socio-ecological problems. They argue how Western capitalist modernity is premised upon a fundamental separation of Society and Nature that transforms the latter into the mere environment of the Anthropos, something which transforms the environment into a resource pool for modern capitalist exploitation. Rejecting the idea that we are currently experiencing an environmental crisis, the authors reason that we are rather living through "a crisis of Western modernity itself and of the kind of worlds that are possible and impossible to build within it." As such, the environment is not what needs to be saved but quite the opposite: it is a subject that actively needs to be un-thought if our current world(s)-building crisis is to be overcome. "Against the Environment. Problems in Society/Nature Relations" contributes to critically "unthink" both mainstream environmental sociology and the ways in which modern capitalist worlds are made. In doing so, this paper directs our attention to alternative possibilities for enacting multiple and interconnected ontologies of humans and non-human life.

In "Perceptions of Local Environmental Issues and the Relevance of Climate Change in Nepal's Terai: Perspectives from Two Communities," Nash et al., investigates community perceptions and representations of environmental and climate-relevant issues that are critical to underpinning responses to climate change, within two communities in the Terai region of Nepal: Bharatpur and Kumroj in Chitwan Province, having conducted 30 qualitative interviews with local people. Results highlight that "climate change is yet to penetrate the environmental representations of some communities and there is a need to address the disconnect between local issues and global climate change." The need to make climate change relevant locally, particularly for communities at risk, brings

new directions for the development of action and a novel policy agenda.

Signoretta et al., in “*Fiddling While Rome Burns*”: *The Role of Ecological States in the Association Between Greenhouse Gas Emissions and Subjective Well-Being*,” analyze the hypothesis that the ecological state produces a positive association between greenhouse gas emissions and mental wellbeing. The authors examine this in the context of the countries of the European Union using a hierarchical three-level analysis on the third wave (2011–2012) of the European Quality of Life Survey for a sample of EU citizens.

The findings support their hypothesis, that individuals in all ecological states continue to treat climate change as an environmental and economic trade-off. In the end, the study calls for the emergence of action on climate change issues.

Murphy et al., in “*That’s Where Our Income Comes From*”: *Women’s Perceptions of Links Between Reproductive Struggles and Hydraulic Fracturing*,” analyses how the causes and consequences of the environmental crisis experienced globally are at the root of climate change, but also of the reproductive difficulties that she takes as a case study in her article. The author departs from the great stigmatization around reproductive difficulties, usually relegated to the private sphere, to highlight the links between toxic chemicals and reproductive difficulties—that scientific studies support often resulting in miscarriage, infertility and congenital birth defects. This is a qualitative study that seeks to understand how women living close to hydraulic fracturing operations experienced reproductive difficulties, and how they gave meaning to these experiences.

DeLorme et al., in their article “*Communicating and Understanding Ecosystem Services Assessment With Coastal Stakeholders: Obstacles and Opportunities*,” report on insights and lessons learned from stakeholder engagement, particularly focus groups, conducted during a multi-year, National Oceanic Atmospheric Administration sponsored transdisciplinary project that sought to understand the benefits of natural and nature-based features in the northern Gulf of Mexico region, through the lens of economic impacts and ecosystem services. The results show that economic impacts and ecosystem services can be challenging to communicate due to the complexity of conceptualizing and evaluating. “The paper concludes with a discussion of future research opportunities for improving Ecosystem Services Assessment oriented science and outreach.”

Neenan et al., in the article “*Time to Listen: Children’s Voice in Geoscience Education Research*,” highlight the importance of including children and young people, the future adults, in research and actions related to the social, political and educational dimensions of geoscience, as a

way of focusing and including their voices in decisions and in the readiness to face climate change effects. It is the school-age generation that will be confronted with the worst effects of climate change, such as the greater frequency and intensity of extreme weather events, scarcity of water and food, increasing pollution and toxicity in human environments and in the human food chain, as well as higher order health crises. The present generation of children and youth is growing up in the context of the need to act now and to make difficult socio-political choices, inescapable at local and national levels (in order to) to manage resources and mitigate environmental damage. This article proposes the use of Children’s Research Advisory Groups (CRAGs) to meaningfully include children and youth as co-researchers in geoscience-related research.

Fierros-González and López-Feldman in “*Farmers’ Perception of Climate Change: A Review of the Literature for Latin America*,” present a review of original research articles published between 2000 and 2020, with the objective of highlighting the status of knowledge about farmers’ perceptions and practices on adaptation to climate change in Latin America, highly vulnerable to climate change, also identify research gaps and inform future research. The authors point out, based on the revision done, that the available research is scarce (and), has been based mostly on qualitative analyses of case studies for a few countries. More research that identifies causal relationships is necessary. Data from surveys representative at national or subnational levels, as well as longitudinal data, will be very helpful to better understand farmers’ perceptions. Finally, the use of field experiments and choice experiments can complement the use of observational data.

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Citizen *Social* Science for More Integrative and Effective Climate Action: A Science-Policy Perspective

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Governments are struggling to limit global temperatures below the 2°C Paris target with existing climate change policy approaches. This is because conventional climate policies have been predominantly (inter)nationally top-down, which limits citizen agency in driving policy change and influencing citizen behavior. Here we propose elevating Citizen *Social* Science (CSS) to a new level across governments as an advanced collaborative approach of accelerating climate action and policies that moves beyond conventional citizen science and participatory approaches. Moving beyond the traditional science-policy model of the democratization of science in enabling more inclusive climate policy change, we present examples of how CSS can potentially transform citizen behavior and enable citizens to become key agents in driving climate policy change. We also discuss the barriers that could impede the implementation of CSS and offer solutions to these. In doing this, we articulate the implications of increased citizen action through CSS in moving forward the broader normative and political program of transdisciplinary and co-productive climate change research and policy.

Keywords: Citizen *Social* Science, climate policy and governance, science-policy, citizen agency and behavior, co-production and co-learning

INTRODUCTION

This paper examines why current forms of climate policy are not working and offers some suggestions as to how to further increase citizen engagement in science and policy decisions at different scales of governance that move beyond tokenistic forms of citizen participation. We offer a framework for what we call “citizen social science” (CSS), highlighting the various social, political and institutional barriers that prevent greater citizen participation in climate science and policy decisions. We then present some suggestions as to how CSS can potentially be used to overcome these barriers to enable citizens to contribute more effectively and directly to ambitious formal climate policy goals.

CITIZEN PARTICIPATORY ISSUES WITH CURRENT FORMS OF CLIMATE POLICY-MAKING

National governments make top-down climate policy decisions that often involve little input from lay citizens. Consequently, when it is time for a policy to be implemented there can be public resistance to it or lack of uptake. The challenge, therefore, is not only to make climate policy more robust, but to also further democratize citizen involvement in policy formulation to increase uptake. There have been repeated calls for increased citizen engagement, understanding individual behavior, and greater channels of communication between different stakeholders in both scientific and policy discourses related to climate change that move beyond mere public acceptance of the physical evidence of climate change (Lassen et al., 2011; Beniston, 2013; Schweizer et al., 2013; Swart et al., 2014; Sörqvist, 2016; Carvalho et al., 2017; Sprain and Reinig, 2018). It is never more imperative that the forms and structures of citizen engagement in climate science and policy decisions remain central to climate action given that the Paris Agreement will afford non-state actors (e.g., private and third sector groups) more influence in formal policy implementation (Van Asselt, 2016; Kuyper et al., 2018). The latest Intergovernmental Panel on Climate Change (IPCC) Special Report (Global Warming of 1.5°C an IPCC special report on the impacts of global warming¹ of, 3) has emphasized how the “strengthening of capacities for climate action of national and sub-national authorities, civil society, the private sector, Indigenous peoples and local communities” is key to achieving ambitious climate policy goals that will limit warming below 1.5°C by 2100. But citizens and institutions must act together, now.

However, democratically legitimizing increased citizen engagement within current institutional structures is complex given how such structures demarcate lay citizens from scientific experts and/or government (Miller and Rose, 2017). Even polycentric climate governance systems that are supposed to incorporate private and third sector groups into policy decisions suffer from orchestration from particular government (state) actors, resulting in systematic governance experimentation and learning being stifled (Abbott, 2017). Furthermore, communication practices often exist between citizens, scientific experts and/or government that constrain increased citizen engagement in climate change policy formulation and implementation (Carvalho et al., 2017). Hence, the governance crisis of the sustainability paradigm continues (Peters, 2017), where states continue to dominate the international political discourse of climate change through particular modes of governmentality and sovereignty (Kythreotis, 2012; Bäckstrand and Lövbrand, 2016), ostracizing citizens within the climate policy process and thus delimiting greater citizen participation in helping achieving ambitious climate policy goals made by formal policy actors like the state.

Increased lay citizen participation in climate science and policy decisions can limit the influence of institutional expertise in democratic spaces that often do not speak for the majority of citizens (Sprain and Reinig, 2018). Given the limitations in citizen science translating to effective climate action (Groulx et al., 2017), we argue that increased public engagement in the “politics of science” (Jasanoff, 2003) and what we call the “politics of policy” (how policy is politicized by governments) can help protect against public misinformation on climate change, prevent particular forms of epistemic expertise dominating climate science-policy decisions, producing more transparently public-engaged climate politics and policy. In this sense, citizens can become active agents of policy change through their actions, rather than being just part of a wider normative political participatory process dominated by state policy discourses that have predominantly politicized climate science and policy (Lövbrand et al., 2015; Bäckstrand and Lövbrand, 2016).

The Paris Agreement aims for an ambitious and transformational era of international climate change policy (Kinley, 2017). However, limiting global temperatures to below 2°C by 2100 is governed by techno-managerial language and policy responses to fossil fuel derived energy production (Hoffert et al., 2002; Hoffmann, 2011) rather than identifying lay peoples’ concerns, values and goals for their communities. Framing the climate problem in this more personal way can promote more transformational engagement and ownership in climate decision-making (Nisbet, 2009; Leach et al., 2010), especially given that some research has shown how non-specialists find it difficult to understand how physical climate risks can impact their lives (Pidgeon and Fischhoff, 2011). Failure to consider citizens’ concerns undermines the legitimacy of formal climate policy decisions, limiting the ability of citizens to play a more influential role in instigating policy change through citizen action. Interdisciplinary co-produced research is needed between citizens, scientists and policymakers to span knowledge and spatial boundaries through wider citizen engagement and to produce research that speaks to its end users (Lemos et al., 2012; Kirchhoff et al., 2013; Turnhout et al., 2016; Editorial, 2018; Howarth et al., 2018). Yet, co-production has multiple meanings (Bremer and Meisch, 2017). However, for citizens to have more influential participation, they need to understand how the current science-policy process works with respect to the roles of research and policy actors. This could enable pro-environmental decisions, behavior and actions that complement the science-policy process. With support from other state and non-state institutions, we argue that citizens can become transformative agents of social and policy change with respect to climate change through CSS.

New citizen-centered solutions are needed in climate politics for triggering deliberate social transformations and for providing a deeper inquiry into the structures and processes within society and science (O’Brien, 2012). Such solutions should be based upon social assemblages (Gillard et al., 2016) and citizen agency (Dodman and Mitlin, 2013), rather than overreliance on governments to catalyze transformational change. The withdrawal of the Trump administration from the Paris Agreement in June 2017 has demonstrated how individual

¹ Available at: https://www.ipcc.ch/pdf/special-reports/sr15/sr15_headline_statements.pdf (Accessed Oct 16, 2018).

nation states still hold the balance of power in determining policy outcomes for climate change (Kythreotis, 2015). Societal transformations can be addressed to some extent by “polycentric” governance where non-state actors support global policy-making by working across policy scales to redress the limitations of single scale (e.g., solely national) policies. However, national and international climate politics continues to play a dominant role in the polycentric governance systems and research has only just begun to distinguish between different types of climate governance, rather than assessing their effectiveness in complementing or replacing top-down, government dominated policy-making (Jordan et al., 2015). This all points to a need for increased citizen engagement to act as a further check and balance to formal climate policy decisions that are made in particular spaces dominated by epistemic actors like the state, scientists or even the market (e.g., fossil fuel companies). This certainly will produce a more reflexive “knowledge politics” on climate change that can help circumvent uneven spaces of climate decision-making (Mahony and Hulme, 2018).

ELEVATING CITIZEN ENGAGEMENT

Whilst there is some evidence of successful government- and market-led policy transitions toward cleaner energy and lower emissions (e.g., Obama, 2017), many citizens are left out of this process highlighting an urgent need to engage citizens more closely with framing the climate and energy debate, in addition to concentrating on private sector transitions through market forces that then shape government policy. Rather than thinking about possible economically sympathetic policy solutions for climate change originating from governments, policy-makers and/or even the market, the citizen has to take a more active social role in driving policy change and implementation for both mitigation (e.g., energy use) and adaptation (coping with climate impacts). However, doing this successfully requires greater interaction between climate researchers and citizens. This involves developing ways in which the everyday citizen can understand the way in which climate policy is constructed within and by governments through the traditional science-policy model where truth (e.g., science) speaks to power (e.g., policy choice) (Jasanoff and Wynne, 1998). Enlightening the citizen to how climate research is conducted (and why) firstly gives them an ideal platform from which to react to and then drive new government policies that could meet the speed of transitional change needed to limit global temperatures and avoid dangerous climate impacts. For example, research on climate adaptation has shown the importance of joint-problem framing and knowledge production, especially in contexts where scientific knowledge—whether social, economic, political or environmental—is limited or scarce (Swart et al., 2014; Hugel et al., 2015).

Although increased citizen engagement with climate research is not a full alternative to top-down political agreements or technological change, it can certainly catalyze the speed and ambition of the technological, social, political and economic changes required to meet collective climate commitments regarding mitigation *and* adaptation. Policy-makers and

scientists have a duty to create local spaces where citizens can more fully participate further in related climate decision-making processes as a form of power brokerage (Pielke, 2007; Howarth et al., 2018). Yet, communicating climate research and policy to the general public has many challenges (Hollin and Pearce, 2015; Bernauer and McGrath, 2016). It is possible to perceive climate information without any values affecting it (i.e., bias is always there) (Corner et al., 2012). Greater citizen involvement in climate decisions within the more science-policy process could help ameliorate climate misinformation dominating political discourses on climate change. Recent research has shown how key scientific experts have a central role in utilizing knowledge networks within the formal science-policy process to catalyze climate adaptation action (Kettle et al., 2017), so by making their role more open to the everyday citizen, climate scientists (experts) can augment greater co-production practices between citizens, scientists and government policy-makers.

More integrative and effective climate action and policy can come about when citizens and the public are fully cognizant of the implications of their actions and behavior toward their (local) environment when presented with how both the science on climate change is generated by experts and used by policy-makers. This reduces miscommunication and confusion of climate science and creates the conditions where the relationship between citizen behavior, science and policies are fully transparent. This could trigger an inclination of citizens, scientists and policy-makers to want to foster integrative change rather than the current often benign, top-down and apolitical reactions to climate policy change as merely a government/state responsibility. Citizens can then act as political agents of change by increasing pressure on their elected representatives to help enable such policy change at higher state levels, rather than citizens just being used by policy-makers through tokenistic consultation (Carvalho et al., 2016).

CITIZEN SOCIAL SCIENCE: MOVING BEYOND CITIZEN SCIENCE

Citizen Science (CS) as a methodological tool for understanding large scale processes has burgeoned, arguably as a reaction to the use of particular forms of epistemic expertise that have traditionally and unilaterally contributed to policy decisions (Haas, 1992), rather than consideration of more diverse, but contextual knowledges and forms of social knowing (Irwin, 1995). Citizens can be utilized to obtain larger datasets that enable researchers to assist policy-making practice, democratizing expertise into more formal policy processes (Fischer, 1993). To December 2018 there are 57 active and searchable CS projects related to climate change that are listed on the Scistarter website (Scistarter, 2018). All of these projects involve citizens observing and collecting data, rather than formulating the CS research methods, analyzing and interpreting the data as a means to instigate climate policy action. By acting as volunteers, citizens are important for data collection to inform climate research (Bonney et al., 2014; Lahoz and Schneider, 2014) as a means to understand trends, causes, impacts, and responses to, climate

change (Savo et al., 2016). Climate research, however, requires complex tools, such as models, remote sensing, and ice core and soil analyses to better inform broader policy, and such skills are often beyond the capabilities of lay citizens. Broader policy actors have attempted to further engage citizens more. For example, the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat through collective nations, have recognized the potential of CS and have assisted in initiating and implementing large citizen consultations on climate change (Bedsted et al., 2015). However, there is also a need to engender links between local policy actors and the communities they serve, particularly with respect to climate adaptation (Vogel and Henstra, 2015). So, a question remains whether CS could be used more effectively to further engage different citizens and communities for more tailored local climate policy beyond crowdsourcing to obtain large(r) data sets? There is evidence of governments and municipalities working better to *include* traditional and local knowledge into their governance systems (Leonard et al., 2013) but more work is needed to further integrate citizen action and climate policy-making.

CS has also been traditionally classified into various types, the most relevant for this paper being Haklay's distinction below in **Table 1** between: crowdsourcing (level 1), distributed intelligence (level 2), participatory science (level 3) and extreme CS (level 4) (Sui et al., 2013). Haklay's distinctions show CS as a collaborative and participatory framework that enables citizens to assist in big data collection for scientific purposes. CS therefore, has many advantages for climate mitigation and adaptation practice and policy (Larsen and Gunnarsson-Östling, 2009; Ford et al., 2016b). Yet we argue for a new platform (see level 5) whereby citizens have increased influence within conventional science-policy and participatory frameworks in shaping climate policy, alongside the necessary technical (e.g., negative emissions technology) and policy (a shift from the 'green growth' paradigm) changes that are required (Anderson, 2015).

Though the term "citizen social science" has been previously used in the literature (Purdam, 2014), the way in which it has been explained has remained confined within the paradigm of using CS to create large data sets for policy-making. We define CSS further as representing new methodological and theoretical territory that resonates with more diverse and heterogeneous forms of social knowing, values and cultures of citizens beyond CS (Castree et al., 2014). While CS uses citizens as policy passive objects for research in conducting measurements for big data sets, our proposed CSS framework makes citizens co-learners within the research process by actively enabling them to explore transformatively changing institutionalized research and policy systems. CSS embraces the principles of a "Two-Eyed Seeing" approach in an Indigenous and scientific knowledge systems context; where a co-learning journey (where citizens take a lead, often over government/policymakers, in making decisions about how best to formulate policy) is encouraged for more transdisciplinary research and to bring together different ways of knowing (Bartlett et al., 2012). One way of differentiating CSS from CS is therefore to consider this "two-eyed seeing" approach that repositions citizens as central co-learners that can widen the climate science evidence-base to a more holistic understanding of

perspectives for the benefit of all. Recent research has illustrated how blending scientific and traditional knowledges through citizen co-learning highlighted key environmental stressors under uncertainty (Mantyka-Pringle et al., 2017). Hence, this demonstrates the difference between citizens getting involved in public engagement exercises within formal policy processes and apparatus, and citizens being catalysts and drivers of climate policy transformation. With public engagement, participants often work within pre-conceived state ideas and traditional governance structures that are institutionally entrenched in top-down power dynamics (e.g., a particular policy standpoint based on ideology) (Morrison et al., 2017) designed to protect the political economy status-quo. Co-production or co-learning through CSS moves beyond conventional public engagement and makes the citizens initiate action and policy responses based on their specific forms of social knowing and values. This organic form of bottom-up collaborative knowledge-making can help to eliminate any cultural issues and insensitivities that may emerge upscale when formulating policies. It can also catalyze transformative change through the eyes of everyday citizens by allowing them to be exposed to climate policy decisions that they would not normally be involved or interested in. Therefore, CSS is underpinned by multiple disciplines and methods of co-production enabling citizens to make more context specific, transparent and explicit contribution to climate policy-making and action.

BARRIERS AND (POTENTIAL) SOLUTIONS TO IMPLEMENTING CSS

While we argue that implementing CSS at a larger scale is key for achieving Paris climate commitments, there are a number of barriers to successfully implementing CSS effectively. The following is a suggested approach to begin dealing with such barriers. Working toward more integrative and effective climate change solutions between citizens and policy-makers involves developing a profound understanding of the complex interactions between those different actors with the physical, social, economic and political world that leads to decisional conflict and policy inertia over climate change. This requires changing the "decision environment" as a means to circumvent or at least ameliorate some of these institutionalized barriers (Howden et al., 2007).

Reframing the Climate Change Problem

Most citizens often feel disengaged and unable to influence policy, including climate change policy, or to significantly change their lifestyles to tackle climate change for a range of institutional, social and psychological reasons (Hoppner and Whitmarsh, 2010). As a collective problem, climate change can feel overwhelming and individuals lack self-efficacy to act (Koletsou and Mancy, 2012). Prevailing social norms to consume and lack of trust in governments or other people to take action also erodes motivation to act (Whitmarsh et al., 2010). For many, climate change (policy) also threatens assumptions about quality of life, fairness, progress and individual freedom,

TABLE 1 | Levels of participation and engagement (adapted from Sui et al., 2013).

Increasing levels of citizen participation and engagement ↑	(Level 5)	“Citizen Social Science”	<ul style="list-style-type: none"> • Citizens as key agents of research, action AND policy change at ALL levels of engagement and scales of the decision-making process
	Level 4	“Extreme Citizen Science”	<ul style="list-style-type: none"> • Collaborative science–problem definition, data collection and analysis
	Level 3	“Participatory Science”	<ul style="list-style-type: none"> • Participation in problem definition and data collection
	Level 2	“Distributed Intelligence”	<ul style="list-style-type: none"> • Citizens as basic interpreters • Volunteered thinking
	Level 1	“Crowdsourcing”	<ul style="list-style-type: none"> • Citizens as sensors • Volunteered computing

leading to political and ideological division in responding to the issue. However, citizen engagement in policy and behavioral change is more likely to occur if issues are framed around audience values and more local and tangible concerns; and if individuals believe their actions make a difference (Whitmarsh et al., 2010). For example, at the individual level, giving people feedback on their energy use via energy displays can encourage energy conservation behavior (Darby, 2006); while acting as an organization, community or city can give people a sense of collective efficacy to address global problems like climate change (Sweetman and Whitmarsh, 2016). Framing climate change as a local issue may help engage individual citizens if they feel a sense of place attachment (Devine-Wright, 2013), although this might also undermine the perceived severity of the issue (Brügger et al., 2015). Framing climate change in terms of impacts and adaptation is less likely to threaten citizens (including those on the right-of-center) than mitigation messages, which tend to imply individual sacrifice (e.g., reducing energy use Howell et al., 2016; while other frames (e.g., reducing waste) and focusing on co-benefits of action (e.g., health, social cohesion) may also be more engaging across the political spectrum (Whitmarsh and Corner, 2017).

Reframing the problem also requires a need to reconsider the role of gender and cultural equality. Climate change is more likely to adversely impact Indigenous people and women due to their increased vulnerability (IPCC, 2014; Halton, 2018). For instance, we know that climate change is having disproportionate effects on the human health of Indigenous people globally (Green et al., 2009; Ford et al., 2010). Calls have also been made for better representation of Indigenous knowledge and Indigenous issues in IPCC assessments and other global climate policy (Mantyka-Pringle et al., 2015; Ford et al., 2016a,c). There are obvious gender differences in environmental concerns and attitudes and impacts (McCright, 2010), particularly in developing countries. For example, two-thirds of the female labor force dependent on agricultural work in developing countries are adversely affected by poor harvest, which leads to food, income and health security issues (UN WomenWatch Women, 2018). To address the current imbalances, more cultural and gender sensitive responses are required to create the social and political conditions needed to address climate-related problems. The most obvious way to catalyze equality is by creating scientific and policy pathways that enable increased involvement of Indigenous people and women in the science-policy realm. This needs to be addressed from the local to international scale (Gay-Antaki and Liverman, 2018). The values innate to CSS promotes gender and cultural

equality in climate change by providing an inclusive and integrative framework by which women and Indigenous people are supported to engage with climate research, policy and taking relevant action. However, there needs to be a degree of top-down support from the science-policy realm to normalize such local gender and cultural equality in climate decisions through CSS. If scientific and policy expert communities do not reflect on gender and cultural imbalances, then how would we expect women and Indigenous citizens to take a lead on climate action in their own communities through CSS? If this two-way process is facilitated, financially supported, and mainstreamed then there would be a greater chance of women and Indigenous citizens being more empowered to transformatively act on their own behalf through CSS (Alston, 2014).

Transformative responses through CSS do not assume a particular scientific approach and therefore must begin with a discussion of participants’ values, based on their moral, aesthetic, experiential, spiritual knowledge concerns and aspirations rather than policy being solely foisted upon citizens in a top-down way. Yet there must be a heterogeneity of climate responses from all areas of society–governments, scientists and citizens who have been previously apathetic to climate change. This process leads to a recognition that there are communal values held by citizens that can serve as a bridge toward an overarching global climate policy goal, like the 2°C Paris target. Discussions about fears and hopes for the future can provide a “lens” through which to discuss climate change research and to explore different narratives and pathways for public engagement that move beyond current techno-managerial and gender imbalanced science-policy approaches.

Conflicts of Interest

Whilst we recognize that conflicts of interest will endure between different stakeholders in making appropriate climate decisions, it is nevertheless omnipresent in the current climate science-policy process. There are a number of existing groups of citizens with conflicts of interest related to climate change science. The most obvious are climate deniers and citizens that benefit from or are dependent on the fossil fuel industry for their livelihood. It is possible that these groups may choose to be involved in CSS to impose their views or advance their standpoint to reaching their political objectives such as undermining or misrepresenting the science behind climate change (Editorial, 2015). In the application of CS, it has been reported that there remain limitations in CS enabling local climate actions (Groulx

et al., 2017). These types of conflicts of interest may also be experienced in CSS and need to be taken into account or at the very least acknowledged so that the process will not be skewed in favor of one standpoint, and therefore remain representative. However, we are cognizant that any policy decisions should not be taken on the basis of the equal representation of all views (as some views are obviously extreme in ideology, anarchic and/or reject observed scientific facts) but on the basis of the scientific knowledge which solves or mitigates the real problem.

Less obvious conflicts of interest also exist in some cultural contexts (e.g., different ways of understanding and valuing the environment), inequality (e.g., class) and ethno-national diversity conflicts (e.g., land ownership conflicts with Indigenous vs. non-Indigenous groups). A potential solution is to ensure that there is a representative sample of the population in the process and citizens' backgrounds are respectfully vetted beforehand. Where there are conflicts of interest between people, the process of CSS acts as a mediation channel to bridge polarized views through a common purpose. It enables new narratives to be explored as different viewpoints are represented and considered within the co-production environment.

CSS Cannot be Implemented as a “One Size Fits All” Knowledge Framework

We are cognizant that CSS can only work if the knowledge domain of citizens is germane to their everyday life. For example, rural farmers should not find themselves working or co-researching on urban transport issues and urban citizens should not find themselves working on agricultural issues unless they hold *real* knowledge in that area to enable more effective action and policy. Apart from the intimate knowledge that some citizens have with their natural surroundings (e.g., Indigenous traditional knowledge), much of modern life involves epistemic dependence on trained experts. The limits of lay knowledge (and particularly lay expertise) in matters of climate change are therefore restricted (Dunlap and McCright, 2015). Low carbon housing and civil engineering projects are classic examples because the majority of citizens are users of pre-made structures they could not design without being trained in engineering science. So there is a caveat about how far CSS can extend in a “rule of experts” context. The uniqueness of the CSS framework is within the way in which infrastructure is used through our behavioral patterns, which is predicated upon how citizens make sense of different forms of knowledges to inform their actions as a means to make real transformative change. Greater government acceptance of citizen potential is needed to quell those hidden assumptions of people not mattering, or not being educated enough to make informed decisions. CSS can expose and ameliorate these hidden assumptions. This is where allying of citizens with knowledge-brokers plays a significant role. The Climate Knowledge Brokers Group (Climate Knowledge Brokers, 2017) is an excellent example of how citizens can get further involved in understanding the causes and consequences of climatic change and to create a focal point for diverse citizen voices to be heard regarding climate change. In this sense

there is a need to move beyond scientists merely having to consider the types of idealized roles they have to play in public policy and politics beyond the science-policy process (Pielke, 2007). Scientists and experts have to consider what role they can play in more openly engaging with citizens as a means to help citizens determine the types of knowledge that can inform policy decisions made by government (and vice versa). This will then more democratically legitimize citizen involvement in policy-making by placing citizens at the center of new policy formulations, rather than politicizing the role of science and scientists in public policy and politics.

Uneven Power Relationships

Making citizens more central within the science-policy process is inevitably constrained by pre-existing uneven power relationships between politicians and citizens, scientists and citizens, and scientists and politicians. These silo relationships are often defined through different vested interests, rigid funding and reporting structures, lack of communication skills among researchers and their (subconscious) beliefs about the lack of skills and critical awareness of “the masses” (Burgess et al., 2017). The barriers to greater citizen involvement because of lack of voice, visibility or opportunity are often formidable and there needs to be more active integration between lay citizens, climate researchers and policy-makers. Currently, important political arenas for climate policy decisions like UNFCCC Conference of the Parties have been dominated by national governments and closed-off to the lay citizen. While lay citizens often (rightfully) demonstrate at such climate negotiations, there remains a physical and political barrier between where state-led political decisions are made and the equitable and just contribution that citizens should make to the climate change political process, as recent research on the Paris Conference of the Parties has shown (Weisser and Müller-Mahn, 2016).

Uneven power relationships also exist between scientists and citizens. Scientists are constrained by how they can approach their research methodology and data collection based on rigid reporting structures of their institutions and funding bodies. Although research bodies such as Research Councils UK and the National Science Foundation (US) now require research projects to demonstrate the impact of their work to beneficiaries outside of academia (RCUK, 2014; NSF, 2018) and data/publications of their research as Open Access (NSF, 2015; RCUK, 2017), there are no specific requirements to involve citizens directly in the co-production of research (even though we are cognizant that more theoretical science may not require co-production research with citizens). However, climate research certainly does given that the anthropogenic climate change problem can be reduced to human behavior (Karl and Trenberth, 2003). Additionally, scientists' biases have been demonstrated in citizen science projects where certain data sources are favored over others (e.g., based on the background/education level of the data collectors). This suggests a belief that citizens do not possess the necessary knowledge or data collection skills to perform robust science to the standards of scientific “experts” (Burgess et al., 2017).

There are also uneven power relationships between scientists and governments. Notwithstanding the systemic problem of

not enough research professionals and academics being able to work with government regardless of discipline to engender evidence-based policy (Lawrence et al., 2016), with respect to climate change research, many of the broader science-policy arenas in which scientists can contribute to climate action and/or policy-making (albeit in a policy-neutral way) like in the IPCC Assessment Reports, continues to be tainted with a “closed club” syndrome for many academics (Shackley, 1997; Hulme and Mahony, 2010), a pronounced gender imbalance in IPCC membership (Gay-Antaki and Liverman, 2018), and scientist contributions to Summary for Policy-makers (SPM) reports have to go through a final review of government approval of the SPM line (IPCC, 2015). Equally important, certain academics continue to be ostracized in IPCC decisions and processes where the impacts of climate change are felt most (e.g., developing countries) leading to a science-policy information deficit and institutionalized epistemic communities, even though there have been attempts to make the IPCC more “user-friendly” (Petersen et al., 2015; Corbera et al., 2016).

More resources and institutional support are essential to help engage citizens in bottom-up processes that complement and inspire change through existing research and political institutions. CSS needs to be achieved through strategies targeted to different value systems that are not typically related to climate change like biospheric ones (Howell and Allen, 2017). This will have positive economic and social spillover effects beyond environmental benefits, especially in vulnerable communities (e.g., added skills and cash incentives). Governments stand to gain from increased citizen engagement in research in times of austerity (Dickinson et al., 2012) and the private sector can enhance their corporate social responsibility by supporting employees in CSS projects. There is a need to move climate research toward a more collaborative role in which it is co-produced by citizens, industry, decision-makers and scientists so that the research has stronger outreach and generates more effective policies (Pearce et al., 2009). But which sectors are best placed to catalyze CSS projects? The public, private and/or third sectors? A possible starting point we argue is that maybe universities are best placed to initiate and facilitate such CSS projects. They are not so much impartial as designed, in principle, to serve the interests of publics. Rather, they provide a range of knowledge and invention that pluralizes options and speaks to an array of cognitive, moral, aesthetic and spiritual positions existing in the world. Research has shown that those with a higher education share more cultural commonalities over global climate change (Crona et al., 2013). Whilst we are aware of the new instrumentalism in universities linked to business and government control, we feel universities could be best placed to initiate and facilitate CSS in comparison to the private, public and/or third sectors.

Differences Across and Within Countries (scale)

The deployment of CSS will face varied challenges across different countries and within the scalar jurisdictions of each

country. CSS is plausibly easier to deploy in democratic political systems that have a commitment and track record of fostering public participation in environmental and other areas of decision-making. For example, commitments to broad principles supporting the CSS deployment have been made under the Aarhus Convention of 1998 and in the European Union Directives on Public Participation (2003/35/EC) and Access to Environmental Information (2003/4/EC) as well as many other more specific directives such as the Water Framework Directive (2000/60/EC). However, the prospects of CSS deployment are less obvious in non-democratic countries where political leadership is not representative or accountable, public participation is not legitimate or encouraged, and where political freedoms are curtailed, and civil society organizations do not welcome freedom of speech.

There are also challenges for CSS within countries at different scalar jurisdictions depending on the system of government and the various powers attributed to government at different jurisdictional scales. Levels of political autonomy and a willingness to embrace more networked and polycentric governance with respect to climate change can result in a failure of knowledge upscaling if citizens are not equipped to deal with the “politics of scale.” This especially comes into play when citizens with only their local experience(s) are asked to speak as “researchers” on national or global issues. But CSS would not exclude these diverse knowledges, but rather warn cautiousness during implementation and acknowledge that there are caveats about how far CSS can extend in a “rule of experts” context across different spatial jurisdictions. This has been acknowledged in the literature regarding the problems of political power and scale when trying to implement more networked forms of climate governance (Morrison et al., 2017) through social knowing.

One possible solution is to give local citizens greater participatory influence in local processes of governance and policy-making and forming stronger links between communities and local policy-makers. For making local climate decisions, one example could be to employ an opinion poll company to choose the citizens to participate in local consultation processes, much like is done with citizen juries. By providing selected citizens with knowledge on climate research and how policy is constructed, citizens become more actively engaged in policy and can deliberate the type of policies to be utilized by local/national governments through “mini publics.” This has proved successful in Ireland, where a nationwide exercise in deliberative democracy demonstrated that citizens with limited initial knowledge become “enlightened” (Suiter et al., 2016) and more likely to change their minds on salient issues based on the best available evidence. Other novel ways of eliciting public opinion and engaging them include citizen awards/incentives for new ideas that promote climate action within the community, and citizen draws that allow citizens time off work to volunteer in local and state council meetings related to climate change (similar to jury duty, but without the legal powers). With citizens enjoying a more central role in helping to determine formal policy, government still has an important enabling role to play by investing more in financial and human resources. This can then more clearly align the roles that citizens and government authorities play

in the policy process, promoting a more transparent bottom-up approach to climate-related co-planning issues (Mees et al., 2017). This further bridges the gap between how climate change is governed by citizens, governments and the market across international, national and local jurisdictions. Particularly at the local scale though, CSS could provide more active engagement by bringing citizens into the pre-consultation phase during policy development, rather than citizens just being used in a tokenistic way within the initial stages of policy planning by governments.

CONCLUSION

This paper has examined how CSS can offer a fruitful way of contributing to more integrative and effective climate action and policy that moves beyond the traditional science-policy model. We have discussed a framework for CSS followed by potential barriers and solutions. With respect to the barriers mentioned above, a sub-set of citizens and policy-makers across the board will have to work hard to create arenas where existing power asymmetries can be suspended through institutions, venues and gatherings that permit a rough “communicative equality.”

We argue that the barriers to CSS are not insurmountable and CSS can truly catalyze transformative change if citizens and policy-makers can become more aligned through processes of social knowing, especially at the local scale. By breaking down the tension between expertise and lay knowledge, experts and citizens can collaboratively explore alternative social contexts outside of

traditional science (Blue, 2015). This could then catalyze the co-production of alternative policies between citizens, scientists and policy-makers that address emerging climate issues in specific communities. Bridging citizens, scientists and governments through a CSS narrative framework that increases recognition of human qualities and needs would help reconfigure formal climate policy-making through the democratic systems already in place. Taking this transformative pathway places greater responsibility for tackling climate change in the hands of citizens, consistent with the principles of democratic governance and democratic legitimacy. However, governments, the private sector, the IPCC, and the UNFCCC still have critically important roles in helping facilitate this citizen transformation.

AUTHOR CONTRIBUTIONS

AK initiated the core idea of citizen social science and led in writing the paper with extensive development and input from CM-P, TM, NC, LW, AC, JP, CC, and BM. All authors contributed to the theoretical and conceptual development of the paper.

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Risk Inequality and the Food-Energy-Water (FEW) Nexus: A Study of 43 City Adaptation Plans

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Goals aimed at adapting to climate change in sustainable and just ways are embedded in global agreements such as the Sustainable Development Goals and the New Urban Agenda. However, largely unexamined, are the ways that narrative understandings conveyed in adaptation plans consider and attempt to address inequality in climate risk to urban populations and FEW-systems. In this paper, we examine whether and how adaptation plans from C40 member cities address inequality in risk, by planning actions to reduce hazard exposure or tackling the drivers of social vulnerability. C40 is a network of 94 of the world's cities fostering policies to address climate change. We apply a mixed methods approach, including a discourse analysis and meta-analysis of adaptation plans. The discourse analysis helps to unpack framings of urban equity issues as they relate to policy actions, and the meta-analysis seeks to quantitatively investigate patterns of framing and policy across adaptation plans. Our findings suggest that FEW-nexus thinking is not yet embedded in narrative understandings of risk and planned adaptation actions, within the adaptation plans we studied. In the city adaptation plans we analyzed, we found multiple frames coexisting behind the broader adaptation visions (e.g., risk and resilience). Rather than converging, issues, and principles such as those of equality, coexist with economic issues in an imbalance of incongruent political movements and priorities. Techno-infrastructure and economic investments and concerns tend to take precedence over concerns and interests for inequality in climate risks. We discuss some of the institutional factors explaining this. Knowledge integration, for instance, is constrained by the existence of a plurality of sectors, levels of government, power, values, and ways of understanding and managing climate risk. We also suggest that the relatively low importance of equality considerations in the adaptation plans will likely limit the capacity of cities to support broader goals such as those of the New Urban Agenda and the Sustainable Development Goals.

Keywords: inequality, FEW nexus, urban adaptation, discourse analysis, meta-analysis, urban climate governance

INTRODUCTION

Goals aimed at adapting to climate change in sustainable and just ways are embedded in global agreements such as the Paris Agreement, Sustainable Development Goals and the New Urban Agenda. These agreements seek to move environmental and climate concerns into the urban policy action arena by developing strategies for risk management. Ideally, these strategies would be supported by the three pillars of sustainability (economy, equality, and environment), while increasing cities' resilience to chronic and acute physical, social, and economic stressors and hazards (Zeemering, 2009; Campbell, 2013; Romero-Lankao et al., 2016a; Simon et al., 2016). However, in practice, tradeoffs are often present that shrink the size one pillar and augment another.

In the last decade, scholars and decisionmakers have shown increased interest in the mechanisms by which urbanization and climate change are coevolving to compound the unequal risk of floods, wildfires, and other hazards to urban populations and their supporting food, energy, and water (FEW) systems. However, actions to improve equality on the ground have been less evident (Revi et al., 2014; Romero-Lankao et al., 2017c). Incorporation of equality into urban adaptation plans is important because the most vulnerable communities within cities, most often are more exposed, have lower socio-economic status, make lower contribution to GHG emissions, and have lower levels of access to FEW systems, and livelihood options to mitigate risk and adapt (Boone, 2010; Hughes, 2013; Agyeman et al., 2016; Romero-Lankao et al., 2016a; Shi et al., 2016; Reckien and Lwasa, 2017).

It is widely accepted, in the literature of social vulnerability, that social inequality shapes differences in climate risk and vulnerability and in capacity to mitigate and adapt to these hazards (Ribot, 2010; Romero-Lankao et al., 2016a). However, largely unexamined, are the ways in which different narrative understandings relate to suggested actions in existing adaptation plans. In this paper, we examine whether and how adaptation plans from 43 C40 cities address inequality in risk, by planning ways to reduce inequality in hazard exposure or tackling the drivers of social vulnerability (Reckien and Lwasa, 2017). We apply a mixed methods approach, including a discourse analysis and meta-analysis of adaptation plans for 43 C40 cities (**Figure 1** and **Supplemental Table 1A**). In this approach, the discourse analysis helps unpack framings of urban equality issues as they relate to policy actions, and the meta-analysis seeks to quantitatively investigate patterns of framing and policy across adaptation plans.

TRACING EXISTING SCHOLARSHIP

Three areas of scholarship, relevant to this paper, include urban adaptation, and governance, inequality in climate risk, and the food, energy, and water (FEW) nexus (Leck et al., 2015; Araos et al., 2016; Shi et al., 2016; Romero-Lankao et al., 2017c; Wiegand and Bruns, 2018; Heikkinen et al., 2019). We use findings in these areas as a basis to suggest a conceptual framework (section Conceptual Framework), which

will be used to map attention given, in urban adaptation plans, to FEW interactions with inequality, and thereby gain knowledge of how far these considerations have penetrated urban adaptation planning.

Urban Adaptation and Climate Governance

Having proven to be important agents of change globally, cities, and transnational networks occupy a central role in the global governance of climate change because of many reasons (Bulkeley and Betsill, 2013; Romero-Lankao et al., 2018). There is a wide acknowledgment among scholars of the incapacity of national actors alone to produce policy actions that can address the complex dynamics of climatic risk (Gordon and Johnson, 2017). Attention has shifted to the array of governance initiatives undertaken outside of interstate climate negotiations and policies. These initiatives, taken by state, municipal, market, and civil society actors operating at multiple local to global levels, are seen as key to creating the kinds of innovations necessary to address environmental change and climate risk (Acuto, 2013; Shi et al., 2015; Gordon and Johnson, 2017). In recent years, in what has been termed the second wave of urban climate governance (Bulkeley, 2010), cities have moved beyond symbolic commitment to climate change action, to its integration into their planning and development policies (Aylett, 2014). For many cities, part of this movement has included participation in local and city-networks such as ICLEI, the World Association of Major Metropolises (Metropolis) and the C40 Cities Climate Leadership Group (C40) (Bouteligier, 2013; Gordon and Johnson, 2017).

C40 is a network of 94 of the world's cities concentrating more than 650 million people and one quarter of the global economy. This peer network of cities seeks to address climate change through the design and implementation of policies seeking to mitigate greenhouse gas (GHG) emissions and climate risks (<https://www.c40.org>, February 28th, 2019). A body of literature has examined different aspects of the C40 global and city governance influence. For instance, some portray the C40 as an orchestrator of global urban climate governance steering member cities toward particular climate actions (Gordon and Johnson, 2017), or creating new inequalities and sometimes even intensifying existing ones (Bouteligier, 2013). Others analyze whether the kind of change the network promotes is incremental, reformistic, or transformational (Heikkinen et al., 2019).

In this study, we start from the assumption that member city agendas may differ from that of the C40 network (Heikkinen et al., 2019), and examine how, in their adaptation plans, city officials understand and manage inequality in climate risk to urban populations and FEW-systems.

Risk and the FEW-nexus

Studies on FEW nexus have grown recently (Endo et al., 2015). As it pertains to human food, energy, and water systems, the term nexus refers to the relationships, as defined by linkages and interdependencies, between two or more FEW resources and systems, including trade-offs and feedbacks between them (Leck et al., 2015; Romero-Lankao et al., 2017c). FEW-nexus scholarship has grown in recent years, but differences in motivation, purpose, and scope pervade the field (Stringer et al.,

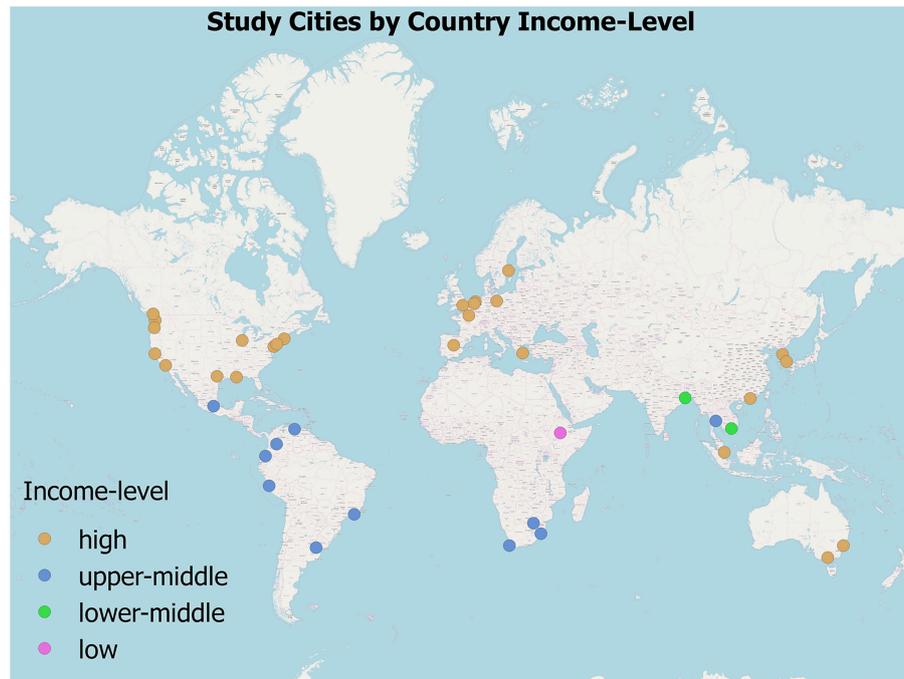


FIGURE 1 | Cities covered in the analysis of adaptation plans. Based on World Bank income category as of 1 July 2015, at the country-level. Low-income economies are those with a GNI per capita, of \$1,045 or less in 2014; middle-income economies are those with a GNI per capita of more than \$1,045 but <\$12,736; high-income economies are those with a GNI per capita of \$12,736 or more. Lower-middle-income and upper-middle-income economies are separated at a GNI per capita of \$4,125.

2018). A FEW-nexus approach can be used to analytically examine links and interdependencies between FEW-systems, but it also functions as a *boundary object* that engages decision makers and academics across a science-policy interface aimed at understanding and managing FEW-system links and interdependencies (Wiegleb and Bruns, 2018). In governance, its concepts are sometimes used to achieve integrated management across FEW sectors and jurisdictions (Bizikova et al., 2013).

Here we will examine how linkages and interdependencies between FEW-systems are acknowledged and prioritized at the city level and whether integrated FEW-management is a goal of adaptation plans. Or if, as suggested by existing scholarship, bringing together diverse policy domains creates its own set of challenges. The most important is given by the difficulties involved in moving decision makers beyond their accustomed ways of understandings and action precisely because this involves a collective engagement of disparate sectors, ways of knowing, levels of government, power, and values (Romero-Lankao et al., 2017c).

FEW-nexus studies tend to be motivated either by the scarcity of FEW resources or by threats to FEW-resource security due to development and environmental pressures (Galaitis et al., 2018). We will focus on the latter, which tends to be framed using either a security or a risk approach (Corry, 2012). In the security approach, the focus is on an existing threat such as an ongoing drought or disruption of energy or food supplies (Comfort, 2005). In the risk approach, however, the

emphasis is on how human development and environmental dynamics are interplaying (or might interplay) to create the potential for harmful events (Trombetta, 2008). While security thinking leads decision making to look for the current, direct causes of harm to urban populations and FEW-systems, risk analysis analyzes the potential causes of harm, current or future. We use a risk approach here, because it fits better with both climate change scholarship, ours included, and the framing used in 87% of the adaptation plans (Field et al., 2014; Romero-Lankao et al., 2017a) (**Figure 2**).

Within our sample, we look at how adaptation plans address inequality in risk. Following the IPCC, we define risk as the potential for adverse effects on lives, livelihoods, health, and assets (Field et al., 2014). Risk may spring from exposure to floods, sea level rise, and other threats and vulnerability of people and the FEW-systems that support them. Such vulnerability, or the propensity to be negatively affected by events or impacts, results from the multiscale interplay of factors in five domains: Socio-demographic, Economic, Techno-infrastructure, Environmental, and Governance (SETEG), which have been used by Arup and by us in prior work (Arup, 2014; Romero-Lankao and Gnatz, 2016). While people can be susceptible to hazards, they also have capacity and agency to modify their circumstances and behavior to mitigate risks or adapt. Capacity is the unequally distributed pool of resources, assets, and options governmental, private, and non-governmental actors can draw on to mitigate and adapt

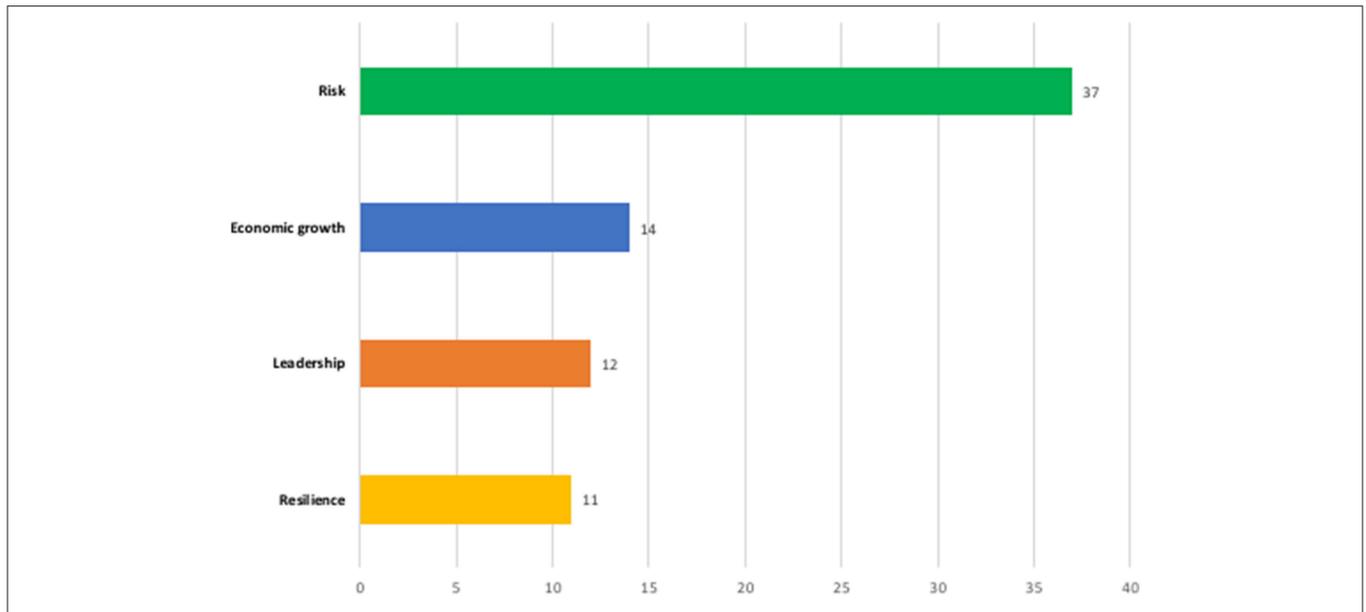


FIGURE 2 | Framing the adaptation vision. After reading and summarizing each adaptation plan, four notions capturing cities' broader frame or vision were identified. See **Supplemental Table 1B**.

to risks, while pursuing their development goals and values (Vincent, 2007).

To understand how policymakers are prioritizing these issues, we examine how in their adaptation plans, city officials attribute climate risk to a series of locational and SETEG factors, and what policy actions they suggest to manage these (section Study Design).

Urban Adaptation, Inequality, and Equality

For centuries, the notions of inequality, equality, and justice have been the subject of compelling philosophical, conceptual, and ethical debates, with persistent disagreements in definition, scope and policy implications whose discussion is beyond the scope of this paper (Ikeme, 2003; Agyeman et al., 2016).

The concepts of fairness and justice can be related to discussions of the differences in definitions of equal and equitable. The word justice comes from the Latin *jus*, meaning right or law, and refers to either an actual or ideal situation in which: (a) benefits and burdens in society are distributed according to a set of allocation principles where the basic rights and needs of individuals and groups are considered and respected (distributive element); (b) the rules and regulations that govern decision making preserve basic rights, liberties, and entitlements of individuals, groups, or communities (procedural element); and human and other biological beings are treated with respect and dignity by all parties involved (interactional element) (Jost and Kay, 2010). Likewise, equality, which we use here in its opposite, conveys an ideal state of perfectly balanced or even distribution of goods and services across populations, while equitable can allow an element of self-determination. In a neo-liberal conception, as long as each member or group has an equal chance to obtain access to resources and options, a distribution can be termed

equitable because it is self-determined on an equal playing field. Such equitable distributions are seen in this conception as fair or just because no one has had an advantage in gaining access to resources and options (Ikeme, 2003; Hughes, 2013). However, this conception ignores the power of assets and options, once attained by some individuals and groups, to create or compound differential access to assets and options for others thus creating social inequality (Agyeman et al., 2016). Social inequality thus creates self-feeding systems that are not fair or equitable because they deny, to marginalized people and groups, access to assets and options necessary to avoid risks at the same they deny access to police systems and institutional features that could help them gain access those assets and options.

Inequality determines differential location and access to places, water, food, energy resources, and decision-making options in a city where resources are distributed unevenly across populations (Reckien and Lwasa, 2017). Typically such uneven distributions result from markets, power, other institutional mechanisms and risk mitigation and adaptation policies that engender or perpetuate socially defined categories of wealthy or poor, or of included and excluded populations (Stein, 2011; Romero-Lankao et al., 2016b) based on class, caste, gender, profession, race, ethnicity, age, and ability (real or perceived).

Undergirding our analysis in this paper is an assumption that, in the context of city climate action, an understanding of how inequality creates differences in exposure and vulnerability is fundamental to creating fair and effective risk mitigation and adaptation. Policies aimed at creating risk-equality should contain mechanisms to ensure the fair distribution of risks of negative impacts and of benefits (assets and options) to undertake climate action across city populations (distributive justice). Creating equality also means generating equal opportunities for

participation and recognition for all, including underrepresented groups (procedural justice) (Bulkeley et al., 2013; Hughes, 2013; Reckien and Lwasa, 2017).

Among the resources and options that vary with inequality to create differential urban vulnerability, access to food, energy, and water are so basic and primary that they can be used as bellwethers of an uneven distribution of many other resources conditioning vulnerability Biggs et al., 2015; Romero-Lankao et al., 2016b. When considering the fair distribution of resources, assets and services related to distributive justice, it is important to recognize that differences in gender, race, socioeconomic status, and culture are part of procedural barriers that condition participation in policies affecting distribution. Thus, a cultural value can inhibit poor and marginalized populations from effectively participating in decisions (e.g., where to locate infrastructural investments in water and electricity) that affect their wellbeing, property, resources, climate risks, and capacities to adapt and mitigate.

CONCEPTUAL FRAMEWORK

Using discourse analysis, we qualitatively unpack how, in their adaptation plans, city officials' frame inequality in urban climate risk. We then combine discourse analysis and adaptation analysis to examine some of the issues addressed by the adaptation actions suggested in the plans. Lastly, we use a meta-analysis approach to quantitatively investigate patterns of framing and adaptation action across cities.

We will map narrative understandings in the adaptation plans of how inequality creates differences in exposure and vulnerability. We will also examine if and how adaptation actions contain mechanisms to ensure the fair distribution of assets and options to manage climate risks (distributive justice), and generate equal opportunities for participation and recognition for all, including underrepresented groups (procedural justice).

Discourse Analysis

Various strands of social science scholarship have used discourse analysis to examine texts, images, papers, books, and reports to define the ideas and concepts—which we will call understandings—through which actors understand and act upon the world (Foucault, 1972; Sharp and Richardson, 2001; Hajer, 2004; Keller, 2011; Wiegleb and Bruns, 2018). Rather than being neutral, these narrative understandings privilege some socio-environmental facts and may suggest some policy actions over others (Sharp and Richardson, 2001; Hajer, 2004; O'Brien et al., 2007; Trombetta, 2008). We draw on section Conceptual Framework and on the Sociology of Knowledge Approach to Discourse to map the discourse of 43 adaptation plans (Keller, 2011). The sociology of knowledge analysis of discourse includes three components: knowledge structuring, discourse production, and power effects. Here we will only focus on the first and the third. We excluded the second, which entails an examination of the influence of sociopolitical context on framing and action (Keller, 2011), because our study focuses on discourse as it crystallized in the plans, and not on the influence of each city's sociopolitical context on framing and action.

To help us determine *knowledge structuring*, we mapped, through their references to issues of concern, the general interpretative frame city officials use to make sense of a climate change issue in their adaptation plans. For instance, do city officials frame climate adaptation as a problem of risk, or of resilience? However, setting issues such as those related to inequality in climatic risk on the adaptation agenda also relates to the way in which city officials determine what kind of problem climate change is. What causal SETEG factors are involved in the creation of climate change impacts? Are these impacts only the result of location and geography, or exposure? Or are they also the result of prior policies and unequal patterns of development determining differences in the vulnerability of people and FEW-systems within cities?

Drawing on the discussion of existing literature (section Conceptual Framework), we will map how adaptation plans address inequality in hazard exposure and in the following multiscale (SETEG) factors determining vulnerability (Arup, 2014; Romero-Lankao and Gnatz, 2016).

- Locational (exposure) factors conditioned by the presence of populations and critical FEW infrastructures in places that could be adversely affected by floods, heatwaves, and other climate hazards (Nicholls et al., 2008).
- *Socio-demographic* factors consist of age, gender, and demographic structure of a city or the behavior of individuals and groups (Donner and Rodríguez, 2008).
- *Economic* factors relate to uneven economic growth, urbanization, income, and affordability of food, energy, water, and other resources (Uejio et al., 2011).
- *Techno-infrastructural* and built environmental factors include land use change and the distribution, quality, and robustness of water, sanitation, electricity and related, FEW critical infrastructures, and systems. Critical FEW infrastructures include electric power, natural gas and oil, water supply, and food distribution systems, but because we acknowledge the role of transportation, telecommunications, health, emergency and other services, we also included these as critical urban FEW infrastructural systems (Rinaldi et al., 2001).
- *Environmental* factors such as the biophysical and climatic characteristics affecting an urban area's predisposition to hazards relate to exposure. For instance, coastal cities are prone to sea level rise, storm surge and coastal flooding, saltwater intrusion and tropical storms.
- *Governance* factors consist of the fit between areas of concern and authority, cooperation, and cohesiveness among governing bodies and levels of government, policies and actions, and the legacies of actions and policies around-land use planning; and through investments, location and climate proofing of FEW infrastructure and service networks, which shape the geography of urban risk (Aylett, 2014).

Power effects relate to the intended or unintended consequences emerging from the discourse. Elements of the power effects include the *dispositifs*, a French word describing the institutional, organizational and infrastructural elements, which we define here following Foucault and Keller as the suggested apparatuses of adaptation action, such as

- a) Personnel and organizations charged with undertaking adaptation policies;
- b) Institutional and organizational processes seeking to evaluate, monitor and understand the climate change problem, or to foster awareness among city actors, decision makers, and populations. We will include these under institutional-behavioral adaptation actions (note that (a) and (b) seek to address the sociodemographic and governance factors within our SETEG framework);
- c) Investments in and climate proofing of critical FEW infrastructure (artifacts), which we will include under techno-infrastructure actions. (These address the techno-infrastructure factors within our SETEG framework); and
- d) Other discursive or non-discursive adaptation actions, such as environmental and economic adaptation actions (which address respective factors within our SETEG framework).

Such “*dispositifs*” are shown in the literature to hold the potential to address climate risk to people and FEW-systems in cities. In our analysis we sort “*dispositifs*” among techno-infrastructure, institutional-behavioral, economic, and environmental action categories (Romero-Lankao et al., 2017b).

Adaptation Analysis

We also include insights from the climate adaptation literature to add accuracy to our discourse analysis. In the climate adaptation literature, institutional-behavioral actions include changes in the procedures, incentives, or practices of city actors, and often work through existing urban competencies and hybrid actor arrangements in sectors, such as urban planning, health, water, energy, and disaster risk management (Fisher, 2013; Romero-Lankao et al., 2017b). Institutional behavioral actions entail the creation of organizations charged with mainstreaming adaptation into other sectoral and developmental policies such as urban planning, transportation, and disaster management; with evaluating, monitoring and understanding the climate change problem; and with fostering awareness among city decision makers and populations. In the environmental justice literature, these actions are fundamental to procedural justice by broadening participation in, recognition, and commitment to adaptation across governmental, private, civil society, and community actors (Bulkeley et al., 2013; Shi et al., 2016; Reckien and Lwasa, 2017).

Techno-infrastructure actions are critical in the creation of artifacts, such as energy, water and sanitation. They are often framed in the climate adaptation literature, as efforts to discourage growth in risk-prone areas and to protect critical urban infrastructural systems through investments in climate proofing, and changes to design, operational, and maintenance practices (Romero-Lankao et al., 2017b).

Other adaptation actions include economic and environmental policies. The former aim at creating enabling conditions for autonomous action by governmental and nongovernmental actors, and to support broader development goals. Funding programs from public and private sectors are fundamental. By strategically allocating funding (whose amount and sources vary widely across cities), local governments

can effectively respond to climatic risks (Aylett, 2014). Environmental *actions* seek to manage the biophysical, climatic, and hydrological factors affecting an area’s predisposition to hazards (Brink et al., 2016; Kabisch et al., 2016). Environmental actions take into account and manage the role of biodiversity, greenspaces, and other ecosystem services in mitigating hazard risk and reducing the vulnerability of urban populations and FEW systems to climate change (Levy et al., 2014).

STUDY DESIGN

Meta-analysis is often applied to find commonalities within a variety of research papers and methods (Littell et al., 2008). It involves the pooling of data that quantitatively examine whether causal relations described in individual papers (e.g., drivers of climate risk, determinants of vulnerability of food, energy, and water insecurity) hold across a broader body of scholarship (Misselhorn, 2005; Romero-Lankao et al., 2012).

While meta-analysis is frequently combined with systematic literature reviews to synthesize the results of previous research, in our approach, we combine meta-analysis with discourse analysis to systematically investigate patterns on the framing of inequality in risks within a selection of 43 adaptation plans.

Selection and Analysis of the Adaptation Plans

This study resulted from a prior report commissioned by the C40. Although the C40 has 94 affiliated cities, we only got access to 60 adaptation plans for analysis. Of these, we selected 43 plans, 4 of which are from cities located in lower-income, 12 in middle-income and 27 in upper-income countries. As can be seen in **Figure 1**, our selected sample also has a good representation of C-40 cities from Latin America, Europe, North America, Africa, and South-East Asia.

We built on our prior work on FEW nexus, climate adaptation and inequality cited in section Conceptual Framework, and on the review of the adaptation plans, to map how city officials prioritize policy actions to manage inequality in risk. Although we couldn’t analyze how individual city officials actually understand the climate change adaptation and FEW issues we studied, we did analyze the understandings of these issues conveyed in the plan. We will refer to these understandings, conveyed in the plans, as narrative understandings.

Our data extraction and synthesis followed an examination of discourses and a meta-analysis approach (Littell et al., 2008; Keller, 2011; Romero-Lankao et al., 2012; Wiegleb and Bruns, 2018). Our conceptual framework functioned as a starting point to design and test a review template and to agree on our own definition of terms and fields (available upon readers’ request). We then used this template to extract data from each of the 43 adaptation plans. First, each selected plan was carefully reviewed by at least two members of our research team to ensure systematic and consistent data extraction. Factors influencing risk to people and FEW-systems were identified and coded into the five SETEG domains (i.e., sociodemographic, economic, techno-infrastructure, environmental, and governance). Adaptation

actions were classified into institutional-behavioral, techno-infrastructure, economic, and environmental.

We further subdivided these categories of SETEG factors and adaptation actions into terms, as described in the second column of **Supplemental Tables 1A,B, 2A–E, 3A–D**). After summarizing each adaptation plan, mention counters were developed, based on mention of the terms, to capture overall narrative understanding (**Supplemental Tables 1A,B, 2A–E, 3A–D**). Once a term was found, the counter maxed at “1” for that particular topic to avoid duplicate counting. Limiting mention counts to one per plan is the most effective way to avoid bias in answering the question: what plans address what topics? Although this method does not seek to answer what plans emphasized what topics. It does answer the question what issues were emphasized in the plans overall. We use two approaches to refer to the percentages:

- 1) Number of plans with mentions of an issue/total number of plans
- 2) Number of mentions of an issue/total number of mentions of all issues within a category

The first gives a view of the relative importance, attributed by urban policymakers, to particular issues within plans compared with all plans. The second gives a view of the relative importance, attributed by urban policy makers, to particular issues compared to all issues within a given category (e.g., techno-infrastructure vs. institutional-behavioral actions). Together, these measures give a two-scoped view of the relative priorities given by urban policymakers to the issues addressed in the plans.

Although we feel this study offers many relevant insights, it was faced with some constraints that may affect its outcomes. While we included 43 cities from low-, middle-, and high-income countries, these were not selected using a sampling approach. Due to our determination to have at least two members review each plan, and our group’s language limitations, we could only review plans written in English and Spanish. This meant we were not able to analyze the discourse in many plans that might have offered additional insights. Readers of this paper should, therefore, keep in mind that while the combination of discourse analysis with meta-analysis to identify patterns in understanding and action is innovative, our study is exploratory in nature. Furthermore, while our use of a discourse analysis to examine the framings of inequality in risks exposed some of the narrative understandings conditioning policy actions, it did not include an examination of why and how the socio-political and geographical contexts in which city officials operate shape their interpretations and planned actions. Lastly, since we studied plans and not implementations we could not determine how (or if) the suggested adaptation actions were implemented.

While ethical questions regarding this study might be raised around the fact that it was commissioned by the C40 to study the adaptation plans of C40 cities, giving rise to concerns about scientific objectivity, we feel that our analysis of these plans was objective and sound for two reasons: (1) We studied the adaptation plans as independent documents and not as they pertain to the C40 or its mission; and (2) The methods used in the study were evenly applied across city adaptation plans

without regard to any city’s membership, income level or status in the C40.

NARRATIVE UNDERSTANDINGS AND POLICIES IN THE ADAPTATION PLANS

This section is organized around three topics. The first and second include a mapping of the narrative understandings—or knowledge structuring—crystallized in the adaptation plans. This not only in terms of what interpretative frame is used but also in terms of what locational and SETEG factors are identified as key determinants of climate risk, and whether inequality is considered in this conveyed understanding. The third topic refers to the power effects in the form of adaptation actions suggested in the adaptation plans to address inequality in risk to people and FEW-systems.

Interpretative Frames

We found that the urban adaptation plans analyzed here embed adaptation in a larger vision for the city, often with a multiplicity of coexisting frames. Many of these interpretative frames are not only full of symbolism, as in the resilience framing we will describe later in this section, they also feature key—and sometimes, contradictory—organizing principles of policy action (**Figure 2**). Rather than converge toward an integrated understanding, these concepts often coexist in a tension of incongruent and unbalanced sets of principles and related actions. In this disharmony, economic and investment concerns and interests (e.g., infrastructure and economic investments) tend to take precedence over concerns and interests for the environment and the marginalized (see next subsection).

Frequently cities appear in the adaptation plan narratives as leaders, development hubs or engines of innovation and investment, key to growth and stability nationally, and internationally. Adaptation in this context forms part of a broader sustainability vision present in many cases for the creation of a vibrant, economically prosperous, and socially just cities, or cities that are habitable, secure, resource-efficient, socially and economically inclusive, and competitive internationally (Seattle, Tshwani).

In many adaptation plans, city officials frequently see climate change as posing risks, but also offering opportunities. These include opportunities to attract investment, generate high-value jobs, strengthen research and development, or foster circular or green economies. For instance, the Singapore plan states that the city is poised to tap economic opportunities offered by global warming, such as investments in new growth areas, the creation of high-value jobs, the promotion of green growth, and of R&D capabilities.

Interestingly, 87% or 37 of the reports apply a risk approach to frame climate change issues (**Figure 2**). Risk is often framed in the adaptation plans as the probability of occurrence of a hazard, such as sea level rise, multiplied by a consequence such as property damage. While differences in emphasis exist, a dominant narrative emerges, underlying the risk approaches in these plans. Common to this narrative is the idea that

strategies for the protection of urban areas from the risks and FEW constraints associated with climate change require a scientifically grounded technical assessment of how changes in temperature, precipitation, and sea level are likely to affect critical infrastructures, resources and economic activities in the cities.

Adaptation plans reviewed in this study illustrate that resilience is, increasingly, becoming embedded in the discourses of urban decision-makers. Resilience is not only seen in the plans as an ecological principle, but also, frequently, as an opportunity. Such opportunities, when coupled with appropriate actions, can increase a city's economic, energy, environmental, and food security, in addition to protecting the quality of life and safeguarding property (e.g., Durban). It is, therefore, common for the adaptation plans to frame the hazards and disruptions brought about by climate change as somewhat of a blessing in disguise. In this discursive thread, cities may even view themselves as symbolically endowed with a power of resilience like "the mythic phoenix," able to take advantage of disruptive events and carry on through challenges over the years. In such cases cities become a phoenix aware of how the threats cities face—and their responses to these threats— expose several interdependencies that city officials must better comprehend (San Francisco). An almost mythic idea of its own resilience can also be found, for instance, in the New Orleans plan, which describes a city certain that the creativity and resilience of its people and places have been key in its capacity to bounce forward, after being faced with a decade of hurricanes, oil spills, and the Great Recession.

Inequality in Climate Risk

We compared levels of attention paid to climate risk associated with five selected SETEG factors, and examined whether the plans mentioned inequality in reference to these factors (inequality within each domain, **Figure 3**). This comparison revealed that because city officials are, by necessity, generalists, adaptation plans deal with many climate change issues at a time, from those related to economic development and land tenure to those associated with health, disaster management, housing and critical FEW infrastructures (**Supplemental Tables 2A–D**).

Evidence from the narrative understandings conveyed by the plans suggests that FEW-nexus thinking is not yet embedded in city officials' priorities, or that such considerations create a conundrum that officials are reluctant to tackle. Of the total of risk factors, those related to food, energy and water systems were mentioned in 6, 14, and 20 reports, respectively (**Figure 3**). Where they did appear, food, energy, or water systems are treated separately, in most cases, without consideration of how their interdependencies can amplify or mitigate risk. The influence and vulnerability of FEW-systems was often framed in terms of techno-infrastructure issues associated with age, design or capacity characteristics (Blue bars, **Figure 3**). For example, the plans mention that FEW-systems and infrastructures are vulnerable because they are old, designed without consideration of the new (and unstable) normal that climate change will bring, and in need of retrofitting and climate-proofing actions. Buildings are also vulnerable because of poor quality design

and construction, age, and lack of maintenance (**Figure 3; Supplemental Table 2C**). Inequality also tends to be given a lower priority and appears mainly in relation to other factors and very rarely in relation to FEW systems.

Inequality considerations were included in 24 plans and represented 26 percent of the total mentions of *techno-infrastructure* risk factors. However, scant consideration was given to how techno-infrastructure and built environment factors condition unequal risk through such distributive mechanisms as differential access to water or sanitation, or differences in the provision and placement of infrastructures and services such as electricity, waste disposal, tree shading, parks, hurricane shelters, and evacuation routes.

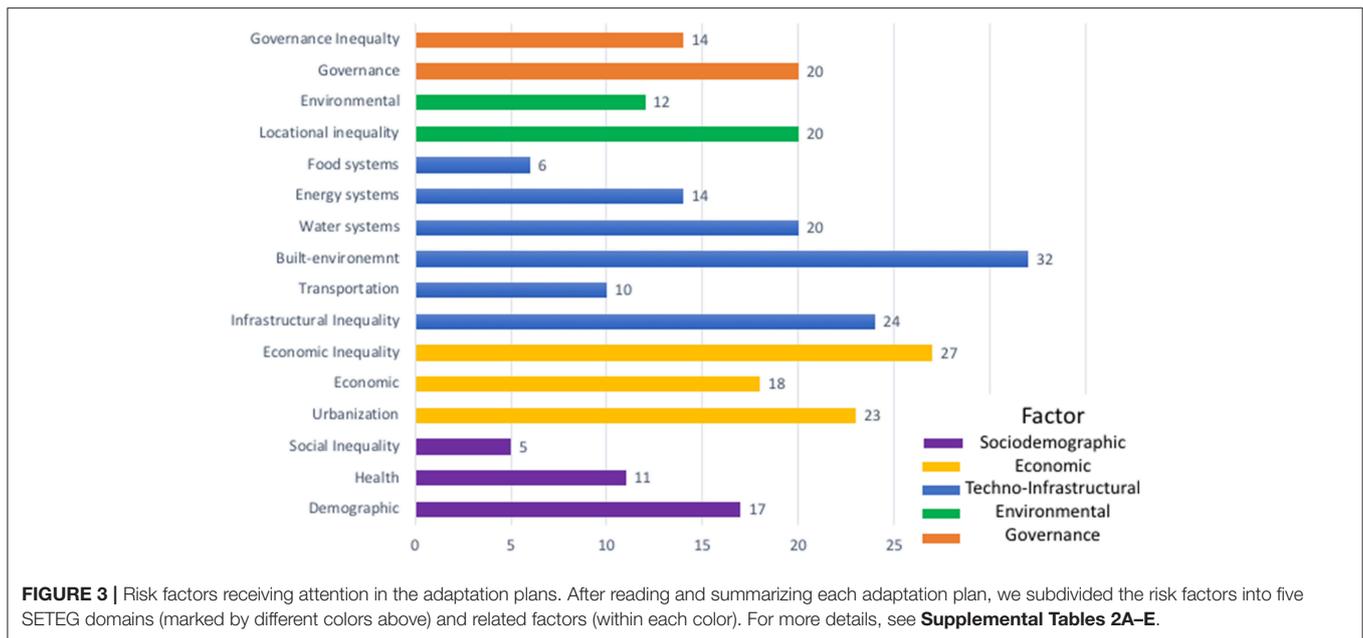
Locational (*exposure*) factors were mentioned in 32 plans (green bars, **Figure 3**) as related to differential exposure of populations and FEW-systems to climate hazards. Adaptation plans in Peru, Mexico City, and Cape Town point to how the poor are priced out of desirable neighborhoods and are often forced to live in hazardous areas. In Seattle, San Francisco, and New Orleans, adaptation plans show concerns for how inequality makes poorer populations more likely to occupy low-lying areas, prone to flooding or more likely to experience heat island effects because these areas are more affordable.

Related to location, *environmental* risk factors were mentioned in 12 plans (green bars, **Figure 3**). Some of these mention that many informal settlements locate on areas, where the high-water table and inadequate infrastructure make them particularly vulnerable to flooding (e.g., Cape Town, Buenos Aires, Tshwane, Mexico City, and Lima). Cities from the Global North also offer examples of how low-income communities living in brownfields or in flood risk areas face higher levels of exposures not only to sea level rise, floods and heatwaves but also to contaminated land (e.g., New York, and New Orleans).

Regarding *economic* factors, twenty-seven adaptation plans (67%) refer to economic development as a key determinant of risk, and twenty-three (53%) of all plans mention urbanization as a broader driver of risk (yellow bars, **Figure 3**). Interestingly, 27 or 62% of the adaptation plans referred to unequal economic growth conditioning access to determinants of a population's capacity to mitigate risks and to adapt. Such determinants include location, and access to secure land, affordable, accessible, and good quality housing, energy, water, food, and transportation (yellow bar, **Figure 3**).

In the adaptation plans of Lima, Mexico City and Cape Town, the narratives acknowledge deep inequalities and high poverty rates that relate to the existence of informal, unplanned settlements whose populations have precarious housing without adequate FEW resources necessary to protect themselves against hazards. Recognition of such conditions is rare in the adaptation plans of the global north. New York is one of the handful of such cities indicating that nearly half of its people live in or near poverty, and lack access to good quality housing and other resources needed to adapt.

While 17 adaptation plans refer to *socio-demographic* factors such as population size and growth, age, gender, and pre-existing medical conditions as determinants of vulnerability, 20 plans



convey an understanding of governance as a determinant of risk and vulnerability (purple bars, **Figure 3**). Such governance conditioned risks operate through investments and the location of FEW infrastructures and service networks, and through the legacies of actions and policies around-land use planning or its lack though this is not generally acknowledged in the plans (orange bars, **Figure 3**).

As for inequality, *socio-demographic* and *governance* factors, creating social exclusion by class, gender, race, migration, and minority status were mentioned in 13 and 5 plans, respectively, (orange and purple bars, **Figure 3**). Adaptation plans from cities in middle- and low-income countries tended to mention the influence of social exclusion on inequality in access to affordable energy, water, food, and sanitation, and reliable transportation systems more often than plans from high-income countries. Race, however, appears in the adaptation plans of the US cities of New York, New Orleans and San Francisco as a predictor of risk. These plans indicate that people of color are more likely to live in areas more at risk of flooding and subsidence, to live in poverty, to be unemployed and to have pre-existing health conditions associated with higher hazard risks. These plans also recognize that their marginalized populations have lower capacities to mitigate and adapt (**Supplemental Tables 3A–D**).

Policy Actions to Address Inequality in Risk and FEW-nexus

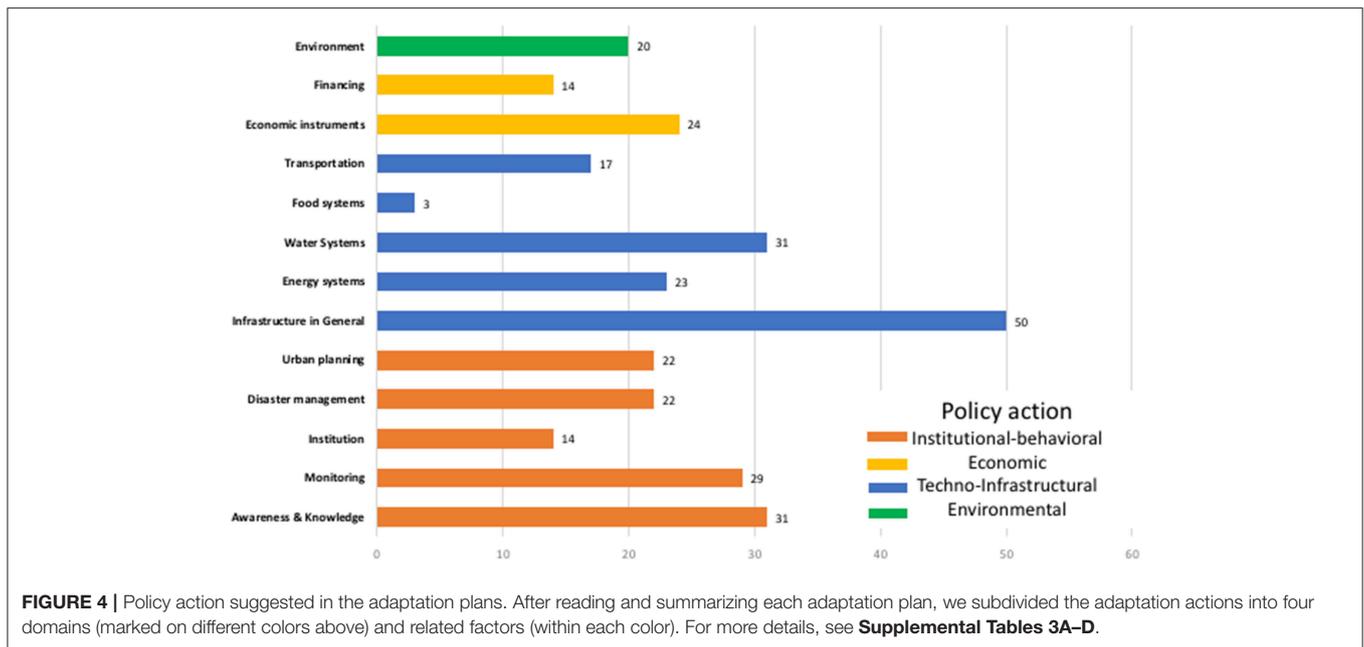
In our mapping of the *power effects* emerging from adaptation discourse among policymakers, we examined whether planned adaptation actions aimed at either reducing hazard exposure or tackling the drivers of social vulnerability considered inequality. The adaptation actions identified were organized into “*dispositifs*” as defined in section Tracing Existing Scholarship. We sorted “*dispositifs*” among techno-infrastructural,

institutional-behavioral, economic, and environmental action categories.

Our findings suggest that, while proposed adaptation actions tend to target many issues at a time, they also tend to prioritize infrastructural and economic issues, and that inequality is a secondary concern. Furthermore, city officials tend not to address the links and feedbacks between critical FEW infrastructural systems but rather to suggest actions to manage each infrastructural system at a time.

Technological-infrastructural actions, which can be a means of fostering distributive justice, received the highest number of mentions (with 124, or 41%, blue bars, **Figure 4**). However, by and large distributive justice was not considered. Instead, actions were presented in the plans as a means to protect buildings and infrastructure through changes to design. Similar to what we found in our examination of narrative understanding, suggested policy action did not address the links and interdependencies among critical FEW-systems but rather focused on one sector at a time. Examples of planned infrastructural adaptation actions included:

- Improving energy redundancy and reliability of (e.g., distributed power), flood fitting the design of surfaces, and increasing the extent of cooler, green surroundings (Changwon, Chicago, Karachi, New Orleans, Paris, Seattle).
- Introducing low-carbon or renewable energy sources, reducing coal usage for electricity generation, promoting energy-efficient and resilient technologies, appliances, and designs in buildings and developments—e.g., cooling systems, LED and fluorescent lighting (Amsterdam, Quito).
- Adapting water infrastructures to withstand heavy rain events, drought, and heat. Climate-proofing water systems and implementing a water sensitive approach to urban design and flood mitigation through blue and green infrastructures (Copenhagen, New York, Rotterdam, San Francisco).



Techno-infrastructure actions were most frequently organized around resilience, low-carbon utilities and buildings, promoting a circular economy, and risk as a source of investment opportunity (**Supplemental Table 3A**). For instance, Amsterdam and Boston suggested fostering a circular economy to reduce waste and increase recycling throughout economic activities and districts. Other cities, such as Copenhagen, suggested basing adaptation on a risk and resilience approach aimed at improving infrastructure adaptability to new or unexpected conditions by achieving a city-wide, multiple-purposed, and longer-term risk mitigation vision.

There were a few exceptions were plans used techno-infrastructure actions aimed at addressing inequalities in risk. For instance, the following actions were suggested:

- Reducing intra-urban differences in water scarcity, access and use; increasing water coverage to poor and informal populations without regular, safe, and continuous water service (Cape Town, Durban, Johannesburg, Kolkata, and Mexico City); and providing access to weatherization of homes to low income families (Seattle).
- Scaling up development tied to renewable energy services to accomplish a lower energy impact while achieving reduced poverty and promoting economic development (Durban, Tshwane).
- Fostering structural investments that consider the consequences from interrupted energy supply during and after extreme events, and target those that are more affected (Durban, Tshwane).
- Renovating slums, informal, or poor settlements (Addis Ababa, Buenos Aires, Cape Town, Durban, Kolkata, Mexico City, and Tshwane).

Institutional-behavioral actions were second in the number of mentions (118 or 39% of the total). The focus in order of importance was on knowledge and awareness, monitoring, urban planning, disaster risk management, and institution building (orange bars, **Figure 4**).

Awareness and knowledge, and monitoring were addressed in 31 and 29 of the plans, respectively. These plans suggest a suite of strategies to systematically evaluate, assess, understand, and monitor the kinds of climate risks and vulnerabilities they face (**Supplemental Table 3B**). They also suggest using scientific and technical expertise as a vital source of knowledge. For instance, Amsterdam suggests improving the city's knowledge and understanding of data to become active partners, steering events toward sustainability based on a knowledge of interconnections between systems such as energy and water.

Two crucial adaptation instruments received attention in 22 adaptation plans each: disaster risk reduction (DRR) and urban planning. Elements of DRR included early warning systems, cooling centers for poorer populations, and climate-sensitive management protocols (e.g., Bogota, Kolkata, Mexico City, San Francisco, Quito, Rio De Janeiro, and Sydney). Urban planning was mentioned as a fundamental tool for anticipating climate change impacts, fostering early action and even preventing risks (orange bars, **Figure 4**). Some plans (e.g., Lima and Tshwane) acknowledged institutional barriers to effective implementation, such as weak law enforcement. Others pointed to gaps in the levels of authority and autonomy to control the investments and decisions that are fundamental not only for effective urban planning but also for managing the drivers of climate risk in the city.

FEW thinking with relation to equality received scant attention within planned institutional-behavioral actions. We

found only the following few examples of strategies to enhance equality within each sector:

- Community based adaptation actions such as upgrading informal settlements, building flood-water drainage, and sewer systems in poor areas (Mexico City and Tshwane), and training poor communities for the management and attention of disasters (Bogota).
- Increasing the share of renewable energy per capita through demand management actions, such as agreements with a number of utilities, incentives that support energy efficient practices, and reduced electricity consumption during peak hours (Amsterdam, Durban).
- Inducing water conservation through water restriction, tariffs, and reduction of leaks (Cape Town).
- Enforcing polices and by-laws that make healthy food accessible to all (Boston) and reserve space for local decentralized food hubs that can supply small traders while reducing ecological impact, through the support of small scale, sustainable farming practices (Durban).

Within the economic instruments suggested in 38 adaptation plans, equality considerations were, likewise, virtually absent. While many of the plans seek to create enabling environments for independent action by both governmental and non-governmental actors, for example through infrastructural investments, they largely aim at enhancing their economies without regard for structural inequality or uneven distribution. Through these actions, the plans also aim to support broader goals such as the Sustainable Development Goals. Indeed, the governments that produced many of the adaptation plans we analyzed are driving investments in major flood defenses, and in the transportation, water, and sanitary services sectors, but generally steer away from equality considerations in these investments and are more concerned with how they will fund them. Some cities, particularly from high-income countries, are explicitly and actively partnering with the private sector (Amsterdam, Copenhagen). One of these plans acknowledges that society at large will pay a large dividend to have infrastructures privately constructed and operated (Copenhagen).

Environmental actions were considered in 40% of the plans, and many of these contain actions primarily focused on increasing or protecting biodiversity (e.g., Karachi, Montreal, Seoul, and Los Angeles), and on strategies for managing ecosystem services (green bar, **Figure 4** and **Supplemental Table 3D**). For instance, the plans suggest actions to green the cities' streets, parks, and open spaces in order to serve multiple risk mitigation purposes. Other planned actions include efforts to increase biodiversity and reduce the urban heat island effects (e.g., Sydney, Vancouver, Melbourne), to increase urban agriculture (Seoul), and to better manage such hazards as runoff or fires (e.g., Rotterdam, Melbourne, Rio de Janeiro, and Portland). Nature- or ecosystem-based adaptation actions are also suggested to increase the resilience of vegetation to climatic and ecological impacts (such as erosion, Montreal), or to establish temporary rainwater catchment systems (Mexico City). Some cities also suggest conservation or rehabilitation

of degraded ecosystems (Tshwane, Quito, and Mexico City) and protecting or restoring natural protections in coastal areas (New Orleans).

ADAPTATION PLANS AND RISK INEQUALITY

In this study, we examined evidence from 43 adaptation plans to determine whether and how they considered the factors driving inequality in exposure and vulnerability of people and the FEW systems that support them. To do this, we combined a discourse analysis with a meta-analysis of adaptation plans for 43 C40 cities. We are not the first scholars to conduct metanalysis. Examples of existing literature include (Misselhorn, 2005; Romero-Lankao et al., 2012; Endo et al., 2015). Nor are we the first to examine environmental discourse, even with regard to FEW systems. For instance, existing discourse scholarship has shown that a risk approach is prevalent among FEW nexus scholars (Wiegleb and Bruns, 2018). Because risks lack immediacy—says the analysis—discourse around FEW risks entails connecting a future scenario to a policy, “presented as a way of preventing that risk from materializing into real harm” (Corry, 2012, p. 244).

Our methodological innovation lies, rather, in our combination of discourse analysis with meta-analysis. We used this combination to examine narrative understanding and planned adaptation actions in 43 city adaptation plans. We integrated several theoretical strands of scholarship, such as FEW-nexus thinking, adaptation, and inequality, climate change risk, and adaptation and discourse analysis. Nevertheless, we did not examine why and how the socio-political and geographical contexts, in which city officials operate shape their interpretations and planned actions. Nor were we able to determine how or if the suggested adaptation actions were implemented. These represent the short-comings and limitations of our study that make it largely exploratory in nature. Notwithstanding these limitations, however, some clear patterns emerged that can help guide future research and policy.

We found that FEW-nexus thinking is not yet embedded in city officials' narrative understandings of risk and planned adaptation actions, even when unpacking interdependencies among food, energy, and water systems may help cities tackle some of the root causes of vulnerability and risk (Romero-Lankao and Norton, 2018). Other scholars have already pointed to the fact that, while promising, FEW-nexus thinking faces many practical challenges. For instance, knowledge integration is constrained by the existence of a plurality of sectors, levels of government, power, values and ways of understanding and managing climate risk (Leck et al., 2015; Romero-Lankao et al., 2017c). Scholars also suggest that local governments lack the institutional and organizational capacities needed to appropriately manage the complexity and uncertainty associated with climate risks, let alone inequalities in the vulnerability of people, or how that vulnerability interplays with FEW systems. Officials within sectors involved in managing climate risk, such as food, energy, water, disaster risk management, and urban planning hold diverse organizational and cultural values. They

lack the incentives, rights, financial resources, and responsibilities needed to work across sectors and jurisdictions (Scott et al., 2015). Additionally, decision makers involved in DRR and adaptation policies lack interaction and coordination because of differences in language and political culture (Schipper, 2009). An examination of these factors is an essential first step to develop the skill sets, tools, funding, and incentives needed to foster nexus thinking in risk mitigation and adaptation practice.

In the city adaptation plans we analyzed, we found multiple frames coexisting behind the broader adaptation visions conveyed in their narratives. Rather than converging, issues and principles such as those of equality, coexist with economic issues in an imbalance of incongruent political movements and priorities (Anguelovski and Carmin, 2011; Campbell, 2013). In this disharmony, techno-infrastructure and economic investments and concerns tend to take precedence over concerns and interests for inequality or the environment in climate risks.

Clearly, challenges exist with under-investments, backlogs and deferred maintenance of infrastructure. Urban infrastructures in many developed countries are deteriorating, and in developing countries infrastructure construction and maintenance have often failed to keep pace with the dynamics of urbanization (Kraas et al., 2016). Adaptation plans recognize that by working as a risk amplifier, climate change is projected to intensify these challenges, through at least two mechanisms: long-term, slow impacts such as constant deterioration of storm water system due to floods mentioned in the adaptation plans of 27 cities, or extreme events such as hurricanes (mentioned by 10 cities) and damaging critical FEW infrastructural systems.

Still, with a few exceptions, equality concerns were not the priority. In the adaptation plans, narrative understanding and policies to address techno-infrastructure challenges were frequently organized around resilience, low-carbon utilities and buildings, promoting a circular economy, and risk as a source of investment opportunity. All these strategic decisions advance cities as centers of economic and infrastructural growth. However, they run the danger of fostering inequality in access, related to distributional justice, by creating climate proof places that become more exclusive and expensive, pricing out marginalized populations who end up living in less desirable areas and lacking access to critical FEW infrastructures (Coutard, 2008; Zérah, 2008).

In their adaptation plans, cities of high-income countries are seeking to explicitly and actively partner with the private sector (Amsterdam, Copenhagen). Policy-makers in these cities reason that moving infrastructural development and operation to the private sector can be a way of diverting development costs away from government and reducing the need for politically unpopular taxes. However, this hasn't often shown itself to be a good strategy, as private interests must inevitably draw profits from their projects, leaving less for the public good. Ultimately, this will have implications for inequality in risk, as the poor communities, those most in need of investments in climate proofing, are more likely to be excluded not only from decisions (procedural justice) but also from reaping the benefits of techno-infrastructure interventions (distributional justice) (Coutard, 2008; Zérah, 2008; Revi et al., 2014).

Socio-institutional actions relate to the distributive and procedural aspects of equality in different ways (Reckien and Lwasa, 2017). For instance, by involving vulnerable populations in decisions on land use and location of infrastructural investments, in the generation of knowledge, or in the monitoring of climate risks (Moser, 1998; Moser and Satterthwaite, 2010; Bouzarovski, 2014). Nonetheless, rather than using participatory instruments such as community based adaptation (Ebi and Semenza, 2008; Dodman and Mitlin, 2013), the plans mostly suggest using scientific and technical expertise as a vital source of knowledge. There are reasons for this. Climate change adaptation is highly data-dependent, demanding that city officials engage in new ways of gathering data, collaborating with scientists, using scientific information, and dealing with uncertainty (Hughes and Romero-Lankao, 2014). Yet, the focus on technical knowledge is a key element of prevalent cultural values that inhibit poor and marginalized populations from effectively participating in decisions on where to locate FEW critical infrastructural investments that affect their well-being, property, resources, climate risks, and capacities to adapt and mitigate. Although our current study, based purely on textual analysis, did not attempt to examine socio-political context (knowledge production), our conclusions do suggest that sociopolitical context was at play in the creation of the plans. Even beyond that, they suggest that common elements in socio-political context may be drawing cities away from actions based on effectively addressing such complex concerns as vulnerability and inequality toward those least conflicting with economic priorities.

The relatively low importance of equality considerations in the adaptation plans will likely limit the capacity of cities to support broader goals such as the Sustainable Development Goals, Sendai Protocol for Disaster Risk Reduction and New Urban Agenda (Simon et al., 2016). The purposefully inclusive scope of the New Urban Agenda and of the targets and indicators in the urban SDG (Goal 11) provide a unique opportunity to include equality considerations in adaptation (Romero-Lankao et al., 2018). Prospects for progressing and mainstreaming climate change agendas, therefore, depend on demonstrating that climate agendas do not always and irreconcilably conflict with development priorities, such as those related to equality. From a longer-term perspective, they are essential and complementary to them.

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PR-L led the design, gathering, analysis and interpretation of data for the work. She also drafted and revised the work critically for important intellectual content. DG contributed to the design, analysis and interpretation of data for the work. He also drafted and revised the work critically for important intellectual content.

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Against the Environment. Problems in Society/Nature Relations

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The dominant manners in which environmental issues have been framed by sociology are deeply problematic. Environmental sociology is still firmly rooted in the Cartesian separation of Society and Nature. This separation is one of the epistemic foundations of Western modernity—one which is inextricably linked to its capitalist, colonial, and patriarchal dimensions. This societal model reifies both humanity and nature as entities that exist in an undeniably anthropocentric cosmos in which the former is the only true actor. Anthropos makes himself and the world around him. He conquers, masters, and appropriates the non-human, turning it into the mere environment of his existence, there solely for his use. If sociology remains trapped in this paradigm it continues to be blind to the multiple space-time specific interrelations of life-elements through which heterogeneous and contingent ontologies of humans and extra-humans are enacted. If these processes of interconnection are not given due attention, the socioecological worlds in which we—human as well as others—live cannot be adequately understood. But misunderstandings are not the only issue at stake. When dealing with life-or-death phenomena such as climate change, to remain trapped inside the Society/Nature divide is to be fundamentally unable to contribute to world reenactments that do not oppress—or, potentially, extinguish—life, both human and extra-human. From the inside of Anthropos' relation to his environment the only way of conceiving current socioecological problems is by framing them in terms of an environmental crisis which could, hypothetically, be solved by the very same societal model that created it. But if the transformation of some of the world(s)' life-elements into the environment of the Human is part of the problem, then, socioecological issues cannot be adequately understood or addressed if they are framed as an environmental crisis. Instead, these problems need to be conceived as a crisis of Western modernity itself and of the kind of worlds that are possible and impossible to build within it.

Keywords: capitalism, environment, environmental crisis, nature, social sciences, society, sociology, western modernity

INTRODUCTION

Sociology studies interaction—specifically, it studies interactional distributions and enactments of power-knowledge and ontologies. That much still remains true. But there have been considerable changes—both within and outside the social sciences—since the times of Marx, Weber, Simmel, and other classical sociologists. The field's opening to the study of environmental issues has shattered many of what have historically been its epistemological and ontological foundations. As is the case

of all of the social sciences and humanities, “thinking through the environment” deeply “unsettles” many of sociology’s core assumptions^{1,2}.

In order to be able to adequately understand “environmental issues”—and among them the very much urgent issue of climate change—sociology needs to move beyond the analytical exclusive focus on human interaction(s). There have been several proposals in this direction, but they still remain less than mainstream research stances (although it is arguable that this is less the case now than it was some decades ago). It is not possible to remain trapped inside the confines of what humans do with each other and expect to understand the myriad interrelations of human and extra-human life-elements³ of the world(s). To remain enclosed by an *a priori* defined privilege of human interaction is to stay incapable of seeing the true extent of the networks of life-elements that compose the socioecological phenomena that sociology studies. This does not mean that sociologists must become experts of all things, which would undoubtedly lead them to become experts of nothing. But there is a need to significantly widen the scope of the interrelations that we study. Humanity still has an important place in research, but the analytical focus must move from the intra-human to “the web of life,” to adopt Moore’s (2016a,b) concept.

To be precise, the problem at hand is the Western modern paradigm of knowledge and practice in which sociology moves itself (i.e., the paradigm for whose constitution and maintenance it contributes). Among other things, this paradigm is patriarchal, colonial, capitalist, and anthropocentric. It institutionalizes forms of existence that enact specific types of human-nature relations where the second term is subordinated to the first (Santos, 1991, p. 14 *et seq.*; Santos, 2006, p. 91 *et seq.*, p. 169 *et seq.*; Plumwood, 1993; Lander, 2009; Latour, 2010; Moore, 2016a,b).

Given this, what is needed is not a calibration of research elements similar to the one that was done from the 1960s onward when, to accompany formal political decolonization happening in the Global South, sociology started opening its doors to the study of human worlds outside of the West (obviously, there where sociologists preoccupied with extra-Western phenomena before this date, but they were far from being the majority). To replicate this now is unsustainable because we are not dealing with more human elements to add to the mix. For some decades now, we have been facing an irruption of the extra-human into what has historically been a human-focused field of inquiry. It is not further human populations that are entering our field of vision but trees, and animals, and water, and gases, and rocks.

¹We are borrowing the formulation of Rose et al. (2010): “Thinking through the environment, unsettling the Humanities.”

²This article’s arguments focus on the case of environmental sociology. The fact that we are both sociologists is not irrelevant to this choice as it makes sociology the discipline whose limits and potentialities we know best. Nevertheless, the issues discussed are of broader paradigmatic consequence to the (heterogeneous) whole of Western modernity. As such, we are inclined to believe that many of what is said might be pertinent to discussions held in other fields of knowledge that still regard themselves as studying “environmental” phenomena.

³We use the term “life-elements” to refer to all entities of the world(s) that, in one way or another, contribute to the collective enactment(s) of life. These are both biologically living elements and all the other things of the world(s) that, together with the former, make up what Moore (2016a,b) calls the “web of life.”

As such, any attempt to merely add up a new element—the environment, nature, or whatever one chooses to call it—to our considerations simply does not work⁴.

If epistemological and ontological changes stop there, as they are prone to do, sociology is not doing anything very original. It is merely replicating the same Cartesian divide of Society vs. Nature that has, since its beginning, characterized it. For 200 years, sociologists have mainly dealt with this divide by focusing on just one of its poles—the better one, the most interesting one; or so we thought. To add the environment to our conceptualization of the world still leaves us trapped in a conceptualization of an anthropocentric world. We still focus on Society. We just start taking into account the ways in which human action conditions Nature.

“Thinking through the environment” (Rose et al., 2010) *should* be unsettling for sociology. It should lead us not to rethink but rather to fundamentally unthink (Wallerstein, 2001) what sociology has taken for granted for far too long. This exercise of unthinking Western modernity and its foundational epistemological and ontological assumptions leads to the radically relationist study of the multiple and heterogeneous interconnections between different life-elements of the world(s), neither of them *a priori* classifiable as belonging to “humanity” or “nature” but rather thus constituted through and along the very process of interrelation. As such, adding up Nature to Society (or Humanity, or Culture, or any equivalent) does not do. This position validates the reification of both terms and keeps them, as they have been for 500 years in slightly different ways, in relation to each other (Moore, 2016a,b). And, given human privilege *vis-à-vis* the non-human, Society’s relation to Nature wrongly distributes agency, viewing it solely as a human capacity, thus turning nature into mere passivity. Even narratives on the Earth’s revenge on humanity reinforce this insofar as in them nature’s action is mostly re-action to the effects of what humanity—the only true actor in this story—does.

Unthinking what we know—including what we know about how we know—implies refusing to understand this issue in terms of humanity’s relation to nature but rather conceptualizing it in terms of the space-time specific interrelations of different elements of the web of life. These are not in relation to each other, and much less are they in a binary relation in which one of the parts acts upon the other, the former’s actions generating a set of consequences on the latter. These multiple life-elements enter into multiple space-time localized relations *with* each other, collectively establishing contingent, dynamic, and conflictual arrangements of human and extra-human beings and things—in Haraway’s (2016, p. 34 *et passim*) formulation, composing “multispecies muddles.” In other words, through their collective practices they compose collectives; they collectively enact worlds.

⁴See Moore (2016a,b) for a critique of this “green arithmetic,” “the idea that our histories may be considered and narrated by adding up Humanity (or Society) and Nature, or even Capitalism plus Nature. (...) [S]uch dualisms are part of the problem—they are fundamental to the thinking that as brought the biosphere to its present transition toward a less habitable world. (...) [T]he categories of “Society” and “Nature”—Society without nature, Nature without humans—are part of the problem, intellectually and politically” (Moore, 2016a, p. 2).

In this essay we propose to unthink some of sociology's foundations of knowledge and practice. We do this by focusing on the Western modern dominant concept of nature, and particularly by discussing its transformation into the environment. The first section starts by looking at the Cartesian conception of the world in terms of Society/Nature, which necessarily subordinates the life-elements placed in the second term to those placed in the first. We then locate the Society/Nature divide within the wider Western modern dualistic logic, which is inherently totalizing and hierarchical. With this background, we argue that current mainstream sociological approaches to the study of human-nature relations have not sufficiently broke with its paradigmatic Western modern origins, making them unable to understand the multiplicity of interrelations between life-elements by which socioecological phenomena are enacted. The following section starts by looking at how nature is turned into the environment of Western modern humanity, which is an essential process for the latter's dominant approach to the government of human life. We then discuss how this is inextricable from capitalism insofar as it allows nature to be enacted as a series of commodities. Following this we argue that if the concept of the environment is inherently problematic, then environmental sociology has a foundational problem that it may be unable of solving. The section ends by contending that, due to these conceptual and practical problems, the environmental crisis is the wrong framing for the current Western modern crisis of enactment of socioecological ontologies and worlds.

There are far more sociological concepts and practices in need of unthinking. And much more could be said about nature and (its conversion into) the environment. Our position in this essay is quite humble and has no pretension to exhaustively discuss all that need to be unthought. We are merely pointing to some of the perplexities that have been bothering us in our common research, thus adding to the collective effort(s) of unthinking Western modern enactments of life with the hope that others will find this exercise relatable to their own intellectual and political concerns.

QUESTIONING NATURE

The last 50 years have seen the emergence of many significant contributions to the exercise of unthinking Western modern enactments of the world(s) that inspires this essay: from the historical-philosophical *tours de force* of Foucault (1994, 2005a,b, 2012a), Kuhn (2009), or Feyerabend (1993), to science and technology studies (STS) and actor-network theory (ANT), passing through several schools of feminist and decolonial thought⁵. All of these have been listened to and developed by many other researchers, and we build our own work from and alongside them. Nonetheless, the critical exercise of unthinking

⁵There are too many references to quote for any of these (internally very much heterogeneous) lines of work. We merely highlight some of those we consider to be especially relevant for this exercise of unthinking. For STS and ANT, see Callon (1986), Latour (2007, 2010), Latour and Callon (1981), Law (2002, 2004), and Mol (2002). Haraway (1991) and Plumwood (1993) present two feminist positions that are particularly relevant for issues discussed in this essay. For the case of decolonial thought, see Dussel (1995); Mignolo (1995, 2000); Lander (2005), Said (2003), and Quijano (2007).

and re-enacting is still far from being the norm for research carried out within sociology. This is undoubtedly the case of research on matters of human-nature relations.

Most sociological research on the general field of the relation of humanity to the rest of the cosmos has a firm footing on the Cartesian division of Nature and Society (or Culture, or any equivalent) (Descartes, 1982). As is the case of other fields on inquiry, research on "the environment" develops both through stances that are (to various degrees) critical of certain arrangements of practices characteristic of Western capitalist modernity and through positions which present—and, many times, believe—themselves as defending the axiological neutrality of science. Both of them are very much heterogeneous and this analytical partition is merely a shorthand. But most of these stances tend to implicitly validate and solidify the Social Contract argument of Hobbes (2002), Rousseau (2003), or Locke (2001), according to which the creation of any sort of civil and political—in essence, social—state is inherently dependent on the exit from the state of nature⁶. In this fashion, the sum of human beings, all of them exemplars of *ego cogito*, is withdrawn from the rest of the cosmos. All that is not humanity is thus transferred to one or more of the following categories: chaos, vital threat, landscape, romantic ideal, and/or resource reservoir.

No matter what category each of the constitutive parts of the non-human is put in—and the exact distribution varies dynamically according to space and time—it is thought of as being in relation to humanity. However, by definition, it is not part of humanity. Human and non-human (natural), their ontologies are different, even if the existence of each of them is ontologically dependent on the existence of the other. *Ego cogito* does not change his or her essence because of the action of the elements of the non-human⁷. He is *in* himself and *from* himself. In the same manner, nature's essence is unchangeable. The modern project of dominion of nature (Plumwood, 1993; Scott, 1998; Serres, 1998; Latour, 2010; Debaise et al., 2015) operates around the idea of taming nature, of molding it to humanity's wishes (or rather to the wishes of some members of humanity). In this fashion, Western modern human action is able to reshape nature's appearance, to cut down trees, to relocate animals and plants, to make water change its course, to hollow out nature by extracting what lies within it, to disrupt its homeostatic equilibriums. But this does not change nature's essence as Nature opposed to Human, as Nature in so far as it is non-Human. Nature's role as the Great Outside of the Human is not up for questioning. Paradoxically, it is assumed to remain (ontologically) the same even as it is made to change (geologically, geographically, biologically, etc.) by human action. It remains reality out-there, existing independently of how it is perceived, prior to statements made about it, in a definite and singular form (Law, 2004, p. 23 *et seq.*). It can be seen,

⁶Hobbes, Rousseau, and Locke had fundamental divergences on several topics, which cannot be discussed here. Nonetheless, they shared the general argument mentioned.

⁷He might modify his lifestyle as a response to altered environmental conditions, but this is another matter altogether.

interpreted, measured, classified, used, etc., precisely because of its ontological stability.

The Society/Nature divide is a fundamental foundation of Western modern thought patterns, which are inherently dualistic (Santos, 1991, p. 14 *et seq.*; Santos, 2006, p. 91 *et seq.*; Plumwood, 1993; Said, 2003; Castro-Gómez, 2005; Lander, 2009)^{8,9}. There are many dichotomies that play a relevant role in Western modernity—Mind/Body, Self/Other, White/Non-white, Metropole/Colony, West/East, and so forth. But Society/Nature, alongside Subject/Object and Male/Female, are the fundamental modern dichotomies in reference to which all others work (Plumwood, 1993, p. 41 *et seq.*). Importantly, modern dichotomies are expressions of hierarchical relations, one of the terms being privileged and the other subaltern. As Plumwood (1993, p. 41 *et seq.*) argues, this hierarchical logic is where the command role played by the former three dichotomies becomes clear: the privileged term of every other dichotomy—Mind, Self, White, Metropole, West, etc.—tends to be seen as having characteristics associated with Masculinity, Society, and the active and rational Subject, whereas the subordinate term—Body, Other, Non-white, Colony, East, etc.—tends to be associated with Femininity, Nature, and the irrational (in the sense of being incapable of rational thought) and passive Object.

This hierarchical logic is clear in the dominant conceptualization of Society/Nature. The mythologem that is the state of nature is what one leaves in order to collectively create a social existence, the only one that truly matters, the one that, although imperfect, is far better than the alternative of nature—with its chaos, dirtiness, discomfort, aggression, etc. And we must keep in mind that, within this paradigm, nature is in fact the only alternative to society. It is the sole alternative because dichotomies are exercises in totality-as-way-of-ordering-reality, i.e., they are representations of a universe in which nothing can exist outside either one or the other of the two entities in relation, thus conceptually eliminating even the

imagination, not to mention the *praxis*, of an existence unrelated to this logic (Plumwood, 1993; Santos, 2006, p. 91 *et seq.*).

Most sociological research on issues of the environment implicitly solidifies this philosophical stance. Uncritically taking for granted that there is something fundamentally different (i.e., better) in humanity (or society, or culture, or whatever else one chooses to call it), this heterogeneous field of inquiry tends to practice a “sociology of the social” (Latour, 2007) which, paradoxically, is extended from the social to its outside—without ever truly rearticulating the terms of their relationship. For Latour (2007, p. 160 *et passim*), a sociology of the social is doomed to be unsuccessful in its enterprise of understanding the uncertainty and dynamism of human life because it tries to explain the social by the social instead of focusing on the myriad processes of association of human and extra-human life-elements by which both “the social” and other realms of thought and practice are enacted. The practice of a sociology of the social to study issues considered to be outside the social creates an epistemic conflict: not only should the social be explained by the social but nature, for centuries understood in Western modern thought as explaining itself as much as society does (as long as science was able to progressively determine its/their laws of operation), now also is (at least in part) explainable by the social¹⁰. The passivity of nature characteristic of Western modern philosophy, opposed to the reflexive action of humans, is thus reinforced—even in narratives about the Earth’s revenge on humanity because of the damage the latter inflicts upon it nature’s action is re-action, making humanity into the true actor of the story insofar as without it no movement would have been made by the other term of the dichotomy.

A sociology of the social can do nothing but fail when trying to understand the heterogeneous interrelations of human and extra-human life-elements. It fails by design—albeit not reflexively so—because such a sociology is firmly grounded on the Society/Nature divide and, from this standpoint, multiplicity is not visible. If it cannot be seen, the myriad connections between different life-elements cannot be made into this sociology’s central research topic. As such, the worldly relations explored by this field must be reduced to those that are understandable in terms of Society/Nature. In this manner, as a starting point, the world’s life-elements are distributed into the categories of this dichotomy. When research starts, this has already been done, which leads to the placement of the elements of the two categories in relation *to* each other—fundamentally distinct, one of them acting over the other. If they are in relation *to* each other, they cannot be in relation *with* each other. This would presuppose that there are more than two elements in relation, it would

⁸One should bear in mind that the idea that there is a difference between mind and body, as well as between humanity and nature, is not an idiosyncrasy of Western capitalist modernity (Plumwood, 1993, pp. 69–103 *et passim*). However, as Moore puts it, “capitalism was the first civilization to organize itself on this basis” (Moore, 2016b, p. 84).

⁹Law and Lien (2012a) remind us that nature and society (or culture) are paradoxically both coherent and non-coherent in Western modernity. On the one hand, there is an undeniable will to make them singular—only one Nature and one Society, which are the same everywhere. On the other hand, since both nature and society are enacted by the practices of actor-networks that are bound to particular places and temporalities, each local network enacts—slightly or pronouncedly—different ontologies of nature and society, and therefore different forms of their relationship. But even if no two enactments of Society/Nature are the same, at any given space-time, the Western modern dualism of Society/Nature that is being enacted tends to be (re)presented as singular (i.e., as *the* form of Society/Nature). And, since these different enactments coordinate themselves in various ways, they converge (dynamically and contingently) to form one ontology of Society and one ontology of Nature—that is always dependent on their multiplicity. In this manner, much like Bauman (1989, 1991) has shown, Western modernity’s inherent ambivalence emerges as its defining characteristic, making ontological multiplicity not that which negates ontological unity but rather that upon which this unity is made (Law, 2002, 2004; Mol, 2002; Law and Lien, 2012a,b). We will return to this in the conclusion of this essay.

¹⁰Nature is now *at least in part* but not *entirely* explained by the social. The extension of a sociology of the social to the study of phenomena historically considered to be outside of society presupposes that natural phenomena are conditioned by human action. As such, what happens in society changes nature—geographically, geologically, biologically, even if not ontologically—, making nature only understandable if society is taken into account. But this logic does not negate scientific specialization, i.e., it does not deny that there are natural phenomena that can only be understood by the natural sciences—even if even the latter have increasingly started to take into account a (mostly homogenized and abstract) role played by Humanity in the shaping of the phenomena they study.

presuppose that worlds are not yet taxonomically distributed into categories, leaving their life-elements relatively free to roam and communicate with one another with disregard for analytical borders. It would assume that these worlds are not only where these life-elements act and exist but also that they are the contingent and dynamic result of this very action and existence—a form of existence-as-action which can only be carried out by the efforts, work, and energy of space-time localized humans and extra-humans.

This leaves a sociology of the social with only one way of conceiving human-natural relations. If life-elements do not interact in ways that enact worlds—which, among other things, perform-contain contingent stabilizations of nature and society—, then, it is from within each of the two realms of Society and Nature that all things must emerge, eventually overflowing from one to the other. In other words, a sociology of the social can only conceive a world in which phenomena specific to one of these realms condition existence in the other. This is a cause and effect model of limited interrelation in which, generally, human action—the action of the Human—develops through human-specific processes that occur in the environment of Nature. There is no significant interplay in the generative process by which these phenomena start; they occur because humans do things with one another. But what they do together has such a magnitude that converts them into causes of—mainly damaging—natural processes (e.g., deforestation, emissions of greenhouse gases). Human actions emerge as causes of these phenomena, leading to a set of consequences which occur in the realm of Nature, depleting and degrading it. This can, eventually, come back to haunt us; but we alone caused it and the second level consequences—from human to nature back to human—by which natural phenomena with human causes damage Society do not make Nature into a true actor in this story. Granted, this cause and effect mode of thinking can be made into something complex, attuned to the idea that different human processes can combine themselves to cause one outcome and that the same human phenomenon can contribute to several environmental consequences. But this only works if the Society/Nature divide is accepted and validated. And even then this limited conception of action and interaction is inherently incapable of seeing much of the actions and interactions by which the worlds in which we—humans as well as others—live are collectively enacted.

Only by rejecting this dichotomy as something that exists *a priori*, as something that predates action(s), and by understanding it as the contingent and dynamic result of (both human and extra-human) action(s), can multiplicity be taken into account. The multiplicity of heterogeneous relations between different life-elements—human, animal, plant, or mineral—is what enables each and all of them to act and to enact different arrangements [or, in Moore's (2016b) term, “bundles”] of human and extra-human (Callon, 1986; Law, 2002, 2004; Mol, 2002; Latour, 2007, 2010; Haraway, 2016; Moore, 2016b). And the life-elements that are distributed into nature or society—which are not predetermined once and for all but rather are the object of historical and spatial conflicts, as black slaves and most women could attest—act in ways that make inappropriate the cause and effect thought models of sociology of the social's

study of the environment. When different life-elements come together to act—both in peaceful and (mostly) in conflictual ways—, they are not *a priori* “nature” or “humanity” but are thus made through and along their collective actions. And the actions of different networks of human and extra-human life-elements constantly overflow each of the networks that originally performs them to reach other such networks, creating multiple flows of mutual communication between what is, at a certain time and in a certain place, constructed as social and natural.

Given these shortcomings, a sociology of the social provides an inadequate framing for the understanding of the myriad relations between humanity and nature. No matter how critical it may be, research developed within this paradigm falls back into a form of Western modern reification of both Society (or Humanity, etc.) and Nature. In other words, it starts from an implicit decision to distribute the world's life-elements into these two—and only these two—categories and then proceeds to ascribe them two ontologically incommensurable essences. It is only if this conception and practice of sociology is rejected that it is possible to comprehend the myriad interrelations between (human and extra-human) life-elements. In order to move beyond this paradigm, after having started to explore the conversion of the extra-human into Nature, we now continue the discussion by looking at the enactment of Nature as the environment.

NATURE BECOMES THE ENVIRONMENT OF THE HUMAN

Perhaps the main shortcoming of the extension of a sociology of the social to the study of the relations between human and extra-human is immediately visible in the expression “environmental sociology.” What does this sociology deal with? The environment of something that does not belong to it. It deals with reified nature, understood as the outside that is all around equally reified humanity¹¹. As Serres puts it, “the word *environment*, commonly used in this context (...) [.] assumes that we humans are at the center of a system of nature” (Serres, 1998, p. 33).

Such a sociology most definitely does not study the dynamic and heterogeneous interrelations between different things of and in the world, it does not highlight how these temporally and

¹¹ Although we are discussing the specific case of environmental sociology, other environmental social sciences deal with the non-human in a generally similar fashion: they accept and solidify the fracture between Society and Nature, they grant a privilege to the Human, and they contribute to the transformation of nature into mere surrounding of *ego cogito*. Different social sciences have historically approached the environment in different ways. But, insofar as their practitioners regard what they study as the “environment,” these social sciences also share an epistemic positioning. A specific social science, sociology included, can have practitioners focused on understanding the socioecological enactment of worlds, as well as practitioners who study the human (or social, etc.) dimensions of “environmental” phenomena. The latter work in the same *episteme* as environmental sociologists, even if the former might not. Since this is a Western modern conception, in general terms, the natural sciences subscribe to the same conception of nature-as-the-environment-of-the-Human, albeit their focus is on the other side of the divide (with some researchers trying to bridge it without unmaking it, much like what happens in the social sciences).

spatially specific interconnections between human and extra-human life-elements are precisely the processes by which worlds and those who live in them are collectively enacted. In short, it does not address the various forms of creating certain space-time specific arrangements of life, i.e., of creating contingent and precarious realities and of distributing their component elements in them by processes of categorization as human and other-than-human (Law, 2004; Latour, 2007, 2010; Debaise et al., 2015; Haraway, 2016; Moore, 2016b).

Instead, sociology starts from the positive exception of the Human. In Western modernity, given the hierarchical relation of the terms of the duality that is Society/Nature, the Human is not only outside of the non-human; it is above it. It is epistemologically, ontologically, and morally superior to Nature¹². Nature appears in relation *to*—and never *with*—humanity, merely as the *milieu* of its life chances, as the resource reservoir from which humanity derives “natural resources” and, depending on space and time, as *locus* and *arche* of potential threats to its life.

As Foucault made clear, the emergence of a biopolitical rationality of government¹³ in eighteenth century Europe elevated the concept-*praxis* of (human) population to the role of central subject-object of intervention (Foucault, 1980, 1994, 2006, 2009, 2010). Around this period, the exercise of power took as its main preoccupation the protection of the human life of the collective that is population, aiming to increase its life opportunities by guaranteeing that its behavior did not deviate from statistical-scientific normality in ways that endangered it. The consolidation of industrial capitalism, the maintenance of colonial residents and administrations, and military strength-in-numbers within (as well as outside) Europe, all required large quantities of relatively healthy human beings. In order to meet this requirement of protection of human life (at least of that human life which power-knowledge conflicts lead to be placed into categories of the Human), governmental interventions became more effective by indirectly guiding these human collectives instead of directly prescribing and adjusting their conducts. As such, governmental exercises assumed the form of interventions on the *milieu*, the environment in which populations lived, aiming to change the manner in which collective phenomena were shaped by changing the conditions which framed the possibilities for each unit of the population to act (Foucault, 2009, p. 29 *et seq.*). The underlying logic is simple to explain, even if the processes by which it is enacted are very much complex. Want to decrease mortality rates and increase the general health of the inhabitants of a certain city? Don't prohibit individual behaviors that make people sick, like unsanitary eating or hygienic habits. Don't threaten individuals with the strong arm of the law in order to stop them from doing what has been scientifically discovered to be harmful for them.

¹²The Human is morally superior to Nature insofar as ethics is defined solely as an affair of humanity. Nature is not less moral, it is not immoral, it simply is—and in that pure existence, it is amoral in reference to the Human who thus becomes the only potentially moral entity.

¹³“Government” is understood by Foucault (1983, 2009, 2010, 2012b) as the “conduction of conducts,” which always occurs within the framework of a given governmentality, i.e., a certain “art of government” or “rationality of government.”

Instead, construct and maintain centrally regulated urban sewage systems, create a process of regular garbage collection, or lower taxes on food rich in protein and vitamins.

Granted, Foucault's focus is not on the environment understood as Nature—even if the phenomena which affect a human population's life are both “natural” and “social”: laws, commerce, traditions, or taxation, as well as food, climate, or disease (Foucault, 2009). Furthermore, his periodization of Western modern intervention on the environment in order to govern life is off by some 200 years (McBrien, 2016; Moore, 2016b; Parenti, 2016). But his insight on the central role played by the environment of humanity in Western modern governmental exercises must not be downplayed¹⁴. If one dates the start of Western modernity to the transatlantic colonial arrival of 1492 (Wallerstein, 1993, 2004; Dussel, 1995; Mignolo, 1995, 2000; Lander, 2005; Quijano, 2007; McBrien, 2016; Moore, 2016b), it becomes clear that humanity (at least that part of humanity which arrived on American shores and its descendants) has since then constructed the extra-human as being up for grabs.

This is the geohistorical¹⁵ moment of the start of the Western modern logic of “mastery and possession” of nature—“the master words launched by Descartes at the dawn of the scientific and technological age, when our Western reason went off to conquer the universe” (Serres, 1998, p. 32). As Dussel (1995) argues, the *ego cogito* was historically preceded by the *ego conquiro*, the Human who, having arrived outside of Europe, immediately defined the world of the non-human as existing solely for his benefit. This was the premise behind the definition of the “New World”—and, with it, of the totality of the non-human—as *terra nullius*, mere nature without humans which could for this motive be freely appropriated by humanity (Johnston and Lawson, 2005, pp. 364–365; Mignolo, 1995, p. 260 *et passim*; Plumwood, 1993, p. 111, pp. 161–163; Wolfe, 2006). The process by which large portions of humanity were relegated to categories of Nature-outside-humanity was simply the necessary condition of this

¹⁴See Parenti (2016, pp. 170–171 *et passim*) for a theoretical framing of Foucault's biopolitical logic of government through the *milieu* in terms that make it possible to mobilize his thought in the study of the multiple interrelations between human and extra-human life-elements. Parenti does this by highlighting the dimension of biopower which deals with the enactment of non-human nature(s) as a way of enacting specific human arrangements—which, given the necessary interconnections between human and extra-human implicated in these power-knowledge exercises, by definition makes them into specific human-and-extra-human arrangements. He calls this dimension of biopower “geopower”: “if biopower is about harnessing, channeling, enhancing, and deploying the powers of bodies at the scale of territorially defined populations, then *geopower* is similarly the statecraft and technologies of power that make territory and the biosphere accessible, legible, knowable, and utilizable” (Parenti, 2016, p. 171). The extension of Foucault's work to issues of human-and-extra-human enactments of collective life is being carried out by the environmentality (i.e., the environmental governmentality) school of thought. A brief exposition of environmentality's general stance can be found in Malette (2011).

¹⁵According to Moore, the multiple interconnections between human and extra-human life-elements through which material-symbolical worlds are enacted makes geology a fundamentally historical phenomenon. As he puts it, “the co-produced character of resource production, unfolding through the human/extra-human nexus,” which he names “the *oikeios*,” turns geology into “geohistory”: “Geology, in other words, becomes *geohistory* through definite relations of power and production; these definite relations are geographical, which is to say they are not relations between humans alone” (Moore, 2016b, p. 95).

operation of humanity's mastery and possession of the world of the non-human. So, a double disqualification is at work in Western modern paradigm's conception of Society/Nature: on the one hand, to the Human belongs the world, subordinating nature to humanity; on the other hand, the Human is reduced to the part of humanity which in fact masters and possesses nature, *de facto* and/or *de jure* de-humanizing most human beings (in various ways), thus disqualifying them as they are placed in the concomitantly disqualified space (and time¹⁶) of nature (Dussel, 1995; Moore, 2016b, pp. 78–79 *et passim*).

This is the paradigm in which environmental sociology moves itself. What it sees and how it sees it are strongly conditioned by the manner in which nature is transformed into the environment of humanity. As environment, nature is enacted as the mere surroundings of the Human, the latter existing at the center of an undeniably anthropocentric cosmos. Since this is a Western modern cosmos, *Anthropos* is clearly defined. He is *ego cogito* but that is not all that he is. *Anthropos* at the center of the universe, *Anthropos* for whom the universe exists, is also a capitalist being—perhaps this is what he primarily is, as the world-ecology school of thought argues by defending the “Capitalocene” as the most precise concept to encapsulate the current geohistorical era (Moore, 2016a,b). As such, within the Western modern paradigm, nature is enacted as the environment of *homo oeconomicus*.

As the environment of modern *homines oeconomicae*, nature—or, to be more precise, all supposedly non-human elements of the anthropocentric world—are made into resources to be conquered, dominated, and appropriated (Serres, 1998; Moore, 2016b). The reification of the extra-human as Nature is the first step of a process by which all discrete units of this Nature are enacted as potential resources to be used and depleted with all the might and the right the Human confers upon himself at the expense of all other beings and things. The environment of humanity is humanity's reservoir of potential resources. In this manner, nature-as-environment loses any meaning in itself and all of its potential significance derives from the use Western modern capitalist humanity gives it. Its lack of meaning outside of Western modern capitalist standards makes reified nature into an entity whose discrete units, both those that are known and those that might be known, are made into things-as-potential-commodities. It is not the case of the non-human being immediately enacted as commodity. Rather, it is enacted as something that, in itself, is nothing besides a collection of smaller things, each one of them potentially commodifiable¹⁷. In other words, nature-as-environment has no meaning besides that which Western modern capitalism is able of giving it and each

of its components, and this societal model is only able to give meaning to commodities (or, to put it more precisely, it is only capable of ascribing meaning to something by commodifying it). At any given time, the environment has some discreet units that are not commodified, as well as others that are. According to the space-time specific necessities of capitalist modernity, the life-elements that are categorized as any form of Nature are brought from the field of potential commodity to that of actual commodity (and vice versa), thus expanding the total field of capitalist commodification of the non-human world¹⁸.

This *modus operandi* of commodification by grabbing parts of the environment and re-signifying (i.e., re-enacting) them as things with mercantile value transforms these life-elements into “fictitious commodities.” For Polanyi (2001, pp. 71–80 *et passim*), a process of commodification has a “fictitious” character when it ascribes market value to things that were not produced with the explicit intention of being sold as merchandise. Thus, the commodification of such things de-signifies them insofar as the market is fundamentally incapable of exhausting their total meaning. In other words, they are far more than something with market value and to transform them into commodities is to reduce all of their cultural meaning to market criteria, which makes them into elements of the world whose total significance capitalism is not able to grasp, even though it is very much capable of using and abusing them. Polanyi's foremost examples of such “fictitious commodities” are money, labor, and land—the last of which he describes as “the natural surroundings in which [society] exists,” making “land [into] only another name for nature” (Polanyi, 2001, p. 75).

Polanyi's discussion of “fictitious commodities” is framed in epistemological and ontological terms that are conflictual with the position we espouse in this essay. He is clearly conceptualizing commodification through the lenses of Society/Nature, reifying land-as-environment, as well as essentializing the remaining “fictitious commodities,” as is apparent when he writes that “labor, land, and money are obviously *not* commodities: the postulate that anything that is bought and sold must have been produced for sale is emphatically untrue in regard to them. In other words, according to the empirical definition of a commodity they are not commodities. (...) None of them is produced for sale. The commodity description of labor, land, and money is entirely fictitious” (Polanyi, 2001, pp. 75–76). In this sense, when he writes that “land is only another name for nature”, he immediately adds that this nature “is not produced by man” (Polanyi, 2001, p. 75).

Following Moore (2016b)—and taking a cue from a staple position in STS and ANT—, we can argue that, in Western capitalist modernity, everything that is commodified is “originally” produced as a commodity (by being grabbed from the resource reservoir that is the environment and enacted as

¹⁶One of the upmost indicators of this disqualification is the representation of humans as existing at the head of the arrow of time, always moving forward through multidimensional-albeit-linear progress, whereas non-humans, in the state of nature, are immobilized—or at the very least very much slowed down—in a time of very little value by Western modern standards. See Fabian (2014) for a framing of this logic in terms of what he calls the “denial of coevalness.”

¹⁷This applies to human beings reified as part of Nature as well as to extra-human life-elements, i.e., to unpaid domestic labor developed in the *oikos* for the reproduction of human biological life as it turned into wage-labor as well as to fossil fuel reserves as they turned into one modern capitalism's main energy sources.

¹⁸See Moore (2016b) for a discussion of how capitalism functions by making a zone of exploitation of paid work-energy dependent on a zone of appropriation of non-paid human and extra-human work-energy. Life-elements are never placed in one of these zones once and for all but rather are moved from one to the other according to capitalism's space-time specific needs and capabilities.

a commodity). The point is that there is no such thing as Nature out-there with an original essence that puts it outside the collective action of human-and-extra-human arrangements by which space-time specific ontologies and worlds are enacted—some of them as commodities. The process of “originally” producing something as a commodity is precisely this enactment.

Nonetheless, Polanyi’s insight is valuable in two ways. On the one hand, it makes clear that commodification is inherently incapable of exhausting the potential meanings—the potential life—of the elements of the world(s) which are commodified (i.e., other enactments of these life-elements are possible and none has the totalizing capacity of exhausting all that any of them might be made to be). On the other hand, Polanyi’s argument highlights that the peculiar market-based enactment of some life-elements as commodities is inherently damaging, both to them and to the world(s) to which they belong to (i.e., which they, together with other life-elements, compose).

In this derivatively polyanian sense, the process of turning non-human elements of the world(s) into a series of “fictitious commodities”—i.e., into resources for human production and consumption, into things that exist solely to guarantee the life of the Human¹⁹—is at the very core of Western modernity. This societal model exists because the extra-human is turned (reified) into Nature, which in turn is transformed into the environment of the Human and dealt with (i.e., enacted) as a reservoir of potential commodities. It is this particular kind of commodification that enables the typically Western modern capitalist human modes of action and existence that do not reflexively take into account the manner in which different networks of human and extra-human life-elements act together to enact certain types of worldly arrangements (i.e., certain types of worlds). In other words, this sequential process starts with the reification of the non-human, follows to its conversion into the Great Outside, there solely for the use of the Human, then fragments this environment into discreet units, and lastly picks and chooses which units will be commodified in a given space and time. It is this process that enables the kinds of careless human action and existence that disregard the wellbeing of the extra-human, *in extremis* disregarding the very condition of possibility of its existence. Given that the different life-elements of the world(s) do not adjust themselves willingly to Western modern fragmentation of reality—or, to be more precise, Western modern’s enactment of fragmented realities—, the forms of human action and existence that are made possible by the sequential process of reification of the extra-human are both genocidal and suicidal. The practical symbiosis of human and extra-human life-elements of space-time specific networks, symbolically denied in Western modernity, implies that the uncaring disregard that leads to the extermination of the extra-human also describes a suicidal operation by which the Human disregards its own conditions of possibility, its own conditions of a future, of any future²⁰.

¹⁹The life of the Human should be understood as a specific manner of living symbolically valued in Western modernity.

²⁰See McBrien (2016) for a discussion of capitalism as a world-ecology inextricably linked to extinction, which the author frames in terms of the necrotic properties of capitalism. According to him, “capitalism was born from extinction, and from capital, extinction has flowed” (McBrien, 2016, p. 116). Capitalism is

If this is the “environment” in “environmental sociology,” then, this field of inquiry has a problem. Not one it can discard or correct but something more profound, which marks its very core, making “environmental sociology” inextricably linked to this enactment of the environment. As such, the only way of successfully facing this problem is to unthink the core concept of the environment. But given the intimate connection of this concept to the field of sociology that studies it, to unthink the environment is to leave environmental sociology behind in direction to a conception and a practice of sociology that has discarded the Society/Nature divide and taken as its focus the myriad interrelations between different life-elements of the world(s) by which contingent, precarious, and dynamic “multispecies muddles” (Haraway, 2016, p. 34 *et passim*) are enacted. This would be a sociology which, while being attentive of human peculiarities, would not presume humanity to be the only peculiar entity in the cosmos and would rather assume that giving due attention to the interconnectedness of human and extra-human life-elements of specific space-times is fundamental to the adequate understanding of the phenomena it deals with. In other words, in order to make environmental sociology relevant at a politically and intellectually fundamental level, it must be unmade and reforged into something very different from what it was and still predominantly is.

If the environment is part of what must be unthought, a field of inquiry that takes it to be its core concept—or at least one of its core concepts—cannot frame the right questions for the right issues, thus making it unable of providing hypotheses and coordinates for action which might be used to face the problems at hand. It is unable of providing these hypotheses and coordinates because it is not looking at the phenomena that need to be looked at. The prime example of this is perhaps the focus on environmental problems, many times conceptualized as an (the?) environmental crisis. There can only be an environmental crisis if the extra-human is reduced to the Great Outside of the Human. Only in this paradigm does human action damage what is fundamentally other-than-human, creating a sustainability problem.

Within this paradigm, many are the solutions proposed to this unsustainability of the life of the Human. These tend to be framed in the general terms of greening capitalism, of making sure that Western modern capitalism survives

not only a productive system; its productive process is inherently based on destruction and death. If capitalism is a necrotic socioecological system, then, it is simultaneously genocidal and suicidal. Capital accumulation is only possible through the conversion of life into death—into resources to be depleted or into things to be annihilated because they stand in the way of these resources. In this manner, “extinction is both the immediate success and ultimate failure of the real subsumption of the earth by capital; the ecology of capital is constructed through attempted erasure of existing ecologies—ecologies that include humans” (McBrien, 2016, p. 117). This logic highlights the inseparable link of genocide and suicide in capital’s necrosis insofar as it leads to a increasing production of negative value: if capital needs nature to appropriate and extinguish in order to generate value, then, the very process of capital accumulation decreases the part of nature that is available to be thusly appropriated, symmetrically increasing forms of nature that are hostile to this accumulation and cannot be incorporated into or avoided by this *modus operandi* in the *longue durée* (e.g., toxic waste, garbage, greenhouse gases). See also Moore (2016b) on the extinction of Cheap Nature by capital accumulation.

by trying to reduce the rate of world(s)-destruction, thusly guaranteeing the eternal reproduction both of this societal model and of its inherent destruction of worlds, including itself. The main approach to this is technocratic (Crist, 2016; Hartley, 2016), appearing in the form of proposals to reforest critical areas of the planet; of geoengineering projects (Altvater, 2016); of attempts to reduce greenhouse gases emissions by replacing fossil fuels with renewable energies or through regulated market trade of carbon credits (Vossole, 2013); and so forth. At best, these are all short-term palliatives aiming to minimize—but not to fundamentally combat—climate change and other “environmental” problems. All of these solutions are doomed to fail simply because what is problematic is Western modern capitalism itself—within which both the damages and the solutions are being enacted (Serres, 1998; Moore, 2016b)²¹.

Environmental sociology is, at most, a very minor player in this game of climate/environmental-palliative prescription²². But it does share with this technocratic approach the same core concepts of the environment and the environmental crisis, thus reflecting many of the same shortcomings that are apparent in policy-making, engineering, economics, the natural sciences, and other technocratic fields. So maybe it is time to leave environmental sociology behind. In the face of contemporary threats to planetary life, it is increasingly urgent to move on to the radical relationism of space-time specific multiple and heterogeneous arrangements of different life-elements of the world(s), both human and extra-human. If we start making this movement, the environmental crisis is shown as fundamentally inadequate as a problem with which we should concern ourselves. It is shown to be a life-and-death-enactment fraught with the same symbolical and material problems that have marked Western modernity since its beginning—the very same problems that have brought about a state of affairs in which very real dangers are upon us. Since the environment is a severely limited, blind, and extinction-prone way of enacting the extra-human, the environmental crisis is the wrong framing for these dangers.

²¹We do not intend to reduce all proposals to deal with the environmental crisis to their technocratic variations. There are other types of proposals, namely those emerging from the heterogeneous schools of environmentalism. Their discussion is beyond this essay. Nevertheless, it can be argued that most of them operate in the same epistemological and ontological framework of scientific and policy-related technocracy, and thus share the many of the same problems. Sometimes the solutions they propose are dependent on the same technologies as scientific and policy-related technocracy. But even when they are framed around notions of “going back to nature,” of living in harmony with a Nature that exist out-there, undisturbed by human action, these solutions are firmly rooted in Society/Nature. While seeking to denounce Nature’s degradation by Society, both entities are reified and solidly placed in relation *to* each other—and a relation in which humanity is the only true actor to be found among the multiple life-elements of the cosmos. The will to leave the environment undisturbed does so in more ways than one, making it impossible to leave the environment behind and move on to space-time specific enactments of worlds through the myriad interrelations of life-elements.

²²In general, all environmental social sciences are minor players in this game, with the exceptions of (behavioral) psychology and (neoclassic) economics, which have a relevant role in environmental policy making (Shove, 2010). Nonetheless, even economics and psychology have not shifted the dominance of the natural sciences in this field.

None of this means that all is well; far from it. Although we distance ourselves from certain discourses about the current and/or inevitably coming planetary (i.e., “environmental”) catastrophe²³, here, we stand with Latour (2011): one should give due attention to the Apocalypse brought about through poorly enacted realities of human and extra-human entanglement; it is not because the End has been repeatedly announced throughout history and never came that one should blind him or herself to the fact that profound and rapid changes to the biosphere are verifiable and very likely to increase in the near future, making the Apocalypse a significant material possibility—at least for humanity, but we can be sure that if we go down we will be taking others with us.

There is a vital crisis—literally a crisis of vitality, a crisis of life enactments—but this is a crisis of world(s)-building. It is a crisis of Western modernity and of the types of life-realities that are possible (and impossible) to enact within its boundaries. It is a crisis of a societal model that, as Marx (1975) reminded us, is based on the alienation of humanity from nature, making the latter into a mere means of guaranteeing human life—which is inextricable from the alienation of each human being from what he or she produces, from his or her own self, and from other human beings²⁴. This changes the problems we—both human and extra-human—have to face, making it inevitable to conclude that only through revolutionary change²⁵ of the Western modern capitalist societal model could the world(s)-building crisis be unmade—even if its consequences will very likely shape the conditions of possibility for most, if not all, future enactments of human-with-extra-human arrangements of life.

(DEFINITELY NOT) CONCLUSIONS: UNTHINKING FROM THE MARGINS

How can we leave the world(s)-building crisis behind? How can Western modern problematic enactments of the web of life be successfully unmade and remade in ways that do not oppress the world(s)’ life-elements, both human and extra-human? Unthinking the epistemic foundations of both Western

²³See McBrien (2016) and Haraway (2016) for a critical discussion of “catastrophism” and of how mainstream narratives on the Anthropocene reinforce this worldview.

²⁴See also Moore (2016a, p. 86 *et passim*).

²⁵Having just quoted Marx, the meaning of revolution could be misconstrued by some readers. We are not *a priori* framing it in any way, neither in terms of process nor in terms of teleology. By definition, the fundamental transformation of a societal model is revolutionary. And, also by definition, fundamental transformations are violent—sometimes physically, but always epistemologically and ontologically, and thus materially. But the specific character of such violent actions can only be defined by the actors who collectively develop the multiple space-time localized practices by which such transformations are brought about. Taking an example from decolonial historical processes, the “non-violent” Gandhi-model (Gandhi, 2006) of revolution is not necessarily less violent than the Fanon-model (Fanon, 2001, 2008), although they are carried out by very different sets of actors-elements and practices. The inherent violence of these processes is profoundly variable both in scope and in kind, and only during their development can it be decided and classified in any way. Analytically and politically, physical intra- and inter-species overt aggression is only one of the many forms revolutionary violence can assume.

modernity and of its predominant forms of knowledge, including the social sciences, is the first step for the much-needed reenactment of life. One of the things that this process leads to is to the reforging of environmental sociology into something quite different from what it has been. It leads to dropping the environment from a sociology that concerns itself with the multiple, heterogeneous, space-time specific relations of life-elements by which humanity and nature are contingently made and remade.

But how can this be achieved? Any answer to this question is fraught with the pitfalls of *hubris*. Aiming to provide definite answers to similar questions is a very Western modern stance. It is, without a doubt, possible to attempt to do so—but only at the risk of replicating the very paradigm that created the problems discussed in this essay, as well as many others. We do not have any such proposal to close what has been said. We cannot have it because what has been said is entirely open-ended. And since life is always locally enacted in particular places and times, by particular networks of human and extra-human elements, the problems of life can only be—precariously—dealt with by each of the multitudes that are implicated in its enactments. Answers for problems related to the enactments of life can—and quite likely need to—be inter-locally coordinated, but no one locality or actor is able of providing them for the others. All that we dare to put forward are tentative sensibilities and intuitions.

By their inter-local contingent and conflictual coordination(s), the multiple processes of life-reenactment that are needed in order to overcome life-and-death issues such as changes to the biosphere, deforestation, or the extinction of entire species, are inherently revolutionary. And revolutions are arduous things to make—especially when, like what is at stake in these cases of life-enactments, they cannot be made once and for all.

One cannot leave Western modernity by establishing something else in an instant. It is not possible to enact what one cannot imagine and our—individual as well as collective—imaginings are severely—albeit not completely—limited by Western modern habits of thought and practice. Given this, any revolution of Western modern forms of enacting life can only be done from within Western modernity itself. Fortunately, Western modernity is not homogeneous. It is a succession of life-enactments that have manifold forms, although they share some fundamental (i.e., paradigmatic) assumptions.

As Law and Lien (2012a) remind us, Western modernity enacts the Society/Culture divide both coherently and non-coherently. This societal model has an undeniable will-to-singularity. It attempts to construct singular ontologies of both Society and Nature that are valid everywhere. But, at the same time and with the same relative importance, even within Western modernity there are multiple enactments of society and nature. Each specific space-time makes and remakes their own version of both. This does not annul the will-to-singularity but rather makes unicity inherently dependent on multiplicity.

This is a relevant opening. It allows for revolution from within. It allows for the exploration of the multiplicity, contingency, and ambivalence that are intrinsic to Western modernity as a possible way of reframing what this societal model has tried to

solidify. In this manner, it might be possible to shake things up just enough to turn solids into fluids, to agitate life-elements just enough to make it possible for them to connect with each other in different, non-oppressive and non-extinction-prone forms. Unthinking what and how we know about the elements of life is one of the fundamental processes by which Western modernity can be productively and revolutionarily shaken through its non-coherences.

It is much more likely that this can be done not from the center(s) of Western modernity but from its margins. By definition, these margins are not outside of this societal model and of its predominant ways of knowing. But these are the places where Western modernity, through its non-coherences, comes into direct contact with the possibility of something other than itself. It is from here that a transformative exercise of “border thinking” (Mignolo, 2000)—or, rather, border unthinking—can be carried out. These margins are the places where ontologies and realities are not-quite-made, where they are almost-enacted, where they start to be performed by local networks of life-elements but are then interrupted and discarded²⁶. But even though they are not fully made, they make a statement about the potentiality of other ways of enacting the web of life. And even when these other forms of enacting ontologies of and relations between “nature,” “humanity,” and other categories, are dropped due to their impracticality or their high costs, their potentiality remains.

A sociology that deals with the multiple enactments of the web of life—and definitively not one that is “environmental”—can contribute to this border unthinking. It can do so by looking at how the world(s) can be, not in a metaphysical sense, but by exploring empirically partially enacted potentialities. It can do so by looking for those ontologies of nature, humanity, and so forth, that, although not completely enacted, are perceived and whose making is started by local actors only to then be interrupted and discarded for a myriad of reasons. It is from what can be (made to be) that it might be possible to productively fracture Western modernity’s crisis of world(s)-building in direction to a multiplicity of space-time localized socioecological enactments that do not subjugate life, whether it is contingently distributed and performed as human or as extra-human.

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²⁶See Law and Lien (2012b) for an empirical discussion of these not-quite-enacted ontologies in the case of salmon farming.

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Perceptions of Local Environmental Issues and the Relevance of Climate Change in Nepal's Terai: Perspectives From Two Communities

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The direct and indirect impacts of global climate change entail serious consequences for global biophysical and social systems, including the health, well-being and sustainability of communities. These impacts are especially serious for vulnerable groups in economically developing societies. While climate change is a global phenomenon, it is at the local level that impacts are most felt, and from where responses to climate change are enacted. It is increasingly urgent that communities possess the capacity to respond to climate change, now and in the future. Community representations of climate-relevant issues are critical to underpinning responses. Environmental representations do not directly reflect actual physical conditions but are interpreted through social and cultural layers of understanding that shape environmental issues. This paper investigates environmental and climate-relevant perceptions within two communities in the Terai region of Nepal; the city of Bharatpur and the village of Kumroj in Chitwan Province. Following mixed findings on levels of climate change awareness in Nepal, we set out to explore perspectives on the environment and climate change awareness by conducting 30 qualitative interviews with local people. The study found that issues linked to sanitation and cleanliness were most important in both communities, while reports of temperature and weather changes were less common and typically linked to local causes rather than climate change. Imagined futures were also closely related to current environmental issues affecting communities and did not discuss climate change, though temperature and weather changes were anticipated. However, when talk of climate change was deliberately elicited, participants displayed their awareness, though this was rarely linked to local conditions. We conclude that, in light of other pressing local issues, climate change is yet to penetrate the environmental representations of some communities and there is a need to address the disconnect between local issues and global climate change. Making climate change relevant at the local level by connecting to salient local issues and co-benefits comprises an important step in bridging the gap between more global awareness and its relevance more locally, particularly for communities at risk.

Keywords: climate change, environment, perception, community, local, Nepal, culture

INTRODUCTION

Climate change impacts are set to profoundly change global ecological and social systems, bringing about fundamental changes to human behavior (Evans, 2019). The complexity of global climate systems makes it difficult to accurately predict the nature of climate change impacts, though a degree of certainty rests in knowing that fundamental lifestyle shifts commensurate with the scale of climate change will be required if we are to limit the global temperature increase to 1.5°C by 2100 (Rogelj et al., 2018). In addition to average temperature increase, societies also face increases in the frequency of extreme weather events, air pollution and sea level rise, posing an array of physical threats to human health and well-being, both directly and indirectly (Watts et al., 2018).

Consequently, the impacts of sudden natural disasters (such as shock, emotional distress and post-traumatic stress), and cumulative stresses over time (for example, changes to livelihoods, economic opportunities and social support) from climate change carry serious psychological impacts for those affected (Clayton et al., 2015). These impacts are especially pronounced for citizens living in economically developing countries, particularly for those within developing countries who rely on natural resources to sustain their livelihoods (Aryal et al., 2014).

In addition to continued mitigation, societies will be required to adapt to current and future environmental change. Adaptation in this context refers to a community's capacity to deal with changes, reduce vulnerability to risks, and improve the well-being of communities (Bhatta et al., 2015). While action on climate change maintains a crucial global imperative (Gupta, 2010), variability in environmental impacts and sociocultural differences at the local level also highlight the need to better understand the contexts within which responses to climate-relevant issues occur (Adger, 2003). While global environmental issues such climate change are constructed in top-down ways through scientific, political and other cultural narratives (Adger et al., 2013), they are also blended with and filtered through more vernacular, localized forms of understanding (Byg and Salick, 2009).

In this paper we investigate environmental and climate-relevant perceptions in the context of two rural communities in the Terai (lowland) region of Nepal. Nepal is an economically developing country in South Asia that faces serious impacts from climate change including a predicted temperature increase of 2.8°C by 2060 and up to 4°C by 2090, snowpack melt, glacier retreat, shifting climatic zones, increased extreme weather events, increased periods of drought and erratic precipitation (Becken et al., 2013). In a country where agriculture is the principle industry for 80% of citizens (Paudel et al., 2019) and widespread poverty exists, many of Nepal's citizens are precariously positioned by climate change threats (Leichenko and Silva, 2014).

Following Smit and Wandel (2006), we take a bottom-up approach to environmental and climate-relevant perceptions at the community level. We discuss the findings from 30 qualitative interviews with community members, focusing on

the role of subjective environmental perceptions relating to current and future environmental issues, including community perspectives on climate change, with a focus on the impacts for human well-being. While scientific measurement of ecological impacts provides the foundation for mitigation and adaptation, community perceptions are also critical to ensuring that policy interventions fit community understandings and avoid being misinterpreted or rejected by the community (Leiserowitz, 2007). The Inter-Governmental Panel on Climate Change (IPCC) has also stipulated that local knowledge should be used to inform climate adaptation planning (Carter, 2019).

In addition to comprising physical phenomena, environmental issues, including climate change, comprise important social, cultural, and political dimensions that mediate perceptions of the physical (Hulme, 2009; Whitmarsh, 2011). These are both facilitated and constrained by cultural knowledge, expressed through social norms, practices, institutional structures and prescribed roles and ways of living. The extent to which climate-relevant communications, interventions and policy are received, understood and enacted by local communities therefore depends on the degree to which top-down standardized scientific narratives converge with, or diverge from the micro-contexts of localized forms of knowledge (Zinn, 2004). Culturally-filtered observations and experiences of environmental conditions are a crucial way in which citizens understand environmental conditions and processes of change (Bickerstaff, 2004; Hulme, 2012). Human cognitive biases also influence and distort environmental perceptions. For example, more unusual or memorable weather events tend to exert a stronger influence on perceptions (Trenberth et al., 2015).

Furthermore, perspectives of global climate change may be constrained due to being beyond human perceptual capacity. This means that other locally-salient issues may be perceived as more immediate (Weber, 2010). While people may attribute extreme weather events to global climate change, such interpretations depend on culturally-available narratives that construct such issues, whereas physical climate change is, arguably, only discernible over long time periods. Essentially, a single event cannot unequivocally be attributed directly to climate change, though an individual may or may interpret it as such, depending on their perspective (Hulme, 2014). Similarly, interpretations of local environmental conditions have been found to influence more global climate-relevant understandings. For example, in one study, local perceptions of deforestation, urbanization and air pollution framed explanations of climate change (Maharjan and Joshi, 2012). This suggests that people look for proximate and visible causes in the absence of wider understanding.

Nonetheless, studies have demonstrated evidence that communities who are more in touch with their surroundings are able to accurately detect environmental changes, such as seasonal temperature and weather fluctuations (Gurung, 1989; Tiwari et al., 2010; Poudel and Duex, 2017; Uprety et al., 2017). Other research has found that while community members are accurate in their perceptions of some seasonal and weather-related changes, they are less accurate at perceiving others (Myers et al.,

2013). Environmental impacts also affect different groups within a country or region differently, and not always uniformly (Gentle et al., 2014) and may even be experienced differently by different members of the same community (Maharjan and Joshi, 2012).

Climate change awareness has been reported to be higher in economically developed countries than in economically developing nations, a pattern also found for countries within Asia (Maharjan and Joshi, 2012). Other research has found educational attainment to be the strongest predictor of awareness (Lee et al., 2015). Cultural differences are also evident in terms of climate change risk perceptions; in Latin America and Europe, comprehension of the anthropogenic origin of climate change has been found to be the strongest predictor, while in several Asian and African countries, perception of temperature increase locally was most influential (Lee et al., 2015). Perceptions of temperature and weather change are widespread. Savo et al. (2016) conducted a meta-analysis of 10,660 change observations reported across 2,230 localities in 137 countries, which showed increases in temperature, and changes in seasons and rainfall patterns in 70% of localities in 122 countries.

Nepal is particularly susceptible to climate change, with change in the Himalaya accelerating beyond the global average (Zomer et al., 2014). In the Terai agriculture is the principle economic activity, with around 80% of the population dependent on farming for their livelihoods. Therefore, climate change carries significant risks for the economy, which indirectly affect food production and security. The situation is exacerbated by widespread poverty; in 2010 over 25% of the population subsisted below the national poverty line (Adhikari, 2018). Poorer groups within society are more likely to be exposed to climate stresses and possess fewer resources to adapt (Gentle et al., 2014; Leichenko and Silva, 2014). Nepal is divided into three ecological regions comprising the *Terai* (lowland), *hill* and *mountain* regions, each of which is characterized by different ecological and climatic conditions. The Terai forms a fertile plain located in the south of the country where the majority of food production takes place, and is also the most densely populated region (Paudel, 2012). Of relevance within Nepal, food shortages due to seasonal changes, infestations of new crop pests and a decline in soil productivity have been recorded (Paudel, 2012).

Public awareness is seen as a major limitation to climate change adaptation within Nepal (Withana and Auch, 2014). While some studies have found high levels of climate change awareness amongst Nepalese citizens (Becken et al., 2013), other research has found awareness to be low (Gallup, 2009). In a cross-national study of 5,060 households, Tanner et al. (2018) report that climate change awareness was low (<50% were aware of the phenomenon even if they had been aware of changes in the weather). Awareness in urban areas was lower than in rural areas (56% v 46%), and very low in mountain areas (63% had not heard of climate change). There were also significant proportions of citizens who did not perceive that the climate was changing. Maharjan and Joshi (2012) report that among the Chepang community only 11.8% of respondents had heard of climate change; of those, only 4.8% were able to relate the phenomenon to changes in weather patterns, temperature, rainfall, wind, floods, landslides, and environmental change.

Research on community perceptions of environmental and climate-relevant change in Nepal has recorded perceptions of warmer summers (Tiwari et al., 2010; Uprety et al., 2017); milder winters (Dahal, 2005; Maharjan and Joshi, 2012; Becken et al., 2013); more erratic rainfall (Chapagain et al., 2009; Paudel, 2012; Becken et al., 2013; Devkota and Bhattarai, 2018); increased periods of drought (Tanner et al., 2018); and more frequent foggy days (Shrestha et al., 2018). However, community perceptions are not consensual. Maharjan and Joshi (2012) report that while 47.5% believed that summers were getting warmer, nearly 10% reported that summers were becoming cooler and 38% perceived no change. In addition, 21% believed that winters were getting colder while 22% believed that winters were becoming milder. Furthermore, 37% believed that there was less rain overall, while 13–17% perceived no change in rainfall. They attribute this to differences in “visual salience”; whereby rainfall is more conspicuous and facilitates perception, whereas temperature change is less directly observable.

With specific reference to the Terai region, Maharjan et al. (2011) interviewed farmers in the Western Terai, with 90% of respondents reporting increases in climate-related risks (erratic rainfall, flooding, droughts, riverbank erosion, windstorms, hailstorms, insect infestations). Tiwari et al. (2010) surveyed Terai communities in which over 75% of participants reported delayed onset of the monsoon and changes in flowering and fruiting time for some plant species. Meanwhile, Manandhar et al. (2011) found that more than two-thirds of farmers in the Terai claimed to have personally experienced evidence of climatic change.

As a result of perceived environmental change in the Terai, and in other regions livelihoods and lifestyles are adapting to changing conditions. Khanal et al. (2018) surveyed farming households in Nepal to gauge adaptation practices across the three ecological regions of Nepal, reporting that 91% of households had adopted at least one practice to minimize impacts of climate change. Adaptation may be more anticipatory or reactive and distinguished by duration, scale of implementation (i.e., more local or more widespread) and focus (e.g., behavioral, institutional, economic, technological, informational) (Smit et al., 2000). In a study of climate change adaptation in the rural hill region of Nepal, Gentle et al. (2018) examined household responses in four villages. Adaptive responses to climate change in rural communities were found to be less coordinated and more reactive and unplanned rather than anticipated and coordinated.

Changes to agricultural practices constitute a primary focal point for adaptation and change. These have included changes in the times crops are sown and harvested (Maharjan et al., 2011), switching to more climate resilient crop varieties and tree and plant species (Maharjan et al., 2011; Paudel, 2016; Gahatraj et al., 2018), as well as increased use of pesticides, and income diversification (Gentle et al., 2018). Climate change is also perceived as benefiting some crop species (Rawal and Bharti, 2015). For example, mangos are being grown at higher altitudes than was possible in the past (Chapagain et al., 2009).

Within villages, water practices were changing to conserve water resources (Tiwari et al., 2010), and changes to diets have also been identified (Tanner et al., 2018), with less rice being

consumed due to the effects of climate on rice productivity (Maharjan and Joshi, 2013). Two-story houses are increasingly being constructed for food storage and as refuge from flooding (Maharjan and Joshi, 2013), while buildings are being oriented to withstand windstorms, incorporating single rather than double doors (Maharjan and Joshi, 2013). Seasonal migration and resettlement becoming more common (Prasain, 2018). People are also reported to be planting more trees and grasses on their own land as well as on communal land to protect communities from flooding, wind and dust (Tiwari et al., 2010; Maharjan et al., 2017). Withana and Auch (2014) report that afforestation is viewed as the most effective climate change adaptation strategy by communities.

In summary, perceptions of environmental conditions are key to informing behavior, including the need to adapt to a changing climate. In the context of Nepal, adaptation is particularly salient and it is critical that communities respond to environmental risks in ways that ensure the well-being and futurity of those communities. Given that studies of climate-relevant perceptions have reported mixed findings in terms of awareness, we seek to clarify how Nepalese communities view environmental issues now and in the future. Such perceptions act as important indicators of how local communities make sense of what is happening in their surroundings.

Following our review of the literature, the following questions guide the study approach:

- How do communities in Nepal's Terai perceive their environment?
- How do they see that environment changing in the future?
- To what degree are local communities aware of climate change?
- What is the relative importance of climate change compared to other issues environmental affecting the community?

MATERIALS AND METHODS

The following subsections describe the study design and procedure. Broadly, this comprised a qualitative approach using semi-structured interviews with residents in two communities in the Terai region of Nepal. Thirty interviews were conducted in total. 15 interviews were conducted with residents of the village of Kumroj, a small rural community bordering Chitwan National Park. Another 15 interviews were conducted with residents of Bharatpur, an urban community approximately 12 miles (20 km) away. For each group, we were interested in gauging perceptions of salient environmental issues, including climate change. We selected two different communities to explore the degree to which locally salient issues varied and informed discussions. Before commencing fieldwork, the study design was scrutinized and approved by the Research Ethics Committee in the School of Psychology at Cardiff University.

Participants

Fieldwork was conducted in January and February 2016. A purposive sampling strategy (Silverman, 2015) was used to try to generate a range of different sociodemographic profiles within each community in terms of age, gender and ethnicity. All

participants were aged 18+ and resided in either Bharatpur or Kumroj, both in the Chitwan district. Bharatpur has a population of 280,000 and is one of the largest and fastest growing cities in Nepal. While it is home to a number of small-scale processing industries, agriculture remains the biggest industry. Kumroj is a small town with a population of 8,000. Kumroj borders Chitwan National Park, the first National Park created in Nepal (in 1973). In recent years in-migration has increased pressure on land for settlement and agriculture. Increasing tourism has put additional pressure on the landscape. A number of community development initiatives have attempted to confer Kumroj as an ecological exemplar, with the creation of a community forest initiative and grant funding to encourage domestic biogas installation to reduce deforestation, launched on World Environment Day, 2013. Around 80% of households within Kumroj have installed bio-gas converters to reduce reliance on the forest for fuel.

To arrange fieldwork with local people in Kumroj, we contacted the offices of the World Wildlife Fund for Nature (WWF) in Kathmandu, who had been involved in community development projects in Kumroj. Through WWF, we were able to negotiate access through local community leaders who helped us to recruit participants. Prior to our arrival, the study was advertised by word-of-mouth by community leaders, who identified potential members of the community willing to be interviewed. Extra care had to be taken in gaining access to participants, establishing contact and opening communicative spaces with the community, which could be damaged if pushed too quickly (Wicks and Reason, 2009). The study was promoted as a "*lifestyle and behavior*" project and avoided making reference to the environment, as we wished to avoid recruiting only those members of the community whose motivations and values were strongly pro-environmental. At recruitment, a brief screening procedure was applied; individuals were screened to ensure that they were 18+ and aware of the broad purpose of the study and what would be required in terms of participation. We also purposefully recruited individuals to ensure that we had a roughly equal split in terms of gender, as well as diversity in terms of age, ethnicity, occupation, and income. See **Table 1** for subsample demographics.

To recruit our Bharatpur subsample, we collaborated with the Institute for Social and Environmental Research Nepal (ISER-N). ISER-N is a research and development institute that conducts applied research to inform policy-making and effective sustainable development initiatives across local communities. Using a similar method to the above, ISER-N acted as our guide and point of access to the local community and advertised and recruited a subsample of local people who had expressed an interest in discussing their lifestyles and behaviors.

Procedure

Once participants had been identified, screened, and given further information about the study, they were invited to take part in an interview to discuss aspects of their day-to-day lifestyles and behaviors with the research team. Interviews were scheduled to take approximately one-and-a-half hours, but varied from 45 min to 2 h. A semi-structured interview method (Galletta, 2013) was chosen in which a standard set of questions was covered while also allowing flexibility for follow-up questions

TABLE 1 | Subsample demographics.

		All (n = 30)	Bharatpur (n = 15)	Kumroj (n = 15)
Gender	Female	13 43.3%	7 46.7%	6 60%
	Male	17 56.7%	8 53.3%	9 40%
Age group	18–24	6 20%	3 20%	3 20%
	25–34	8 26.7%	6 40%	2 13.3%
	35–44	5 16.7%	2 13.3%	3 20%
	45–54	6 20%	2 13.3%	4 26.7%
	55–64	0 0%	0 0%	0 0%
	65+	3 10%	2 13.3%	1 6.7%
	Not stated	2 6.6%	0 0%	2 13.3%
Household income per annum	Re –10,000	1 3.3%	0 0%	1 6.7%
	Re 10,000–19,999	0 0%	0 0%	0 0%
	Re 20,000–29,999	2 6.7%	2 13.3%	0 0%
	Re 30,000–39,999	0 0%	0 0%	0 0%
	Re 40,000–49,999	3 10%	1 6.7%	2 13.3%
	Re 50,000+	23 76.7%	12 80%	11 73.3%
	Not stated	1 3.3%	0 0%	1 6.7%

and exploration of other issues of relevance to participants. Such flexibility is an advantage in cross-cultural settings as this allows for greater exploration of cultural factors underpinning issues of interest (McIntosh and Morse, 2015; Hagaman and Wutich, 2017). All participants were required to give written informed consent prior to participation.

Questions in the interview protocol sought to contextualize environmental perspectives within people's wider everyday lives as far as possible. Questions broadly covered perceptions of the environment and the importance of environmental issues environmental problems (including climate change), engagement in environmentally-friendly behavior, the character, motivations for and consequences of behaviors, and comparisons with others in terms of acting in environmentally-friendly ways (see **Supplementary Information**).

The majority of interviews took place at participants' homes. Discussions took place on seats or woven mats in the front yards of houses rather than inside the building itself. A small number of interviews were conducted in other locations, such as a local café, or community building in the case where the home could not be used. We relied heavily on our collaborators and local community leaders to manage interview arrangements in line with our concerns about accessing members of an unfamiliar culture and wishing not to transgress social boundaries. Because people's yards are the area of the home where a lot of day-to-day interaction takes place, providing socially appropriate spaces for interaction.

One of the disadvantages of holding interviews outside was that on some occasions the research team's presence would attract the curiosity of other family members, neighbors and other locals. The sudden presence of others could occasionally alter the dynamic of the interview interaction, particularly if the others who were present began talking or offering their

own perspectives. On one or two occasions the research team had to ask bystanders to limit their contribution so as to allow the participant to speak. To a cultural outsider this would appear potentially problematic and non-conducive to an appropriate interview context, which led us to consider this and other ethical considerations in conducting interview research in different cultures.

Ethical Considerations in Conducting Interviews in Different Cultures

Researchers typically assume that the communities in which they work will be aware of the concept of research and its value, though for many communities research is something abstract, distanced and difficult to make sense of in relation to their ordinary lived experience. This came across clearly in working with each subsample. In Bharatpur, participants were familiar with ISER-N and, owing to participating in other cross-cultural research, were more comfortable with the researcher's presence than participants in Kumroj, who had not been so exposed to researchers and the research process. Further to this, bridging communicative spaces is not confined merely to issues of translation and word equivalence, but of more conceptual differences in terms of the ways that different cultures define reality and categorize their experience (Fong, 2012). Language and culture are woven together in ways that require not only the translation of speech, but the translation of cultural meanings that are often concealed from those outside of that culture. In designing the interview protocol, we worked closely with our collaborators not only to ensure that questions were understandable, but that any cultural assumptions (for example, about the lifestyles, values, and practices of the community) were identified and addressed appropriately. All interview materials were double-translated.

Qualitative methods including interviews, also carry particular ethical implications in terms of power imbalance, where the discussion is primarily directed by the researcher (King et al., 2018). Assumptions about the identity of the western researcher (typically white, middle-class, and educated) on the part of the research participant construct interactional dynamics before a word has been spoken. Similarly, the reflexive researcher will not only consider how their own identity might influence communication, but how their assumptions about the community they are researching enter into framing interactions. While researchers may seek to embark on research practices that are non-exploitative and non-oppressive, researchers are nonetheless complicit in systems of oppression and should be aware of their own privileges.

The interview team comprised a male researcher (lead author) and a female translator to minimize any gender imbalance that might affect trust and participant disclosure, especially for female participants (Campbell and Wasco, 2000; Sikes, 2018). The translator also played an active role in facilitating each interview, asking additional questions and clarifying understanding, as opposed to simply translating questions and responses. It was felt that a combination of cultural insider and cultural outsider benefited the discussion; while the former helped to increase trust and disclosure, the latter encouraged more detailed exploration

of issues that might otherwise be taken for granted by those familiar with those issues (Dwyer and Buckle, 2009).

Conducting qualitative fieldwork in collaboration with translators can also compromise the quality and accuracy of the material generated. In an interview context, the translator adds an additional layer to the interaction. For example, the translator is likely to be more acquainted with the cultural nuances of the interaction than the researcher. Therefore, both the researcher and translator can affect the fieldwork process, as well as disrupting the flow of talk to allow for translation (Van Teijlingen et al., 2011). When fully transcribed, interviews can also show disparity between participant responses and translated responses. van Teijlingen et al. suggest that a way round this is to allow the translator to conduct the interview and only relay main points to the researcher, though this can be impractical, as well as excluding the researcher.

Prior to the interviews, considerable time was spent in developing and pre-testing interview questions. After constructing an initial set of interview questions in English, these were double-translated and then reviewed by our collaborators in Nepal. This was invaluable in not only identifying significant weaknesses in conceptual equivalence between Nepali and English versions of the questions (Larkin et al., 2007), but also in highlighting researchers' cultural assumptions inherent in questions relating to everyday life in "other" places. That is, while a translated question may be conceptually equivalent to the original, it still may not be understandable in another culture (e.g., where researchers from one culture assume that all participants in another culture will have the same access to resources, such as running water). Even when all care is taken with translation, translators may be unfamiliar with a particular geographical region or cultural group. Therefore, it is recommended that questions are pre-tested in the specific cultural contexts in which they will be used.

With reference to interview locations, our decision to hold interviews outside and not in a more private location was primarily guided by social conventions as well as pragmatism, though we acknowledge the active influence of the nature of the space within which such interactions take place (Gagnon et al., 2015). As mentioned at the end of the previous section, on occasion others were present at interviews in ways that influenced participant responses and could have constrained disclosure or breached informal assumptions about confidentiality (though interview questions were not considered to cover personally sensitive topics). Conversely, in discussing lifestyle and behavior issues, the home sometimes served as an exemplar in which participants described their activities in the context of the physical surroundings, which enhanced disclosure. In addition, conducting interviews in familiar environments can reduce the power imbalance between researcher and research participant (Gagnon et al., 2015).

Ethical considerations do not end at the point at which the interview concludes but influence ongoing reflections following the interview (such as translation, analysis, writing-up and dissemination) (Hoover et al., 2018). Acknowledging that translation imposes an additional level of interpretation on the spoken word (Caretta, 2015), we have tried insofar as possible

to contextualize accounts based on participants' direct speech rather than translators' interpretations of what was said. At the end of each interview, participants were provided with a verbal and written debrief in Nepali, in which they were given the opportunity to get in touch with the research team through appointed members of the local community and in-country collaborators should they have any further questions or concerns once participation had ended.

Analytic Approach

All interviews were digitally audio-recorded and translated and transcribed at ISER-N. Written field notes were also taken throughout each interview relating to points of interest and things that might not be captured by the recorder. An "in-interview" system of translation was used whereby questions and responses were translated between English and Nepali by the translator. This method of translation was primarily used to aid communication within the interview itself. When the interview recordings were translated, the translators re-translated participants' responses, which appear alongside the in-interview translations in the transcripts. This was done as the task of translating what at times were lengthy utterances in the moment, could have led to omissions and gaps, whereas in translating participant responses from the recordings utterances could be replayed and listened to repeatedly for clarity, thus better capturing what was said.

An episodic narrative approach was used as an analytic framework by which to explore participants' accounts of environmentally-friendly perceptions and behaviors. This approach treats perceptions and experiences as lived narratives situated within the wider society and culture (Flick, 2000; Jovchelovitch and Bauer, 2000). Narrative interviewing is interested in eliciting particular episodes or features of participants' lives and how they make sense of the world as embodied, culturally and spatially situated individuals (Raulet-Croset and Borzeix, 2014). Interview audio files and transcripts were analyzed using NVivo 11, supplemented by written field notes.

ANALYSIS

Our analysis combined several methods, which we outline here. In line with the early stages of a grounded theory approach (Timmermans and Tavory, 2012) we began by reading through transcripts to identify examples of talk that involved themes relating to health and well-being in the context of environmental issues. As much as possible, given inevitable researcher preconceptions and positions (Caelli et al., 2003) we sought to identify general themes and provisional topics of interest, without imposing a predetermined framework. This manner of bottom-up or inductive analytic reading of the data allows for the broadest possible range of salient themes to be identified. Once we familiarized ourselves with the material through repeated readings, we then developed a system of codes to more precisely categorize these themes. In order to do so, we used a version of template analysis, which is suitable for identifying themes in research data that is commensurate with

In the above account, a positive assessment of environmental conditions is formulated by drawing a comparison between past and present sanitation and sanitary practices. Whereas, in the past, communities were affected by diseases resulting from unsanitary conditions, this had now changed, providing a positive indicator of the local environment as a whole.

In addition to health risks from open defecation, providing proper toilets in rural communities such as Kumroj also minimized other risks from wildlife, and the discomfort of adverse weather conditions:

“If we don’t have a toilet, then we may have to face many difficulties such as while going outside for toilet then we might get attacked from snake or when raining it would be hard to go the toilet. And if we openly defecate then it will pollute the environment and as result we may have to suffer from different diseases, so environment is the most important thing to survive for everyone and we can’t imagine life without environment.” Kumroj, Interview B11).

For rural communities, development of sanitation was considered not only key to well-being, but also, implicitly, key to a good environment. Talk of sanitation in the context of evaluating the local environment also rested heavily on community awareness. What contributed to a lack of environmental quality in the past was not only that proper sanitation was unavailable, but that in the past, communities were less aware of the risks to health and well-being from poor sanitation. Risky sanitary practices were thus maintained as people did not know any better. In contrast, nowadays, communities were more aware of risks from inadequate sanitation and knew how to overcome issues such as contaminated drinking water. In this way, community awareness also contributed to positive judgements of environmental quality:

“The environment here is better in comparison to the past. . . These facilities didn’t exist. There had been problems of drinking water taps. The same tap was used. It wasn’t enough. In society, people had to drink water from wells. They had germs, smoke and dust.” (Bharatpur, Interview A10).

Similar to the accounts of the shift to a better environment through the development of toilet facilities and reduction in the practice of open defecation, an overall positive evaluation of the environment is constructed through comparisons of past and present. For many participants, issues of health, sanitation and hygiene formed the yardstick by which the overall environment was evaluated positively.

Waste and Pollution

While improvements in sanitation and hygiene across both communities provided a positive indicator of environmental quality, there was more ambivalence where participants discussed other issues indicative of environmental quality in their respective communities. For participants in both Bharatpur and Kumroj, distance from industrial development and proximity to green spaces were important factors associated with positive environmental assessments:

“The environment around here is ok, there is no industry and factory so it is not that much polluted here and we are nearby jungle so we have greenery, yeah, it’s good, it’s fine.” (Kumroj, Interview B5).

As illustrated in the above account, environmental quality was implicitly understood as relating to human well-being, in terms of risks from pollution. Such a location for the community, close to the jungle and away from factories, led to evaluations that the environment was good. Conversely, accounts of pollution from other sources within the community itself, suggested a rather different environmental evaluation. At the same time as some participants positively evaluated the environment being relatively pollution-free, others constructed it as a polluted space due to the way that plastic waste was managed. The problem of plastic waste disposal came up most frequently in Bharatpur:

“...looking at increasing population, there can be very dangerous pollution. I feel that it will increase, yes, increasing. The use of plastics is increasing and there is no awareness regarding how to maintain cleanliness, how to save us from the problem. They have no such idea. Due to increasing population density, such symptoms are evident.” (Bharatpur, Interview A14).

Concerns about plastic waste were tied to other concerns about local population increase and the perception that there was a lack of awareness amongst the community in addressing the issue. Such accounts implied that there were no alternatives to using plastic, therefore the problem was in disposing of plastic waste that littered the environment and did not decompose. The main problem causing the pollution was not the presence of plastic waste, but the method used to manage and deal with waste plastic. This chiefly involved collecting the plastic and burning it in open fires. While this resolved the problem of plastic waste littering the community, participants were concerned that the smoke polluted the air and posed risks to health:

“There is plastic around here and there. To dispose plastic, we need to burn it, and if we burn plastic it makes huge air pollution and affects people’s health. The other day I argued with one person not to throw plastic. We must use firewood for cooking and because of that there is again smoke in the air, because of a lack of cooking gas. That’s why it has been a very bad environment.” (Bharatpur, Interview A2).

In contrast to the previous extract constructing the local environment in positive ways as being relatively pollution-free, alternative perspectives such as the above led to very different evaluations of the local environment, with concomitant consequences for the health of the community. While the local community was aware of the contribution of existing informal plastic waste management practices to air pollution, it was nonetheless positioned as being powerless to change in ways that address air pollution as people are locked in to environmentally-damaging practices in order to manage waste and address basic needs. Similar to the need to use firewood for cooking due to shortages of cleaner alternatives, there were no alternatives and burning plastic waste was viewed as unavoidable.

Essentially, such accounts lead to a very different evaluation of local environmental conditions.

Conversely, in Kumroj, a municipal system for collecting plastic waste had been in place for some time, therefore the community's method of dealing with plastic waste was not considered to threaten local environmental quality as much as problems such as poor sanitation:

“People defecate wherever they want around the city area, there are toilets in here no toilets, so people openly defecated. So, I'm concerned about it... Otherwise, there is a facility to collect the waste from municipalities, the van comes and takes away waste. People collect the wastage plastic in sacks, then when the municipality van comes, then they take it away.” (Kumroj, Interview B6).

The account begins by constructing open defecation as the main issue threatening the environment in nearby Bharatpur, implying a negative assessment of the surroundings. This is contrasted with a more positive assessment where the speaker switches to talk about plastic waste management in Kumroj. Therefore, while plastic waste was a problem in both communities, in evaluating the local environment, the different ways in which plastic waste was managed were used to formulate contrasting assessments of environmental quality overall. These contrasting assessments may also connect to the wider importance of health and well-being, in which potential risks are offset by waste management practices in one community, but raised by plastic waste management practices in another.

Deforestation

While plastic waste did not negatively influence environmental assessments in Kumroj as it did in Bharatpur, there were, nonetheless, other issues affecting the community leading to negative environmental evaluations that were not reported in Bharatpur. For people in rural Kumroj, there was a closer felt connection to the neighboring forest as a source of environmental concerns. That is, forest conditions were more commonly invoked in environmental assessments by participants in Kumroj than in Bharatpur. The forest was seen as a valuable community resource, primarily as a source of firewood. Such talk occurred against a context of strikes and fuel shortages, further highlighting the importance of the forest as a source of firewood for local communities, which was being rapidly diminished due to increased demand:

“We restored the forest with a lot of hard work. The strikes have already led to twenty-five percent of the forest to deforest and if this goes on, the forest will be completely deforested in a year or two. There is a new facility called biogas, we have that facility but, we have seventy-five percent biogas but people are poor and some bring the firewood from the forest, steal it and sell it... People have to survive. Having to die today and struggling for it tomorrow isn't going to work. If you have to survive today, you'll have to work for it today. And if they don't have any other way they'll go to the forest and steal the firewood.” (Kumroj, Interview B10).

Despite attempts to increase forest cover and reduce reliance on firewood by providing biogas converters within local communities, this did not address the wider problem of sustaining local people's livelihoods, which caused further deforestation and the potential loss of the forest altogether. From this perspective, the amount of forest cover formed an indicator of environmental quality. Furthermore, for participants in Kumroj, the environment was also judged based upon perceived changes in the amount of wildlife that could be observed locally:

“I think the current environment is worse than the previous environment. I have noticed that the current environment is going down every day instead of going up. Because, previously when I used to go to the jungle I could see the wild animals very near, even sometimes outside of the jungle, but these days we have to go very deep into the jungle to search for the animals.” (Kumroj, Interview B14).

While the need for wood to sustain people's lives were commonly acknowledged within accounts of the pressures on forest resources in Kumroj, deforestation remained a significant concern.

Climate and Weather

While it was not foremost in terms of locally significant issues, participants in Bharatpur and Kumroj also referred to changes in climate and weather conditions in formulating their assessments of the local environment. These changes did not form the basis for positive evaluations of the local environment but appeared in negative or neutral assessments. Talk referred to a narrow range of changes. These mainly involved observations of temperature extremes in which summers were perceived to be increasingly hot, and winters increasingly cold. However, while these observations of climatic change were described causal factors were hardly mentioned. Furthermore, the phenomenon of global climate change was not spontaneously invoked in accounts:

“I would say it's okay, so far Chitwan's environment is fine, although here is not much forest and plants. In winter it's very cold and summer is getting hotter.” (Bharatpur, Interview A6).

What appears initially as a positive assessment of the local environment is tempered by a perceived lack of forest cover and greenery in Bharatpur. In addition, the speaker adds the casual observation that winter and summer are increasingly subject to extreme temperatures, though no reason is offered as to why.

In addition to temperature changes, the other way in which the environment was judged was based on fluctuations in precipitation. In such accounts, there was consensus that rainfall was becoming more erratic and less predictable, and that rainfall overall was decreasing, including at the wettest times of the year. Again, no specific reasons were ventured as to why this was happening:

“Yeah, I think sometimes, I think there's not enough or little rainfall during the rainy season.” (Bharatpur, Interview A1)

stable and consistent weather patterns. As weather patterns had become less predictable, community practices had undergone changes, highlighting the impact of weather-related changes on the local community.

Local Community Perceptions of Climate Change

The previous sections have shown that while participants in both communities spoke about issues related to changes to temperature and weather, both now in the future, these issues were typically unelaborated beyond the reporting of changes when unelicited, and only rarely connected to wider global climate change. Yet these perceptions often paralleled broader climate change trends. In order to gauge the extent to which participants were aware of climate change, we then asked directly whether participants had heard of climate change or global warming.

Using NVivo, we began by mapping climate change themes from participants' accounts in both communities, which then formed basic nodes through which to understand the various ways in which participants in both communities talked about climate change. The conceptual map is shown in **Figure 5**. We then looked at responses in more detail.

Changes in Temperature

Of the participants who were directly asked whether they had heard of climate change, only one or two had not, though nobody claimed to know more than a little. Responses were very similar across both communities. Nearly all participants in both communities referred to changes in temperature and/or weather locally. Extreme temperatures were the most commonly cited indicator, most often connected to hotter summers, but also less frequently linked to colder winters, as detailed above in the section on Climate and Weather. Generally, little was said beyond simply noticing change, though one important impact of temperature change in the Terai concerned the direct consequences for plant life:

“Well...hmm...actually I don't know the reason of global warming. I have heard that the snow of the mountains is melting these days. If it melts it will be hotter. The vegetation will be dry and can't survive, I heard this. It means the temperature increase may affect every living thing on the earth.” (Bharatpur; Interview A7).

Such talk reflects the importance of agriculture for many communities in what is Nepal's primary agricultural region; while the direct impact on plants was highlighted, other impacts of temperature change were not. The speaker also claims to be unaware of the causes of global warming. However, they construct a link between snowmelt on the distant mountains and temperature rise more locally, with potential impacts for the planet.

Links between climate change and health were rare, however, one speaker explained that hotter temperatures brought new disease risks to humans:

“What is there is that the rays of the sun, the layer between sun and the earth is what people call depleting nowadays, isn't it? This leads to an increase in heat. This heat has brought about different diseases. Like, mosquito bites cause various diseases. I have heard from the radio that climate change has adversely affected human beings.” (Bharatpur; Interview A14).

In explaining the causes of temperature rise that bring about health risks from flying insects, the speaker combines elements of ozone layer depletion and global warming. This reflects the way that lay understandings of climate change do not map neatly onto expert definitions, but often overlap with other environmental problems (Rudiak-Gould, 2012).

Changes in Precipitation

Following changes in temperature, particularly in the summer months, changes in precipitation were the other main symptom linked to climate change in both communities. An example of this type of perception is provided in Section 3.1.3, though talk of erratic or reduced rainfall was framed locally and very rarely always unconnected with global climate change. However, when the issue of climate change was deliberately elicited by the interviewer, a greater degree of acknowledgment was given to the influence of the phenomenon on local changes particularly in relation to agriculture:

“Because of global warming, there is not timely rainfall, nothing happens according to the growing seasons. For example, no rain in the rainy season but it is (rainy) in winter time. Nothing occurring at the right time, I guess this is all the impact of climate change.” (Kumroj, Interview B13).

Because of global warming, regular patterns of precipitation and the seasons had been thrown into disarray. This was of particular importance in the Terai in terms of agriculture, and was the primary way in which such changes to established patterns were recognized. For others, while erratic weather had recently been observed, it was of little concern as the weather tended not to be consistent but changeable day-to-day:

“Few years back there was heavy rain, but now there is very little rain, and the summer heat has increased since last year. . . I think it's not really concerning me because every day is different and going on in its own way, so I don't feel really concerned about it.” (Kumroj, Interview B12).

In general, accounts of changing temperature and weather were constructed in ways that assumed a transition from the stable and consistent natural patterns of the past, to a present in which established patterns had been disrupted. However, for those less concerned, changes were viewed as part of natural variability. Ultimately, when thinking about local conditions, climate change typically did not form a part of community perspectives unless introduced by the interviewer. The final section summarizes individual climate-relevant behavioral responses to the issues raised in talking about the environment.

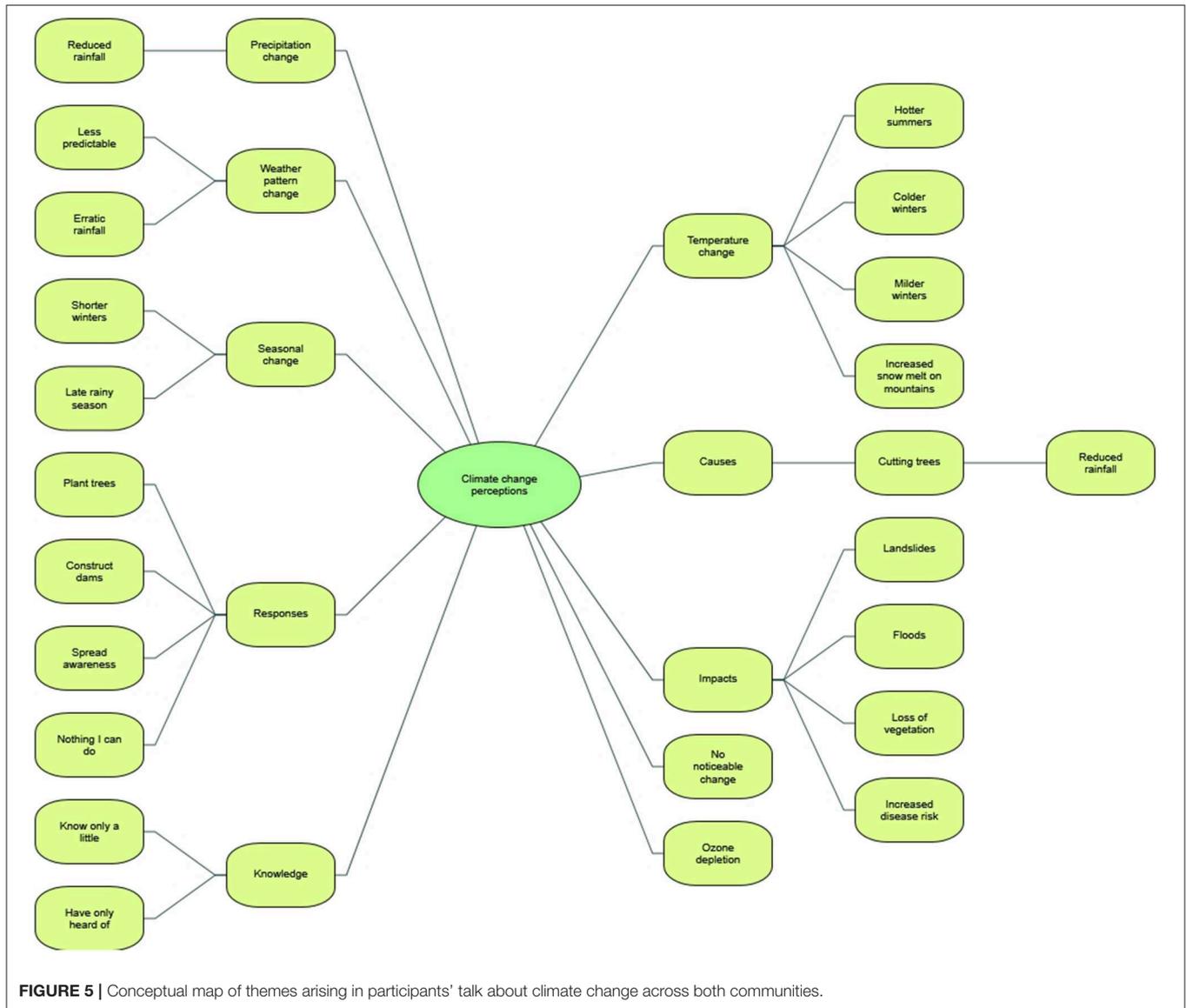


FIGURE 5 | Conceptual map of themes arising in participants' talk about climate change across both communities.

Health and Well-Being Motivates Engagement in Climate-Relevant Behaviors

Because participants in Bharatpur and Kumroj often did not associate local issues with climate change, there was little talk of the need to adopt specific mitigation or adaptation behaviors. However, within each community one or two climate-relevant behaviors were raised in the course of discussing engagement in more general environmentally-relevant actions. For example, planting trees was widely practiced in both communities. Primarily, this was done to provide wood, create shade around homes and provide fruit. Trees were also considered important in preventing drought (see section on Climate and Weather) and other natural disasters such as flooding and erosion (see section Future Deforestation). In addition, a few participants framed climate-relevant behaviors as motivated by the need to safeguard health and well-being:

“Trees I plant in the rainy season, so I plant yearly. Once I cut the old, then I plant new...Trees keep the environment clean and healthier. Trees inhale carbon dioxide and exhale oxygen” (Bharatpur, Interview A6).

While there was no clear link made to climate change, participants acknowledged the value of reducing atmospheric carbon, which was understood as maintaining a “clean and healthier” environment. Essentially, such climate-relevant practices were understood not in accordance with received scientific conceptualisations of climate change, but through more pragmatic perspectives linked to health and well-being.

In Kumroj, the Nepalese government had tried to maintain forest stocks by encouraging villagers to purchase biogas converters through grant schemes. Several participants, mainly from Kumroj, had biogas converters. These were seen as

advantageous as organic waste could be utilized for producing fuel and then used as a fertilizer. Food could also be cooked quicker without the need to light a fire, and it reduced the need to collect wood. While participants did not mention the link between biogas practices and climate change, one of the most important benefits of biogas was that it did not pollute the air and so reduced health risks linked to inhaling wood smoke:

“It (biogas) is clean and the air is also clean. The utensils are also not black. Biogas is more hygienic. People can be safe from colds and coughs and smoke-related diseases.” (Kumroj; Interview B13).

Cleanliness is paramount to the importance of biogas in the above extract. The pollution emitted by burnt wood is illustrated with reference to the condition of cooking utensils, with the implication that the wider environment is being affected in a similar way. In contrast, biogas does not discolor cooking utensils, which illustrates the fuel's superiority in terms of minimizing health risks caused by woodsmoke.

DISCUSSION

This study set out to investigate community perceptions of environmental and climate-relevant issues within two communities in the Terai region of Nepal. Specifically, we sought to address 4 related research questions; (1) How do community members perceive their environment? (2) How do they see that environment changing in future? (3) To what degree are communities aware of climate change? (4) How important is climate change in comparison to other issues? A range of environmental and climate-relevant issues emerged within current and future perspectives. Perspectives were focused primarily on local issues rather than wider environmental conditions. Issues linked to health and well-being were of paramount importance, while climate change was hardly mentioned in either community, either as a current or future problem. However, there was common awareness of temperature and weather changes in the local climate, though the vast majority did not link these changes to climate change. We now move on to discuss the results of our analyses in more detail.

Community Perceptions of Current Environmental Conditions

For participants in both communities, assessments of the local environment were commonly based on evaluations of a single locally-salient issue. Positive issues, such as improvements in sanitation over time, invariably resulted in positive overall evaluations of the environment overall. Conversely, pollution resulted in more negative overall assessments. This highlights the highly subjective nature of environmental perceptions and the way in which specific issues can achieve heightened significance in judgements of environmental quality.

Many of the environmental issues raised in both communities were related to health and well-being, including cleanliness, pollution, and deforestation. It may be the relative proximity of each community contributed to this overlapping of issues. It may also be because they represent basic environmental concerns

common to many communities—keeping the environment clean, healthy, and pollution free. Similarities between communities may also be partly attributable to our sampling method (see section Study Limitations and Future Research) There were also some differences in issues between communities. While plastic waste was more of an issue in Bharatpur, deforestation came up more often in Kumroj—though neither issue was exclusive to each community.

Climate change as an issue came up only once spontaneously, implying that other local issues were more salient. However, temperature and weather changes analogous to climate change did come up in several interviews across both communities, though without attribution to climate change. There was also little consideration of causal factors beyond immediate local causes such as deforestation affecting precipitation, flooding, and land erosion. In line with Leichenko and Silva (2014), it appeared that temperature and weather changes allied to global climate change were already being experienced, though such issues were more atomized and vernacular and sometimes merged with other environmental problems (Rudiak-Gould, 2012). In line with previous work, community perspectives often drew on different issues without attempting to clearly categorize or explain them (Lorenzoni et al., 2007). Xiao and Dunlap (2007) note how particular environmental cognitions can constrain others; it is therefore possible that, when issues are framed locally, wider frameworks of understanding are overlooked.

Perceptions of Future Environmental Change

Perceptions of future environmental change were closely linked to mental representations of current conditions and issues of anxiety and concern. This could be seen in the way that participants rarely spoke about sanitation with reference to environmental change in the future, as sanitation had improved within communities. However, concerns about issues linked to current population increase were projected into the future and anticipated to continue unabated. Previous work has found that existing perceptions of self and other can be elicited through projections of “possible selves” in the future (Harrison, 2018). In the same way, communities' imagined environmental futures highlight salient issues within existing relationships between communities and their physical surroundings.

The Terai region has witnessed large increases in population over recent decades (Population Reference Bureau, 2002), and this was linked to pollution, deforestation and pressure on natural resources. While predictions of temperature and weather emerged from the interviews, such impacts were less frequently mentioned than concerns over population growth, as found in other research (e.g., Butler et al., 2014). Before communities can interpret and respond to climate-relevant issues, it may therefore be necessary to address existing concerns characterized by visions of the present and the future. In addition, the analysis highlights the relevance of sociocultural arrangements and cultural practices that contribute to community perspectives. For example, tree-felling was understood sympathetically within wider contexts of survival and economic struggle, as well as

fuel shortages that left no alternative but to take wood from the forest. Such perspectives serve to highlight the complex nature and wider structural relations sustaining environmentally damaging practices.

Awareness of Climate Change

Climate awareness was relatively unmentioned in discussing the local environment, echoing previous studies (Gallup, 2009; Withana and Auch, 2014). We found little difference between awareness in Bharatpur and Kumroj. A potential reason for this is that the changes observed suggest broader shifts in temperature and weather affecting the wider region, rather than localized effects or micro-climates that might affect one community and not another. Other studies have also reported lower awareness in rural communities (Tanner et al., 2018), though a lack of difference may be due to the higher levels of environmental awareness from NGO engagement in Kumroj. However, while most participants did not spontaneously discuss the issue of climate change, when directly questioned, all had at least heard of climate change and many were able to eloquently demonstrate a good degree of knowledge. Therefore, it may not have been that participants were unaware of climate change, but simply did not consider it a locally salient issue. Tanner et al. (2018) also found that climate change awareness was low, despite respondents observing changes to local weather and climate. It may be that communities look to more local explanations for climate-relevant issues, as was found in some discussions. Therefore, if received knowledge teaches that the lack of rain is due to local forests being depleted, why would communities look to wider, more nebulous phenomena as explanations? The kinds of issues that came up in talk of climate change broadly reflects other research on community perceptions of climate change in the Terai (e.g., Tiwari et al., 2010; Maharjan et al., 2011). The apparent disjuncture between local experience and climate change suggests that the latter may lack relevance for local communities as long as environmental changes can be attributed to more local causal factors. It also suggests two kinds of climate change; a distanced, abstract climate change, and a more experiential, locally-grounded one. Within communities facing such impacts there is a need for a nuanced understanding that blends both. Howe et al. (2013) remark that local perceptions, such as temperature change, can positively bias perceptions of more abstract global climate change, which in turn can generate greater awareness and the capacity to respond to reduce risks to communities. As communities appear to be aware that the local climate is changing in a variety of ways, it is necessary to translate this awareness beyond the local. Reciprocally, more global perspectives need to connect with the concerns and interests of communities at the local level to make climate change more relevant to people's everyday lives. Bain et al. (2016) discuss evidence for initiatives promoting public engagement designed to generate support on the basis of considerations that are independent of climate change, including health and the creation of benevolent communities.

Study Limitations and Future Research

The use of a single qualitative methodological approach utilizing a small sample can only provide a partial insight into climate-relevant and environmental issues confronting the communities studied. Qualitative interview methods rely heavily on participants being able to recall and clearly convey their thoughts in the limited context of the interview interaction. Managing interview interactions in a cross-cultural setting remains a significant challenge and it is possible that the framing of questions could have influenced responses, such as precluding the discussion of global climate change by not deliberately eliciting the topic early in the interviews. Triangulation using other methods and larger samples might help to clarify these qualitative findings. Convergence in perspectives between communities may be attributable to our sampling method. While we categorized Bharatpur as the urban counterpart to rural Kumroj, most participants lived on the edges of the city close to the countryside, which may have generated perceptions that were more aligned with a rural, rather than an urban perspective. Future research might further investigate the apparent disparity between awareness of climate change more generally, and a lack of acknowledgment of climate change in discussions of environmental conditions at the local level. Drawing attention to this gap might also serve to elicit more comprehensive community perspectives and rule out potential shortcomings of a single methodological approach.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Ethics Policy, Cardiff University School of Psychology. The protocol was approved by the Cardiff University School of Psychology Ethics Committee. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

AUTHOR CONTRIBUTIONS

NN, IC, and RM conducted fieldwork with the assistance and guidance of LW and SC. NN was primarily responsible for analysis and authorship of the paper, with significant contributions in both areas from the other authors. All authors agree to be accountable for the content of the work.

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SUPPLEMENTARY MATERIAL

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“Fiddling While Rome Burns”: The Role of Ecological States in the Association Between Greenhouse Gas Emissions and Subjective Well-Being

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Since March 2019, students around the world have taken to the streets to express their anger at the lack of effective actions against the threat of climate change, essentially accusing governments, and adults in general of “fiddling while Rome burns.” This paper puts forward the hypothesis that the ecological state moderates the positive association found in the literature between greenhouse gas emissions and mental well-being, taken as evidence of fiddling on climate change issues. This hypothesis is examined in the context of the countries and regions of the European Union using a hierarchical three-level analysis on the third wave (2011–2012) of the European Quality of Life Survey for a sample of EU citizens. The ecological state is operationalized using a climate change performance index. NO₂ emissions data at the regional level are used as a measure of GHG emissions for regions of the European Union. The findings seem to support the hypothesis that individuals across ecological states keep “fiddling” on climate change issues as a trade-off between environmental and economic considerations. However, the mental well-being of the well-off is being eroded in moderate ecological states compared to good ecological states, which is a call for government to stop “fiddling” and act on climate change issues.

Keywords: mental well-being, ecological state, greenhouse gas emissions, EQLS, regional analysis, European Union

INTRODUCTION

Since March 2019, students around the world have taken to the streets to express their anger at the lack of effective actions against the threat of climate change (Glenza et al., 2019), essentially accusing governments and adults in general of “fiddling while Rome burns.” More demonstrations organized by (adults) Extinction Rebellion (Taylor and Gayle, 2019) a British climate group, have also taken place around the globe. The protests highlight the fear for the doomed future of the earth if effective action is not taken promptly in the next ten year. Psychologists have identified “ecoanxiety” i.e., the “chronic fear of environmental doom” (Albrecht, 2011) as a psychological disorder that present serious mental consequences if not addressed appropriately (Clayton et al., 2017). There is however a paradox between the anxiety felt by individuals about climate change and the positive association found in the literature between greenhouse gas (GHG) emissions, a

major contributor to climate change, and well-being. This positive association is taken as evidence that individuals keep "fiddling" on climate change issues.

Studies on the impact of climate change on mental health and well-being (Fritze et al., 2008; Berry et al., 2010; Clayton et al., 2017) have explored the "direct impacts of climate change on mental health due to trauma caused by extreme weather events for instance; and the indirect impacts caused by a changing climate on the social, economic, and environmental determinants of mental health." (Fritze et al., 2008, p. 1) This paper contributes to this literature on climate change and mental well-being from a different two-fold perspective. Firstly, it focuses on the association between GHG emissions—major contributors to climate change—and mental well-being (Andersson et al., 2014; Fanning and O'Neill, 2019). GHG emissions (such as CO₂ and NO₂) derive mainly from economic activities and consumption practices (Keuken et al., 2015; IEA, 2017) both of which are linked to well-being through pathways that touch upon individuals' identity, for instance, through the employment opportunities offered by polluting industries and social comparisons expressed through lifestyle choices. "Decoupling" between economic growth and its environmental impacts and "downshifted" lifestyles have been put forward in different areas of research as two ways to reduce GHG emissions (Gough, 2016; Büchs and Koch, 2017) and slow down climate change along the way. Exploring the association between GHG emissions and mental well-being might provide evidence on how to approach *decoupling* and *downshifting* given the potential impacts on human well-being (Büchs and Koch, 2019; Fanning and O'Neill, 2019).

Secondly, studies on the association between GHG emission activities and subjective well-being have looked at either the individual level or the aggregate level of the association. However, little is known of the association in a multilevel context that is how individuals' mental well-being responds to the economic and policy context in which GHG emissions take place. Recent research found that states' environmental regimes (Duit, 2016) moderate the association between air pollution and mental well-being (Signoretta et al., 2019). Building on this recent work, it is hypothesized that the association between GHG emissions and mental well-being might be moderated by states' actions in the area of climate change.

Given the novelty of this perspective in the academic literature, this paper puts forward some initial hypotheses and—while recognizing the existing limitations of this work—it explores the potential for future research.

LITERATURE

Studies on the link between greenhouse gas (GHG) emissions, carbon footprints and people's well-being found mixed evidence. On the one hand GHG emissions from different household consumption areas and subjective well-being were found to be weakly associated in Sweden (Andersson et al., 2014) while higher carbon footprints were associated with marginally lower levels of well-being in Australia (Ambrey and Daniels, 2017). On the other

hand countries with declining per capita consumption, measured in terms of either gross domestic product (GDP) or carbon footprint, show significant reductions in average happiness, though countries with growing per capita consumption have no significant change in happiness (Fanning and O'Neill, 2019). Moreover, Andersson et al. (2014) investigated the nature of the association to see how individuals with low GHG emissions and high SWB vary from other respondents and found that individuals holding materialist values have lower subjective well-being, while producing higher GHG emissions. Within this wider body of research, the focus is on individuals' values, environmental attitudes and consumption practices. A less researched side is whether the association between GHG and subjective well-being is dependent on the structural setting in which it takes place i.e. on states' environmental actions.

Recent work found that states' environmental regimes—that is states' commitments in terms of environmental policy, governance, and structures—moderate the association between air pollution and mental well-being (Signoretta et al., 2019). In particular, it appears that the perception of major air pollution problems in everyday life lowers mental well-being of people living in *partial* and *established* ecological states (Duit, 2016)—states characterized by least developed administrative organization and below average levels of regulation, taxation, and research and development spending the first and a well-develop administrative structure, taxation policies, and average levels of research spending in environmental issues the latter. As suggested in this recent work (Signoretta et al., 2019), if there is an influence on people' attitudes toward economic and environmental considerations due to the states' engagement (or lack of) in the climate change arena, then the association between GHG emissions and mental well-being might vary in different ecological states.

Based on this recent work, this paper develops a theoretical framework within which the association between GHG emissions and mental well-being can be interpreted in relation to states' actions in the area of climate change. It can be speculated that individuals who live in ecological states committed to combatting climate change are at a more advanced stage toward the acceptance of changes in social practices needed to move toward degrowth (Büchs and Koch, 2017) compared to individuals living in countries that could be defined as "in transition" toward climate protection. In this context individuals living in countries that are more ecologically committed and at a more advanced stage in the transition toward sustainability in terms of social practices (Büchs and Koch, 2017) might be more willing to accept a cut in their standard of living to curb the effects of climate change (as proposed by "decoupling" and "downshifting" proponents) which will result in a lessened impact on their well-being. Individuals in these countries might feel more protected from the negative consequences of climate change and might be less affected in terms of well-being because of the environmental actions undertaken by their governments in the long run. Based on this argument, living in (poor, in transition, or more advanced) ecological states might influence the strength of the association between GHG emissions and mental well-being. In addition in this range of ecological states,

individuals' well-being might be affected differently depending on their different positions along the socio-economic scale.

As explained through the post-materialism theory, more affluent people in richer societies are more concerned with post-materialist values such as environmental protection (Inglehart, 1997; Fairbrother, 2012; Sulemana, 2016).

More specifically, the paper examines firstly whether GHG emissions have significant positive impacts on mental well-being (Hypothesis 1) as largely reported in the literature, secondly whether this association is strengthened or weakened by "good" ecological states in the area of climate change protection (Hypothesis 2). Thirdly, it is assessed whether the association varies by different socio-economic groups and how i.e., whether the well-being of the advantaged (disadvantaged) varies by regional GHG emissions (Hypothesis 3). Finally, it will be assessed whether the well-being of advantaged (disadvantaged) varies by ecological states' climate change actions (Hypothesis 4). The last two hypotheses will assess whether the well-being of the advantaged (disadvantaged) is more affected by the environmental quality measured in terms of GHG emissions or the climate change policies and actions undertaken by governments.

Methodologically, the paper also argues that for policy purposes it is important to conduct a comparative cross-national study (Signoretta et al., 2019)—as conducted in comparative cross-country health research (Brennenstuhl et al., 2011)—that also takes into account subnational (regional) conditions that are more significant to people's everyday lives. Thus, this work examines differences and similarities across ecological states in the European Union, in terms of climate change performance. In particular, it investigates whether ecological states moderate the association between GHG emissions and mental well-being and how different socio-economic groups are affected by GHG emissions and governments' climate change policies and actions.

DATA AND METHODS

Together with the conceptual innovation, the strength of this study lies in the analytical approach used. Three levels of analysis are employed namely individual, regional, and country levels. The individual data are provided by the European Quality of Life Survey (EQLS), wave 3 (2011–2012), which has a random sample of adult population resident in 34 countries including the current 28 EU member countries (as at October 2018)¹. The survey provides valuable information on the living conditions and well-being of Europeans. For the analyses, a subsample of 21 countries is used, depending on the availability of information at the regional level regarding physical environmental conditions (air pollution, see below). One limitation of the EQLS database is however the lack of information on environmental preferences and attitudes of respondents. In order to supplement the lack of data on individuals' environmental preferences a range of individual characteristics are taken into account as they provide an indication of individuals' support for climate policies (Fritz

and Koch, 2019, p. 1). The theoretical basis for this substitution of data is provided by the postmaterialist theory (Inglehart, 1995, 1997). Though some scholars have questioned the general validity of the theory, it is recognized that advantaged individuals (wealthier, better educated, in sociocultural employment etc.) are more concerned about the environment (Fairbrother, 2012; Sulemana, 2016). For the regional level, the second level of the Nomenclature of Territorial Units for Statistics (NUTS 2) is used. There was a certain degree of discrepancy between the regional information included in the EQLS dataset and the other data sources used for the macro level data (Eurostat, the EU statistical service; and OECD statistics). Consequently, matching was partly undertaken manually. After recoding, a total of 212 regions (NUTS 2 as baseline and if NUTS2 was not available then NUTS1) were used for analysis. As a result, the final sample contains information for 26,978 respondents.

GHG emissions are measured at the regional level as climate change affects individuals and communities by changing the physical environment in which they live. Climate policies and actions instead are primarily carried out at the national level, while the implementation is performed at a more local level. As an example, see Smart Cities, the European Commission's approach to improve the management and efficiency of the urban environment (European Commission, 2016).

Measures

Individual and Local Level

The outcome variable mental well-being is measured by the 5-item scale (WHO-5) developed by the World Health Organization. The WHO-5 reflects both hedonic and eudemonic dimensions (Deci et al., 2008). The five items assess positive mood, vitality and general interest over the past 2 weeks and is an effective tool for revealing the frequency of depressive symptoms in the general population (Layte, 2012). Each answer is scored from zero to five and summed to produce a score out of 25. The scores in the EQLS data set are available rebased between 0 and 10. The higher the score the better the mental well-being of the respondent.

In order to capture socio-economic inequalities and environmental attitudes at the individual level, educational level, employment status, income and ownership of a house are taken into account. Education is a categorical variable, consisting of primary or less, secondary and tertiary education. Employment status has three categories: employed, unemployed, and non-employed (unable to work due to sickness/disability, retired, homemaker and student). The income level of respondents was assessed by relative equivalent household income, using the Modified OECD equivalence scale. To account for the high number of item non-responses, relative equivalent income was coded into five categories, with one category representing respondents with missing income data. Ownership of a house or apartment is used as a rough proxy for wealth, as no other information was available. The ownership of a house variable distinguishes between those who own a house, those who own a house with a loan and those who rent a house (including the category "others").

¹Wave 4 (2016) of the EQLS was not available at the time the study was conducted, hence wave three was used.

Individual control variables known to be associated with depression are included: gender as a dummy variable and age as a metric variable. Household type is assessed through a five-category variable (single, couple without children, single parent, couple with children, and other). Spatial control variables include the degree of urbanization which is measured using four categories (rural, village/small town, medium/large town, and city/suburb). Migration status is a categorical variable consisting of non-migrant, migrant from an EU country and migrant from a non-EU country.

Regional Level

For the regional physical environmental characteristics, NO₂ information (2011–2012) available from the Organization for Economic Co-operation and Development (OECD, 2019) is used. NO₂ is selected as an indicator of human contribution to climate change and as a proxy of economic activities in a region. In addition, the use of this indicator instead of CO₂ emissions avoids overlaps with the Climate Change Performance Index classification which includes CO₂ emissions in the construction of the index (See below).

To test whether NO₂ emissions are a proxy for regional macroeconomic conditions, Gross domestic product (GDP), [expressed in purchasing power standards (PPS)], Real growth rate of regional gross value added (GVA) at basic prices (percentage change on previous year) and the unemployment rate are used. Information was retrieved from Eurostat, the statistical office of the European Commission.

Country Level

To measure the ecological performance of a country, the Climate Change Performance Index (CCPI) for the year 2013 was

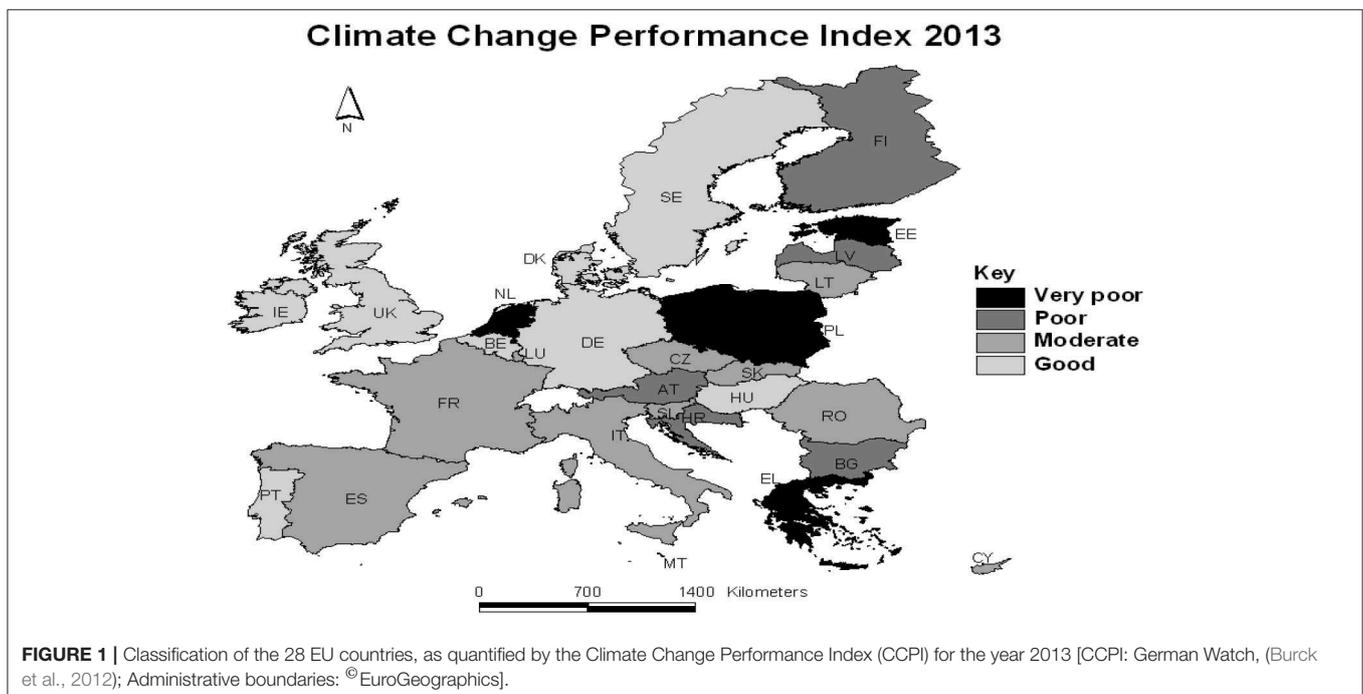
used. CCPI is available for 58 countries responsible for 90% of global energy-related CO₂ emissions (Burck et al., 2012). It is measured via 15 different indicators that are combined into one single composite indicator. The indicators are classified into four categories (weighting in brackets): (1) Emissions: Emissions Level (30% weighting) Emissions Development (30% weighting); (2) Efficiency (10% weighting); (3) Renewable Energy (10% weighting); (4) Policy (20% weighting) (Burck et al., 2016). The CCPI ranking is used in relative rather than absolute terms (Burck et al., 2016). A categorical variable with three categories was constructed, namely: good, moderate, and poor (which includes poor and very poor). **Figure 1** shows countries in each category. To take into account macro-economic conditions, GDP per capita is included at the country level.

Analytical Strategy

The method section consists of a multilevel analysis performed on the total sample, using a hierarchical three level framework: individuals are nested in regions which are nested in countries. Multilevel analysis enables researchers to take the clustering of the data in regions and countries into account, and it allows us to estimate the impact of the GHG emissions on mental well-being.

Seven models are estimated to test our hypotheses, though depending on the significance of the results a selection of the models are reported in the results section.

The first model is a basic model, including the individual control and socio-economic variables only. This is used as a reference model to assess improvements of subsequent models. In the second model, regional NO₂ is added to test the hypothesis that the association between regional GHG emissions and mental well-being is positive as expected in most literature. In the third model the regional and country macroeconomic variables



are included to see whether the relation between regional NO₂ emissions and mental well-being can be ascribed to regions' and countries' macroeconomic conditions. This model will ascertain whether the NO₂ variable is a proxy for economic conditions of a region. The fourth model consists of the categorical variable CCPI. This model tests whether countries' ecological performance has an effect on mental well-being in particular whether subjective well-being is better in good ecological states. In the fifth model, a cross level interaction is tested between the NO₂ emissions indicator and CCPI. This model tests whether the association between NO₂ emissions and mental well-being varies by countries' ecological performance. Finally, two cross level interaction models are estimate between socio-economic position and NO₂ and CCPI (sixth models and seventh model, respectively). The first model tests whether the association varies by different socio-economic groups while the second model tests how the well-being of individuals along the socio economic scale is affected by climate change ecological states. All models were estimated in MLwiN (Charlton et al., 2017).

RESULTS

Descriptive Results

Table 1 presents the mental well-being mean scores by the categorical individual socio-economic and control variables. **Appendix** shows the relevant correlation coefficients between the mental well-being variable and regional (NO₂, unemployment rate and GDP) and national (GDP per capita) variables. All coefficients are significant but very weak, except for the coefficients of the macroeconomic variables which are moderate and significant.

To start with, individuals who live in the countryside, have an income above 120% median and have tertiary education have higher mental well-being (**Table 1**). Moreover, there is a positive relation between NO₂ emissions and mental well-being (**Appendix**) which might be explained by the geographical distribution of NO₂ emissions in EU countries. As shown in **Figure 2**, the distribution of high and low areas of NO₂ emissions across EU regions is quite clear-cut. Regions of high NO₂ emissions are found in Belgium, Germany, Netherlands, UK and Northern Italy, regions performing well economically, which might explain the positive association between NO₂ emissions and mental well-being, noted above.

As far as macroeconomic conditions are concerned, higher GDP per capita at the country level and regional GDP are associated with better mental well-being. As expected, higher GDP per capita at national level and regional GDP are associated with worse GHG emissions at regional as measured by NO₂ emissions. Higher unemployment levels (at country and regional level) are associated with lower NO₂ emission, and lower national and regional GDP and lower levels of mental well-being. Not surprisingly, better macroeconomic conditions (higher GDP levels and lower unemployment rates) are related to higher GHG emission levels, which is explained in the light of the current economic model characterized by the link between economic development and environmental damage (Büchs and Koch, 2017).

TABLE 1 | Mental well-being by individual variables.

	Mental well-being	
	Mean	SD
GENDER		
Women	6.127	2.059
Men	6.460	1.975
MIGRATION STATUS		
Native	6.271	2.029
Migrant from EU	6.213	2.046
Non eu migrant	6.358	2.052
HOUSEHOLD TYPE		
Single	6.088	2.139
Couple without children	6.480	1.984
Single parent	5.652	2.133
Couple with children	6.381	1.846
Other	6.171	2.083
TYPE OF COMMUNITY		
The open countryside	6.494	1.994
A village/small town	6.195	2.034
A medium to large town	6.305	2.036
A city or city suburb	6.263	2.023
EDUCATION		
Primary or less	5.819	2.297
Secondary	6.258	2.037
Tertiary	6.537	1.809
EMPLOYMENT STATUS		
Employed	6.432	1.861
Unemployed	5.851	2.177
Non-employed	6.171	2.153
INCOME		
Below 50% median	5.696	2.325
Between 50 and 80% median	5.881	2.160
Between 80 and 120% median	6.256	1.966
Above 120% median	6.608	1.824
Missing	6.370	2.029
HOUSE OWNERSHIP		
Own a house	6.257	2.055
Own with loan	6.450	1.908
Rent and other	6.152	2.071

In terms of ecological performance (**Figure 1**), Belgium, Germany, Denmark, Hungary, Ireland, Portugal, Sweden and the UK are classified as "good" ecological state using the CCPI. Czech Republic, Spain, France, Italy, Luxembourg, Slovenia and Slovakia perform ecologically at a "moderate" level. Austria, Greece, Finland, The Netherlands and Poland are classified as "poor" ecological states. The very poor performance of the Netherlands stands out among the other neighboring countries and is explained in relation to its inadequate climate policy (Burck et al., 2012), while Lithuania moderate performance stands out among (the poor performance) of the surrounding Eastern European countries. **Table 2** shows countries' climate change performance cross-classified against macroeconomic

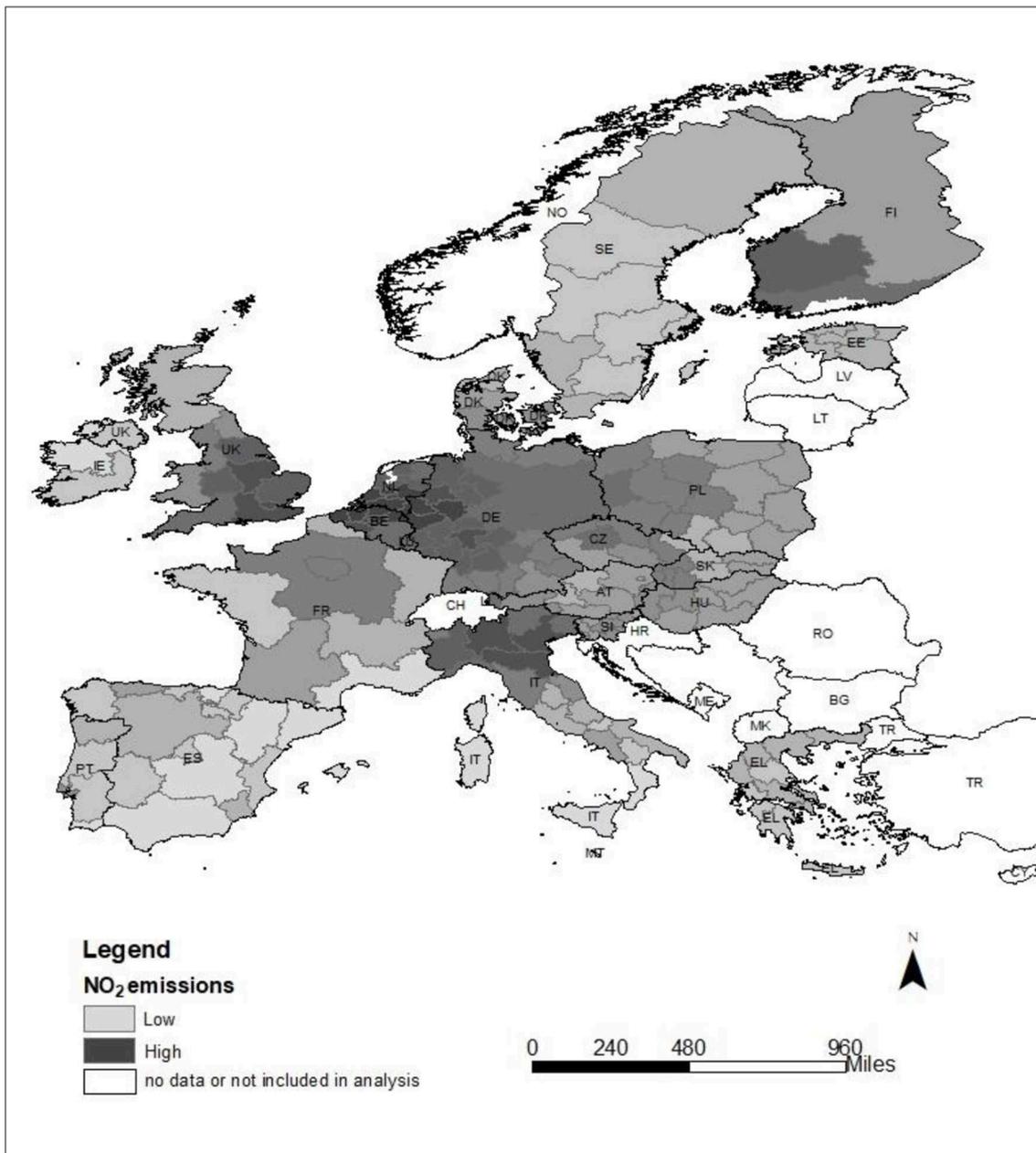


FIGURE 2 | 2011 NO₂ (10¹¹ mol/cm²) emissions across EU countries by NUTS2 regions (Source: OECD).

conditions and the GHG variable. Countries classified as “good” however, present higher levels of NO₂ emissions as these are also countries of high GDP. This may indicate a discrepancy between the environmental performance in terms of NO₂ emissions and governance in countries classified as “good” on the CCPI. In contrast, in this group of countries, individuals have better mental well-being and the macroeconomic conditions are better. Countries’ climate change performance is positively related to a lower average unemployment rate at the regional level, and a higher GDP per capita at country level and regional GDP.

Multilevel Results

In the starting model, the individual socio-economic variables and control variables are included (model not shown). The higher educated, the employed, those with a higher income, men, and those who own a house have higher levels of mental well-being. In *model 1* (Table 3), the NO₂ emissions variable at the regional level is included. In regions with a higher NO₂ level, residents have better mental well-being. This confirms the hypothesis of a positive association between GHG emissions and mental well-being, as found in the literature.

TABLE 2 | Mean scores on mental well-being, GHG emissions and macroeconomic indicators by countries' CCPI.

Countries' CCPI	Good		Moderate		Poor	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Mental well-being	6.42	(2.06)	6.20	(1.91)	6.13	(2.07)
Regional NO ₂	4.80	(2.77)	3.54	(1.73)	4.05	(2.19)
Regional GDP	2.92	(1.14)	2.20	(0.95)	2.24	(1.27)
Regional unemployment rate	8.67	(3.51)	11.17	(5.97)	9.11	(4.64)
National GDP per capita	27.91	(4.91)	23.84	(3.04)	23.65	(7.08)

TABLE 3 | Mental Well-being regressed on NO₂ emissions and macroeconomic variables.

	Model 1			Model 2		
	b	S.E.	p	b	S.E.	p
FIXED PART						
Intercept	6.279	0.106	***	6.338	0.100	***
Income Group (Ref. Below 50%)						
Between 50 and 80% median	0.144	0.052	**	0.138	0.057	0.015
Between 80 and 120% median	0.388	0.051	***	0.348	0.056	***
Above 120% median	0.640	0.052	***	0.572	0.057	***
Regional level						
NO ₂	0.050	0.016	**	0.031	0.017	
Regional GDP (× 10,000)				0.084	0.040	*
Regional unemployment 2011				0.004	0.010	
Regional GVA 2011				-0.007	0.011	
National level						
National GDP per capita (× 1,000)				0.010	0.008	
RANDOM PART						
Country	0.123	0.044		0.059	0.026	
Region	0.088	0.013		0.082	0.014	
Individual	3.763	0.033		3.774	0.036	
Country	21			17		
Region	218			180		
Individual	26,978			22,102		
Estimation						
-2LL	112,619			92315.4		

All models take into account individual educational level, employment status, income and ownership of a house and control for age, gender, migration status and degree of urbanization of respondent residency.

p* < 0.05 level, *p* < 0.01 level, ****p* < 0.001.

In *model 2* (Table 3), the macroeconomic conditions at regional level and country level are added. The NO₂ indicator becomes not significant, which indicates that the association between emissions and mental well-being can be partly attributed to these macroeconomic factors. Also, the regional GDP variable is significant and positive.

Subsequently in *model 3* (Table 4), countries' ecological performance is included, but it has no significant main effect on mental well-being. In the next model, cross level interaction effects are estimated between country CCPI categories and NO₂ emissions (model not shown), to test whether the relation

between emissions and mental well-being varies according to countries' climate change ecological performance. However, the cross-level interaction terms between regional NO₂ emissions and CCPI are not significant (model not shown). In *model 4*, the interaction terms between CCPI and socio-economic position (measured by income categories) are significant and negative for "moderate" CCPI countries compared to "good" CCPI countries. In sum, while income has a strong positive effect on mental well-being, the income effect is weaker in "moderate" CCPI countries compared to "good" CCPI countries. Moreover, the effect is more negative for higher income groups.

Finally, the interaction terms between NO₂ emissions and socio-economic positions, estimated to test whether the relation between NO₂ emissions and mental well-being varies by income groups, are not significant (model not shown).

DISCUSSION

This paper presents an exploratory examination of the complex relationship between regional GHG emissions and mental well-being in the context of climate change actions undertaken by countries within the European Union. To the best of our knowledge, there are no prior studies on the effects of countries' climate change actions in this association.

The theoretical framework assumes that people who live in ecological states committed to combatting climate change are at a more advanced stage toward the acceptance of changes in social practices² needed to move toward degrowth (Büchs and Koch, 2017) compared to individuals living in countries that adopted moderate actions (thus "in transition") toward climate protection. Following this reasoning, people living in more ecologically committed countries are at a more advanced stage in the transition toward climate change protection not only in terms of environmental actions but also in terms of lifestyle changes. Consequently, they might be more willing to accept a cut in their standard of living to curb the effects of climate change—as proposed by "downshifting" proponents—which will result in a lessened impact on their well-being. Individuals in these countries might feel more protected from the negative consequences of climate change and might be less affected in terms of well-being because of the environmental actions undertaken by their governments in the long run. Based on

²For an examination of social practices, well-being and post-growth see Chapter 6 in Büchs and Koch (2017).

TABLE 4 | Mental Wellbeing regressed on NO₂, countries' CCPI and interaction terms.

	Model 3			Model 4		
	b	S.E.	p	b	S.E.	p
FIXED PART						
Intercept	6.451	0.142	***	6.374	0.148	***
Income group (Ref. below 50%)						
Between 50 and 80% median	0.144	0.052	**	0.261	0.078	***
Between 80 and 120% median	0.388	0.051	***	0.487	0.076	***
Above 120% median	0.640	0.052	***	0.724	0.075	***
Regional level						
NO ₂	0.048	0.016	**	0.049	0.016	**
Country level						
CCPI (ref. good)	-0.298	0.184		-0.056	0.207	
CCPI moderate						
CCPI Poor	-0.258	0.190		-0.240	0.216	
INTERACTION TERMS						
CCPI Moderate × between 50 and 80% median				-0.324	0.121	**
CCPI Poor × between 50 and 80% median				-0.066	0.130	
CCPI Moderate × between 80 and 120% median				-0.281	0.117	*
CCPI Poor × between 80 and 120% median				-0.049	0.125	
CCPI Moderate × above 120% median				-0.249	0.115	*
CCPI Poor × above 120% median				-0.039	0.124	
RANDOM PART						
Country	0.106	0.038		0.105	0.038	
Region	0.088	0.013		0.088	0.013	
Individual	3.763	0.033		3.761	0.033	
OBSERVATIONS						
Country	21			21		
Region	218			218		
Individual	26,978			26,978		
Estimation:						
-2LL	112616.31			112606.086		

All models take into account individual educational level, employment status, income and ownership of a house and control for age, gender, migration status, and degree of urbanization of respondent residency.

* $p < 0.05$ level, ** $p < 0.01$ level, *** $p < 0.001$.

this reasoning, the argument put forward is that living in (poor, moderate or more advanced) ecological states might influence: (i) the strength of the association between GHG emissions and mental well-being and (ii) the well-being of individuals at along different socio-economic groups.

The results confirmed a positive association between GHG emissions as measured by regional NO₂ levels and mental well-being (Hypothesis 1). It was also confirmed that this association can be attributed to macroeconomic factors. This means that overall in the EU countries included in this analysis, the NO₂ emission variable can be considered a proxy for levels of

economic activities and consumption practices in a region. This finding seems to confirm a trade-off between environmental and socio-economic considerations in the effect of NO₂ emissions on mental well-being, as there is no evidence that individuals enjoy living in contaminated environments. While the analysis has not included variables associated with specific social practices which might reflect individuals' concerns about the environment, it has nevertheless controlled for socio-economic characteristics as individuals who are highly educated or employed in socio-cultural professions show support for climate change actions (Fritz and Koch, 2019).

However, the hypothesis that this positive association would be weaker in "good" climate change ecological states—as people awareness of negative effects of GHG emission would weaken the association—was rejected, as the interaction terms were not significant (Hypothesis 2). This is not surprising given that countries characterized by better economic performance and worst GHG emissions are also the most engaged in actions to combat climate change. Consequently, there is a discrepancy between climate change actions and environmental quality in terms of GHG emissions. This finding also provides more evidence of a trade-off between social and economic considerations.

Moreover, it was found that while living in countries differently committed to combatting climate change has no main effect on mental well-being, the mental well-being of higher socio-economic groups (as measured by income levels) in moderate CCPI countries is worse compared to good CCPI countries (Hypothesis 4). This finding indicates that the most economically advantaged individuals who live in "transition" countries in terms of climate change actions (i.e., those classified as moderate CCPI are expected to implement more advanced actions in the area of climate change, hence in transition) are the most affected. According to the post-materialist hypothesis (Inglehart, 1995, 1997) residents of richer countries are more willing to curb their standard of living to prevent environmental pollution and wealthier individuals care more about the environment compared to less advantage individuals. It can thus be speculated that while the adjustment to more ecologically sustainable social practices during the transition period might affect well-being negatively, in the instance of more socially advantaged (for instance in education and employment terms) individuals not addressing climate change issues might prove as negative for their well-being.

Limitations

This study is based on a cross-sectional sample of European citizens drawn from the EQLS wave 3 for 2011 and a range of socio-economic and GHG data for the same period. As explained in the Data and Methods section, the wave 4 of the EQLS became available after the completion of the study. Given the exploratory nature of this work, the use of the third wave it is deemed not to compromise the theoretical framework on which this work is based. However, future work could explore the association for more recent time periods including the EQLS wave 4 for 2016 or employ longitudinal datasets.

While this work considered individual level factors which might influence one's own assessment of environmental conditions, including education level and place of residence, future research could be integrated with detailed information on people's environmental attitudes. Information on individual environmental attitudes are not included in the EQLS and consequently could not be employed in the analysis.

In addition, while the paper explores the effect of GHG emissions and CCPI on the well-being of different income groups, future work could utilize a range of indicators of socio-economic positions (education, employment etc.). Moreover, this work is also based on one objective measure of GHG emissions viz. NO₂ emissions. Future work could use different measures of GHG emissions to assess whether the results of this preliminary work are confirmed.

In terms of the geographical unit of analysis, NUTS2 regions are quite large areas consequently individuals may not be directly affected or aware of the regional environmental conditions. However, there are several bottlenecks to the routine use of more detailed data in research that focuses on a cross-country and cross-region EU setting (Signoretta et al., 2019).

Finally, the paper focuses on climate change and uses a relevant climate change classification i.e., CCPI to identify different types of ecological states in relation to climate change actions. Future research could employ other relevant environmental state classifications in the climate change arena and/or the CCPI for different years. To address these limitations, it is recommended that further research on the association between GHG emissions, well-being and the role of the state is undertaken with the aim to explore these findings further in European countries and more diverse political, environmental, social and economic contexts.

CONCLUSION

While the climate change demonstrations around the world show a level of unprecedented awareness and calls for governments to stop fiddling and act on climate change issues, the latest events demonstrate that these are polarizing issues (Taylor, 2019) with no straightforward ways to address them. As well-being is now recognized as one of the main objectives for policy, practice and research (Schwanen and Atkinson, 2015) assessing the well-being impacts that the actions undertaken by

governments in terms of climate change (or for that matter any other environmental issue) have on individuals should become paramount. While economic growth and well-being are still seen as intertwined, the efforts to disjoin them must go hand in hand with a clear understanding of the effects on individuals' well-being. In this context, the path toward the development of a greener state (Eckersley, 2018) that will involve approaches such as degrowth (Fairbrother, 2012; Büchs and Koch, 2019) and decoupling (Coscieme et al., 2019) will have to proceed in ways that sustain levels of well-being in the transition period toward new greener social practices (Büchs and Koch, 2017). More research is indeed needed on the effects of these governments' environmental actions on the well-being of individuals.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: <https://www.eurofound.europa.eu/surveys/european-quality-of-life-surveys>.

AUTHOR CONTRIBUTIONS

PS: conception and design of the work, theoretical framework, statistical analysis, interpretation of results, acquisition, analysis, and interpretation of results, drafting the work and revising it critically, final approval of the version to be published. PB: interpretation of results, revised manuscript critically, contribution to the design of work, final approval of the version to be published. VB: contribution to acquisition, analysis, and interpretation of data for the work, contributed to the statistical analysis, contributed to sections of the manuscript, and revised the work critically.

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APPENDIX

Pearson correlation coefficients.

	NO₂	R_GDP	N_GDP	R_unemp	MWB
NO ₂	–	0.286**	0.237**	–0.504**	0.048**
R_GDP	0.286**	–	0.330**	–0.368**	0.104**
N_GDP	0.237**	0.330**	–	–0.238**	0.076**
R_unemp	–0.504**	–0.368**	–0.238**	–	–0.044**
MWB	0.048**	0.104**	0.076**	–0.044**	–

Key	Details
NO ₂	= NO ₂ emissions
R_GDP	= Regional GDP
N_GDP	= National GDP per capita
R_unemp	= Regional unemployment rate
MWB	= Mental Well-being



Communicating and Understanding Ecosystem Services Assessment With Coastal Stakeholders: Obstacles and Opportunities

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This paper reports on insights and lessons learned from stakeholder engagement, particularly focus groups, conducted during a multi-year, NOAA-sponsored transdisciplinary project. A major project goal was to demonstrate and communicate benefits of natural and nature-based features (NNBFs) (e.g., barrier islands, dunes, and marshes) in the northern Gulf of Mexico region through the lens of economic impacts and ecosystem services. Overall, the findings indicate economic impacts and ecosystem services can be challenging topics to communicate because of complexity in conceptualization and valuation. From our experiences, we recommend using “ecosystem services assessment” (ESA), a more encompassing, accurate, and understandable term to stakeholders. ESA recognizes the integrated human (or built) and natural ecosystem and holistic benefits provided by and to both. The paper concludes with a discussion of future research opportunities for improving ESA-oriented science and outreach.

Keywords: ecosystem services, stakeholder engagement, environmental communication, coupled natural and human system, coastal resilience

INTRODUCTION

An ecosystem services assessment (ESA) is an effort to describe the intrinsic value of ecosystems via direct and indirect benefits that species and natural systems provide to human society (Yee et al., 2017), including flood protection, fisheries, water filtration, aesthetics, and tourism. An ESA accounts for and measures the value of the benefits that we receive from our natural system. The measurement can be either monetary and/or non-monetary. A traditional cost-benefit analysis would include the benefits estimated from an ESA and then compare those to the cost of undertaking a project, such as the restoration or conservation of wetlands. ESAs integrate bio-geo-physical and social-behavioral-economic data that can produce actionable information to improve decision making. This could be especially helpful to communities confronted by coastal hazards (e.g., nuisance flooding, hurricane storm surge), now and under relative sea level rise, and are facing the difficult choice of implementing hard infrastructure (e.g., sea walls) or building with nature. Both the process of developing ESAs and acting on their findings requires community

negotiation and balancing needs of multiple stakeholders (Hauck et al., 2013). Thus, facilitating effective discussions about ESA data with a range of audiences is crucial for coastal resilience, but can be complex and challenging due to lack of consistent terminology and differing conceptions of what ecosystem services or economic impacts involve (Thompson et al., 2016). Researchers need a better understanding of how different stakeholders conceptualize, consider, and talk about ecosystem services and economic impacts to tailor model development and research products to their needs.

For example, the northern Gulf of Mexico coastal land-margin (Figure 1) faces a complex array of socioeconomic challenges such as vulnerable industry, low per capita income, and low level of educational attainment (Centers for Disease Control, 2020; Semega et al., 2020). These socioeconomic issues are exacerbated by present and future bio-geo-physical challenges to critical local industries such as fishing, shrimping, and oystering, which are especially important in rural and low-income areas (Chen, 2017). In particular, rising sea levels will have significant impacts on coastal habitats that are critical for coastal protection and provision of services (Passeri et al., 2015; Sweet et al., 2017; Fleming et al., 2018).

This paper addresses that need by reporting on insights and lessons learned from stakeholder engagement during a multi-year, NOAA-sponsored transdisciplinary project involving Natural and Nature-based Features (NNBFs). A major project goal was to learn how to best demonstrate and communicate benefits of NNBFs (e.g., barrier islands, dunes, and marshes) through the lens of economic impacts and ecosystem services in the northern Gulf of Mexico region (Figure 1). This was accomplished by: (1) estimating changes in traditional economic metrics such as impacts to housing and critical facilities from nuisance flooding and hurricane storm surges under present and future conditions (i.e., sea level rise), (2) demonstrating further

direct benefits (i.e., beyond flood reduction) from incorporation of NNBFs, and (3) illustrating the enhanced value of ecosystem services resulting directly and indirectly from NNBFs.

To succeed in this endeavor, the project team needed to better understand the perspectives, experiences, and concerns of regional and local stakeholders regarding ESAs. We gathered this information through various stakeholder engagement mechanisms (i.e., workshops, presentations, facilitated discussions, data exploration activities, focus groups, webinars with interactive polling, and evaluation surveys). The present paper reports primarily on the focus groups, but also incorporates connections to the other engagement techniques, reflections from our project experiences and team communication, and links to relevant literature. To conclude, we highlight major findings, discuss implications and lessons learned, and offer practical guidance and future research recommendations.

We begin by defining key terms and concepts forming the basis of an ESA, including economic impact analysis, ecosystem services, and ecosystem services valuation. In general, economic impact analysis (EIA) analyzes effects that an exogenous or differential event will have on the economy through direct and indirect impacts (Pleeter, 1980). For our work, we use EIA to demonstrate bio-geo-physical changes to natural environments that have an effect on traditional socio-economic metrics (e.g., jobs, incomes) and built systems (Hagen et al., 2017). This application of EIA is to understand, for example, the number of people affected, value of buildings and contents lost, and amount of infrastructure exposed and/or damaged during storm surge under current and future sea levels.

Ecosystem services valuation (ESV) entails identifying and measuring primarily non-traditional benefits humans receive from the natural environment, which can be expressed in monetary and non-monetary terms. Ecosystem services are benefits received from the natural environment that impact

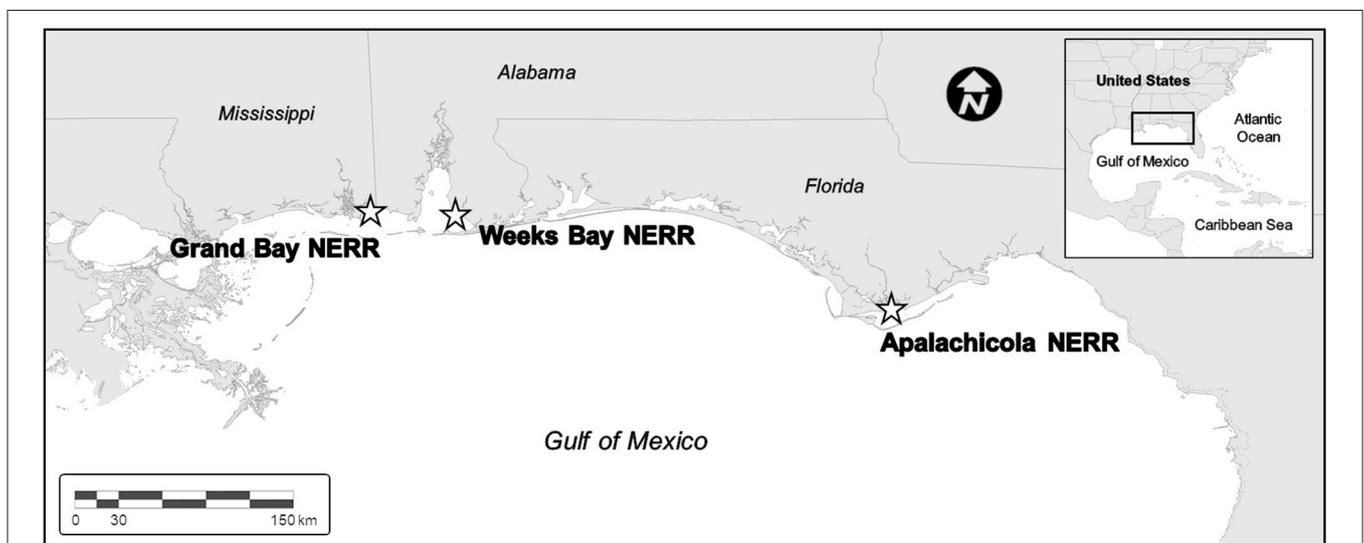


FIGURE 1 | Locations of the Grand Bay, Weeks Bay, and Apalachicola National Estuarine Research Reserves (NERRs) where focus groups were conducted. The overall study spanned the entire coastal land-margin region of the northern Gulf of Mexico, including Mississippi, Alabama, and Florida.

human well-being, including security (personal safety, resource access), material (livelihoods, food, shelter), health (strength, feeling well, clean air), social relations (cohesion, mutual respect), and freedom of choice and action (opportunity to achieve what an individual values doing and being) (Bekessy et al., 2018). Some examples are storm protection, water supply, commerce, food, raw materials, ornamental resources, recreation, science and education, and spiritual and historic connections (Daily, 1997; Millenium Ecosystem Assessment, 2005; Yoskowitz and Russell, 2015).

Including both ESV and EIA to support ESA creates a fuller picture of ecosystem services in a system and can improve decision making (Yoskowitz et al., 2010; Hauck et al., 2013). For example, an oyster reef offers some quantifiable ecosystem services including commercial and recreational fishing, other types of recreation, storm surge protection, and water quality. Other ecosystem services (e.g., aesthetics, spiritual and historic connections) are hard to value monetarily (Bekessy et al., 2018), making them more difficult to quantify but no less valuable. If developed in a transparent and participatory way, ESA has potential to create a shared baseline for decision making among competing interest groups (Granek et al., 2010), though it cannot be the only factor for decision making about complex issues (Bekessy et al., 2018).

In support of the aforementioned transparent and participatory development of ESA, there is a need for further improvement on conceptualizing and communicating this process to better inform decision making. Previous research on ecosystem services communication with stakeholders points to the importance of considering the specific ecosystem context, competing interests and management alternatives, and diversity of stakeholders and their frames of reference and values (Asah et al., 2014; Koschke et al., 2014; Bekessy et al., 2018). Moreover, the types of ecosystem services data needed by stakeholders are context-specific and depend on their intended use of the data in various situations. Thus, research suggests avoiding generalizations about how ecosystem services should be represented in communication (Koschke et al., 2014), and instead emphasizes participatory, deliberative approaches for framing ecosystem services-related functions and terminology to meet the needs of multiple stakeholders (Clark et al., 2000; Raymond et al., 2013). Prior studies have not traditionally focused on communicating economic benefits of NNBFs with mitigation of storm surge or nuisance flooding under SLR or enhanced NNBFs (e.g., Sutton-Grier et al., 2015; Gray et al., 2017).

For the northern Gulf of Mexico, present and future (for the year 2100) flooding scenarios have been produced (Bilskie et al., 2016a,b; Bilskie et al., 2019) and were employed as critical inputs for an EIA to frame conversations with stakeholders. The major focus group research questions explored stakeholders' understandings of EIA, experiences with EIA, and perceptions of the benefits and drawbacks for using EIA data for NNBf-related decision-making. The present study focuses on use of these economic impacts and ecosystem services in an under-studied

communication context while adding to the literature on tailoring ecosystem services-related communication to the needs of stakeholders via a participatory research approach resulting in transdisciplinary outcomes.

METHODS

Focus group interviewing is a social science technique for gathering participant perspectives and comments that can strengthen scientist-stakeholder communication, build trust, and improve decision making and usability of scientific research and products (Lemos et al., 2012; Addison et al., 2013). The focus group process fosters interaction and allows participants to respond in their own words, which can minimize researcher biases and enable emergence of unplanned insights (Eisenhauer and Nicholson, 2005; Newig et al., 2008). Though the focus group method may seem straightforward, careful preparation and implementation are crucial for success (Krueger and Casey, 2000; Stewart and Shamdasani, 2015; Lune and Berg, 2017).

We conducted four total focus groups of between nine and twelve participants each during the project's annual workshops in 2018 and 2019 at National Estuarine Research Reserve facilities in Grand Bay, Mississippi and Weeks Bay, Alabama. The workshops' purpose was to reiterate the project's goals, provide updates on the research, and collect further stakeholder input on the project process and products. The workshops were presented by the team of natural and social scientists and engineers and directed to a volunteer regional project advisory board as well as to local stakeholders in each of the coastal communities. Both the regional advisory board and local community stakeholders were comprised of natural resource professionals (e.g., natural resource managers, community planners, extension specialists) who all participated in this project voluntarily. The advisory board was involved throughout the project from the start, whereas local stakeholder participation varied by geographic venue. The workshop attendees were recruited through professional contacts and networks.

The structure of the workshops remained generally the same and consisted of several presentations on the scientific research and modeling, including ESA considerations; various stakeholder engagement activities (e.g., data exploration worksheets and participatory mapping using an online interface, facilitated discussions, focus groups, evaluation surveys). The ESA presentations included an overview of the concepts and methods, examples, purposes in the project, and demonstration of data applications. There was a question-and-answer session after each presentation.

During each workshop, two purposive sample subsets of attendees convened in separate rooms to participate in concurrent focus groups. One group consisted of advisory board regional stakeholders and one group consisted of local stakeholders. Implementation was the same for all focus groups. Each year, a team social scientist with qualitative research expertise moderated the advisory board stakeholder group and a team science communication expert who had focus group training and experience moderated the local community group.

The focus groups started with an introduction, explanation of objectives, and instructions. The moderator then asked open-ended questions stemming from a flexible interview guide. All participants were engaged while the moderator listened attentively, maintained non-judgmental positive rapport, and asked probing questions when necessary for clarification or elaboration. The groups were audio-recorded with permission; lasted about an hour each; and had a research assistant who took notes.

The interview guide was constructed by the project team and pretested. Many questions remained consistent each year (knowledge, experience, beliefs, and information needs regarding nuisance flooding and mitigation options, including NNBFs). However, there was some variation in questions about ESA. These questions addressed participants' knowledge about ESA; prior experiences using ESA methods and data; perceived benefits and drawbacks of ESA data for NNBF decision making; plans to use ESA data; and recommendations for ESA data outputs, applications, and communication. The 2018 interview guide asked distinct questions about EIA and ESV. However, in response to a team debriefing indicating lack of time for substantial focus group discussion of both EIA and ESV and some stakeholder confusion between the two concepts based on other engagement activities, we only included questions about EIA in 2019.

All focus group audio-recordings were transcribed in entirety by the moderators and double-checked for accuracy. The data set consisted of 106 total pages of typed transcripts. Data analysis involved an interpretive approach which included listening to the audio-recordings and reading all transcripts and notes closely; coding the text (sentences, phrases) manually in a word-processing program based on interpreted relevance of the data and developing categories; and making comparisons within and between the coded data to identify subcategories, relationships, and themes (Miles et al., 2014; Lune and Berg, 2017).

RESULTS

The study findings were grouped into three themes: (1) stakeholders' knowledge about and experiences using ESA, (2) stakeholders' perceived challenges with ESA, and (3) stakeholders' expectations and perceived opportunities for ESA. Overall, stakeholder participants were aware of ESA concepts but had limited experience using ESA methods or data; articulated various challenges with conceptualizing, calculating, or communicating it; and perceived opportunities for implementing ESA in the future. Below, we present these findings, along with supportive illustrative participant quotations.

Stakeholders' Knowledge About and Experiences Using ESA

The focus group participants were generally familiar with ESA, some due to their attendance at the project's workshops and webinars, which included presentations with overviews and demonstrations of these methods. Participants believed both the economic and ecosystem services dimensions of ESA

have potential for providing important and useful quantitative data for NNBF communication (e.g., "if we have some better understanding of the value and the benefits maybe that would encourage people to protect it more") and decision making (e.g., "In our local environment, the economy is directly related to the natural resources so if we're not understanding and protecting our natural resources then our economy is going to tank," and "the most important thing is, you've got to quantify if you're going to justify spending federal money, state money, local money").

Stakeholder participants' experiences using ESA methods and data varied, but overall were relatively limited (e.g., "I only have what I get when I come to these trainings so I try to focus as much as I can on the economic... it's not part of my daily project management-type stuff.") Most of their descriptions were brief, such as, "we'll use it in project proposals... to show what benefits you're getting out of the results," or "We share those numbers with Congress, so they continue to fund us."

Acquiring and working with ESA data was also apparently somewhat of a struggle. For example, participants claimed, "We've tried to do rank assessments for our properties... visitor use... because a lot of our areas are remote," and "We've been trying to look at some economic impacts related to some stream restoration work we've been doing... but it's been kind of a struggle to put that into an easily digestible number or value." Other participants expressed interest in generating ESA data if they had a better understanding of the process, e.g., "We haven't gotten to the point of being able to assign a dollar value to it, but I think that ultimately, that would be helpful in communication."

Stakeholders' Perceived Challenges With ESA

The focus groups identified and discussed various challenges with incorporating ESA in their activities, especially for community resiliency. These challenges can be divided into three broad interrelated categories: (1) conceptualization-related challenges, (2) calculation-related challenges, and (3) communication-related challenges. **Tables 1–4** provide participant quotations supporting the three categories of challenges, and we elaborate on each below, along with subcategories and interrelationships that emerged from analysis.

Conceptualization-Related Challenges

Participants did not seem entirely clear or confident in knowledge about ESA concepts (**Table 1**). For example, economic impacts were defined with brief phrases. Less common were more nuanced understandings of ESA capturing the decision-support capacity of this technique, including how it relates to sea level rise and the project.

Calculation-Related Challenges

The stakeholder participants also had uncertainty and skepticism about ESA methodological procedures. They found ESA calculations to be puzzling (e.g., "I don't really know... how to quantify it," "it can get complicated," and "we've always understood the value to a certain extent, but not the complete value") and it seemed this was a common perception or experience in their professional arenas. The major questions and concerns

TABLE 1 | Example quotations for conceptualization-related challenges for incorporating ESA into their work.

Specific component of challenge	Representative quotations
Defining economic impacts	"It means dollars." "What's the benefit of our investment?" "What's the impact of a project you propose? Is this good for the economy or bad for the economy...if you put a marsh out there?" "What is the cost vs. what is the benefits that it will bring?" "All that stuff we just talked about quantified and put in a tidy paper so people will look at it."
Defining ecosystem services	"[It] sounds like you're talking about the cost analysis to me...It's hard to define." "It seems like it's a big, catch-all term." "What kind of dollar value you can put on ecosystem services, I guess." "Trying to put a number on ecotourism, and recreational fishing, and this and that on these habitats."

centered on how to quantify intrinsic ecosystem services and how to include NNBFs in ESA calculations. Regarding quantifying intangible ecosystem services, participants were concerned about an inability to put a value on quality of life or aesthetic considerations like, *"go[ing] to the shoreline to see the sunset."* Another participant felt that while intangible ecosystem services could potentially add to traditional methods of loss calculation, it amounted to *"fuzzy science"* (see **Tables 2, 3** for full quotes).

Stakeholders had general expectations about ecosystem services that seemed connected to their overall concerns about ecological modeling, such as models not being exact or definitive or not completely accepting modeling results until validated by real-world experience. They also perceived lack of accuracy in measuring intangible ecosystem services to be troubling and problematic. One concern was that placing a monetary value on a location would encourage developers to pay a slightly higher rate to purchase and develop the land. Other concerns related to uncertainties in valuing ecosystems that are not completely understood.

Regarding incorporating NNBFs in ESA calculations, there were some perceptions that NNBFs can compound the methodological complexity. For example, one perception was it is easier to calculate direct benefits of traditional engineered structures like a seawall than indirect benefits of establishing an oyster reef. Further, participants thought there were several situational factors that should be considered in computer modeling when including NNBFs in ESA. These factors, which encompass ecological and social characteristics, include: (1) appropriate scale of analysis pertaining to size of NNBF (e.g., acres vs. linear feet), (2) type and location of infrastructure or habitat the NNBF is expected to protect (e.g., human-built infrastructure vs. natural habitat), and (3) growth rate and future community development patterns.

In addition to uncertainty and skepticism about underlying ESA methodological procedures, there was also concern among

TABLE 2 | Example quotations for challenges related to quantifying intangible ecosystem services using ESA.

Specific component of challenge	Representative quotations
Quantifying intangible ecosystem services	"...Ecosystem service valuation could be...less obtainable information from the community... What intrinsic value they get out of that natural area. How it adds to their quality of life...things you can't put a dollar value on...people may...go to the shoreline to see the sunset and how do you put a value on that? But it's definitely of value and a service that it provides. I'm all for getting to those dollar values- how a marsh can clean up as compared to a waste treatment plant. But there are other values...that I think that term means as well." "We just tend to fall back on the traditional ways of quantifying damages or what we've prevented from being damaged: the structures - commercial, residential, industrial. Those things that are very easy to say they've been inundated, therefore, they're damaged. I think the part where it's challenging...is quantifying these ecosystem benefits...How do you put a dollar figure on productivity increase? There's ways to do it but that's even more of a fuzzy science." "Ecosystem service valuation is based on assumptions...there's always faulty assumptions." "We're having to rely on modeling to kind of figure out what those benefits will be and what the savings may be over time, but time will really tell...We have to wait for an event to happen." "I'm always concerned that it will be undervalued...not giving enough value to certain components of the natural system...who's to say, "This piece of shoreline is worth ten million dollars to this community." Then somebody can come along and say, "Okay, here's eleven million dollars, and I'll put a condo there." "The cynical side of me says fuzzy math when I hear it...I realize there's more of a science to it...In practical application, I have issues...So out there is a marsh. It probably doesn't provide the same function across each acre. I would imagine most evaluations of that services would plot the single value for that scale for that value across that landscape...if anybody sees that number, they assume that's a real number without any range." "I've always been kind of philosophically opposed to assigning very specific dollar values to those ecosystem services from the standpoint of you're putting a line in the sand that it's worth this to us. We don't fully understand the biological or physical characteristics of these systems. What are we missing out on? What value?"

participants that the measures would not be accepted as valid by the broader community and thus a potential obstacle for NNBF-related initiatives. This concern connects the calculation-related challenges with communication-related challenges category discussed below.

TABLE 3 | Example quotations for challenges related to including NNBFs in ESA calculations.

Specific component of challenge	Representative quotations
How to include NNBFs in ESA calculations	<p>"The thing I think is difficult with ecosystem services is...you can talk about how much does an oyster bag cost...but...let's say you put in a living shoreline...when you can say, "If I implement this green infrastructure improvement relative to, say, a formal engineered improvement, then...I can mitigate some water quality"...but that's not immediately quantifiable." "The scale that you're measuring the value. So it is an acre or is it a linear footage of shoreline? ...what is variability in that?" "What you're protecting. Are you putting something to protect some type of critical infrastructure, or are you putting something to protect some sort of natural habitat...how that factors into how you evaluate the economics of it is important." "Especially with infrastructure...with sea level rise...all the coastal roads that are going to have to be elevated, if not moved...We're talking a lot of expense." "Future land use, land cover changes...how development may or may not occur in an area...the cost of the vulnerabilities associated with that."</p>

Communication-Related Challenges

The focus group participants thought confusion about ESA conceptualizations and calculations could be problematic for stakeholder and public communication, acceptance, and support of coastal projects, including those involving NNBFs (Table 4). For example, communicating about ESA to the public was perceived as more difficult to explain than traditional cost-benefit analysis, which was regarded as challenging in itself. Further, explaining assumptions and uncertainties in projects' mathematical models to decision makers and other community members was viewed crucial for transparency, but not an easy task. Participants believed these communication difficulties could be addressed in part by understanding and connecting to local audience values, though there were also concerns that ongoing population growth was resulting in an influx of new residents with different cultural values. Many new residents move to the coast from inland with a romanticized vision that does not appreciate the nuances of what comprises the natural wonder. One technique participants described for connecting with diverse audiences was using emotional messages and storytelling to develop effective and persuasive communication.

Stakeholders' Expectations and Perceived Opportunities for ESA

Despite the challenges, most stakeholder participants expected they would be using ESA methods and data in their various professional roles in the future, such as in helping in project

TABLE 4 | Example quotations for communication-related challenges for incorporating ESA into their work.

Specific component of challenge	Representative quotations
Communicating complexity and uncertainty	<p>"Trying to explain to people...all of the cost-benefit." "...It's not like economics, like you can say we're saving one dollar for every one dollar we're investing...It's kind of hard for the public to wrap their mind around, like, "We're creating X number of habitat units." What does that mean?" "...You've just got to be careful in how you present that information." "How...confident are you with how much uncertainty is associated with those projections that you're going to dish out to the public? Telling that message is a little bit abstract...modeling uncertainty, and confidence levels, and statistical analyses to Joe Blow public. Finding a way to creatively do that in a simplistic manner that people can understand...telling that story is one that we haven't figured out how to do effectively yet."</p>
Connecting to diverse audience values	<p>"Understanding what's important to the people who live here and what's important to me or you may not be what's important to the rest of the constituency." "Unfortunately, our decision makers, they're not listening to ecological economic benefits. They're listening to how many people are moving to my community."</p>
Creating compelling narratives	<p>"I think one of the challenges is tying together the economics, the engineering, and the social side. To weave a story that shows the whole picture." "...What you have to convey now if you're going to try to argue persuasively is the emotional side of an issue...visuals, and telling these stories...and trying to find the right trigger point to get changes made."</p>

selection, determining where to build, and establishing new regulations. For instance, *"we might...use it as leverage for new regulations politically and stuff because...if you can show the politicians or whoever's in charge that you're helping the economy then that gets their attention..."*

The focus groups appreciated the ESA data being incorporated into the project's research and computer modeling, as well as being involved in sharing input and feedback on the process and scientific products. They thought the resulting tools would provide accessible and useful guidance for decision making. They also perceived opportunities for multiple types of applications across various coastal contexts and scales. For example, participants stated, *"if a site selector or a developer is looking at your area, this tool might help them make...better decisions for their business and your community"* and *"from a park service perspective...the sea level predictions, I think, will let us*

target areas that we can continue to open to the public vs. areas that might become natural wilderness.”

DISCUSSION

Overall, the findings further document that economic impacts and ecosystem services can be challenging to communicate to coastal stakeholders because of the complexity of conceptualization and valuation. Though there were several economic impacts and ecosystem services informational presentations during workshops and webinars and related team and stakeholder discussions, activities, and interactions, there seemed to be a disconnect between the economic data and its relevance to NNBFs, especially when considering benefits NNBFs provide through ecosystem services.

Regarding conceptualization-related challenges, there was lack of clarity about differences between types of information provided by EIA vs. ESV and when and how to use those outputs. Stakeholder participants seemed to generalize these two data types into a single, broad “economic data” category, while they do have two distinct and mutually-supportive meanings. There was also some confusion about distinguishing EIA data from the other modeling and decision support tools being produced and refined in this project. While ESV is a flexible concept, similar concerns about both the definition and application of ESV have been observed in other research (e.g., Bull et al., 2016).

Regarding calculation-related challenges, participants were initially hesitant about ESA methods and outputs. Perhaps this reaction reflected their being somewhat overwhelmed by these new concepts, definitions, and gaps in understanding of economic and ecosystem processes. However, the participants were more comfortable with ESA after the workshops and webinars. This finding stems from workshop evaluation survey responses to questions about these concepts and focus group data indicating participants were able to discuss the topics more readily and provide more substantive descriptive examples at later points in the project.

Regarding communication-related challenges, it is well-acknowledged that non-practitioners typically have an automatic mental connection of ESA with money, which is not always the case. This strong perceptual association is known to persist despite explanations by experts that ESV does not necessarily have to be measured in monetary terms, as there are many other potential valuations. Similarly, EIA can include certain factors other than simply dollar value dimensions of impact (e.g., it can be indirect in the form of numbers of people displaced by a flooding event). Various scholars and practitioners have advocated for considering economic impacts and ecosystem services more holistically. For example, Bekessy et al. (2018) caution against uncritical use of ecosystem services to frame communication about conservation issues, in part because the contrast between the economic message and individual emotional connection to nature may be perceived as contradictory. A holistic approach to ESA could complement situated approaches to environmental

communication that recognize the key role of place attachment for coastal communities (Jarreau et al., 2017).

To address these issues, our project team realized it was beneficial to adopt a broader conceptualization of economic impacts and ecosystem services, which had communication implications. Thus, we recommend, and have used throughout this paper, the term “ecosystem services assessment” (ESA) to recognize the integrated human (or built) and natural ecosystem and the holistic benefits provided by and to both. We believe that a simplifying change in terminology to ESA for reflecting the overall concepts of economic impacts and ecosystem services is more encompassing, accurate, and understandable by stakeholders. ESA is developed as a mutual vocabulary that takes an explicitly deliberative approach among researchers and stakeholders, as suggested by Raymond et al. (2013) and Moon et al. (2020).

Another important point is that ESA challenges emerged in this project not only in interactions with stakeholders but also internally within the team. For example, one conceptualization-related hurdle the team encountered was distinguishing economic impacts from ecosystem services impacts of flooding. In addition, team members struggled with the same challenge noted with stakeholders in thinking economic impacts were dollar values only. Another and more communication-related obstacle, involved inconsistent use of terminology (e.g., “economic impact assessment” vs. “economic impact analysis” and “ecosystem services valuation” vs. “ecosystem services evaluation”) during various project activities. This obstacle may not be surprising, as just the term “ecosystem services” itself has a history of being troublesome and plagued with an array of definitions, interpretations, and applications (Munns et al., 2015). The terminology has also had trouble bridging the research to operations divide (Beaumont et al., 2017). However, “ecosystem services” does consider the benefits that humans receive from a well-functioning natural system and by accounting for those benefits encourages protection and enhancement of the natural environment (Daily, 1997). Thus, we advise that those involved in future related transdisciplinary research are careful and consistent in terminology and language across all project activities and throughout the project duration.

There are a number of future research opportunities for improving ESA-oriented science and outreach. In particular, more studies are needed to provide empirically-grounded guidance on best practices for developing useful ESA data and outputs in diverse contexts with engaged stakeholders. Studies specifically examining effectiveness of different ways of communicating ESA results with various stakeholder groups to benefit the complex integrated natural and human system are also crucial. Further investigations using qualitative social science methods are especially encouraged. We believe our study’s findings and lessons learned have implications that can be useful for planning such efforts (e.g., careful attention to wording concepts in interview guides, allocating time for moderator debriefing). Importantly, researchers must have a legitimate willingness to adapt their ESA calculation and communication methods to meet the needs of non-academic stakeholders, as articulated through mutual conversation.

In sum, the obstacles encountered within the project team and while engaging with stakeholders regarding economic impacts and ecosystem services related to NNBFs resulted in recognizing the utility of ESA terminology. The interdisciplinary team solidified their understandings and applications of the concepts and methods and the stakeholder participants became more comfortable discussing ESA topics and better able to provide more substantive input and descriptive examples. We believe this success was due to a combination of factors including experienced project management; team commitment, reflection, openness, and flexibility; strong relationships with project partners and stakeholders; two-way communication; and mutual respect. Project commitment stemmed from recognition by all involved of the importance of ESA for building coastal resiliency and the need to better understand and incorporate the information into planning for present conditions and future changes from interrelated natural and anthropogenic influences.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

All study procedures involving human participants were reviewed and approved by the first author's Institutional Review

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Board. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DD planned and led the research design and performed data collection, analysis, and writing of the manuscript in close collaboration with SS. SH conceived and supervised the overall project, provided important intellectual content, and assisted with data analysis, manuscript preparation, and editing. DY helped with data analysis and provided ESA-related content and editing. RC oversaw broader stakeholder engagement and participant recruitment and editing. All authors contributed to the article and approved the submitted version.

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“That’s Where Our Income Comes From”: Women’s Perceptions of Links Between Reproductive Struggles and Hydraulic Fracturing

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Reproductive hardship is highly stigmatized, which leads to such struggles being relegated to the private sphere. At the same time, numerous studies show links between toxic chemicals and reproductive hardship including miscarriage, infertility, and birth defects. There thus exists a disconnection between *structural* contributors to reproductive challenges and the fact that such hardship is frequently viewed as a *personal* problem. Considering this tension, this qualitative study sought to examine how women who had both experienced reproductive difficulty and lived proximal to hydraulic fracturing operations made sense of their experiences. Analysis revealed that participants emphasized hydraulic fracturing as economically essential at the same time that they tended to minimize fracking as a potential contributor to reproductive hardship.

Keywords: hydraulic fracturing, environment, reproduction, pregnancy, economics

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INTRODUCTION

High-volume hydraulic fracturing (fracking) is a relatively new and controversial technique of extracting oil and gas from shale formations deep beneath the earth’s surface. Initially discovered in 1997, the practice combines more traditional methods of extraction with a horizontal drilling technique that involves fracturing shale with a “cocktail” of chemicals, sand, and water (Rinaldi, 2015). Since 2008, a boom in fracking has brought temporary economic prosperity to rural communities at the same time that it has created significant environmental and human health concerns (Fitzgerald et al., 2016; Murphy, 2020). While it is difficult to prove causal links between chemicals used in fracking and health problems, available research illustrates “significant associations” between emissions from fracking and negative health effects (Wollin et al., 2020; see also; Mrdjen and Lee, 2016). Although men make up 85% of the oil and gas extraction industry workforce (Energy Workforce and Technology Council, 2018), women and infants living proximal to fracking operations face unique health risks. Multiple studies have linked proximity to fracking to reproductive hardships including preterm birth (Whitworth et al., 2018), decreased birth rate and decreased health (Currie et al., 2017), and congenital heart defects (McKenzie, Allhouse, and Daniels, 2019). Despite such findings, struggles with reproduction are stigmatized and personalized, which in turn creates difficulties for those seeking to expose the harmful effects of toxic chemicals (Layne, 2001). The fact that mainstream news depicts fracking as either an economic benefit or an environmental concern further complicates this problem (Krause and Bucy, 2018). That is, those who frame fracking as an environmental concern are frequently criticized as threatening a community’s economic welfare made possible by the oil and gas industry.

Despite significant concerns about the effects of fracking on reproductive health, the perceptions of women suffering such effects remain underexplored in scholarly research. Accordingly, this qualitative study examined the extent to which women who have experienced significant reproductive hardship and live near fracking operations attribute their struggles to their proximity to fracking. This study is grounded in Cognitive Dissonance Theory (CDT), which captures the ways in which individuals negotiate incongruities between cognitions or between cognitions and behaviors (Harmon-Jones and Mills, 2019). The experience of dissonance leads to psychological discomfort; this, in turn, “motivates the person to reduce the dissonance and leads to avoidance of information likely to increase the dissonance” (Harmon-Jones and Mills, 2019, p. 3). We consider CDT in the context of communities economically dependent upon oil and gas extraction while suffering negative health effects, focusing specifically on the Uintah Basin area of eastern Utah. In Uintah County, mining, quarrying, and oil and gas extraction make up the largest economic industry in the area (Data United States of America, 2018), making environmental and human health concerns related to fracking especially controversial within the community. As chronicled in a 2015 issue of *Rolling Stone*, a midwife living in the Uintah Basin noticed growing rates of stillbirth, miscarriage, and birth defects in the region around 2013. When she questioned whether such problems were linked to fracking operations, she received death threats and challenges to her reputation (Solotaroff, 2015). It is within this context that our research participants grappled with economic dependence on fracking and reproductive challenges.

METHOD

After receiving IRB approval, we recruited six women from the Uintah Basin region. One of the researchers with connections to the area posted recruitment materials to Facebook inviting those who met the criteria to contact the researchers. Women were eligible to participate if they self-identified as people who have experienced reproductive challenges (e.g., still birth, birth defects, miscarriage) and lived in the Uintah Basin region. While some participants were recruited via social media, others were recruited via snowball sampling. Interviews concluded with the researcher asking the participant to share our contact information with anyone who met the criteria and was able and willing to participate. In each case, participants made the first contact with the researchers. Participants were asked to take part in semi-structured interviews in exchange for ten-dollar gift cards to Amazon in compensation for their time. Participants were paid regardless of their answers. Women ranged in age from 31 to 42 years old, with one participant not reporting their age. Participants were mothers to two to six children.

Interviews were conducted in late April of 2019. In order to gather an in-depth understanding of the extent to which women who had experienced reproductive challenges connected their struggles to fracking in the area, we asked overarching questions such as, “When did you first become aware of hydraulic fracturing or fracking? Do you believe that fracking poses a threat to public health

or safety? To what extent has your experience with pregnancy impacted your perception of fracking?” To analyze the interviews, we employed a thematic analysis using the constant comparison method (Nowell et al., 2017). Two themes emerged from the data: emphasizing the economic benefits of fracking, and minimizing environmental links to reproductive hardship. Both themes are discussed in detail below. Throughout this paper, all participants are referred to using pseudonyms.

RESULTS

Our analysis revealed that the women interviewed largely remained supportive of fracking due to its economic benefits while minimizing its potential links to their personal reproductive struggles. CDT Theory helps to explain our findings, as these themes indicate dissonance between cognitions about the economic benefits of fracking, potential harmful links between fracking and reproductive health, and a community identity rooted in part in the oil and gas industry. Overall, interviewees reduced dissonance by downplaying potential links between fracking and their personal reproductive health, thus enabling the cognitive maintenance of fracking as beneficial and unrelated to their health challenges.

Emphasizing the Economic Benefits of Fracking

Participants were quick to emphasize fracking as an economic necessity. Although many acknowledged that safety practices could be improved upon, nearly all participants conveyed strong support for fracking. Of all participants, Michelle, a social worker originally from outside the area, was the most leery of fracking safety. Yet even Michelle acknowledged that her community was unlikely to support stricter regulations, much less a total ban on the practice. She explained, “That’s where our income comes from. That’s where, that’s where [sic] the money to support community interests come from.” Along with emphasizing the economic necessities of fracking, participants simultaneously minimized environmental concerns, arguing that too much regulation could curb economic benefits.

Participants frequently spoke to the positive economic outcomes of fracking operations. For example, Rita, a stay-at-home mom whose husband works in the oil and gas industry, noted that fracking enabled the construction of a new jail, a community conference center, and other public buildings, all of which were multimillion-dollar projects. She emphasized fracking as “important. . . . to our infrastructure, as well as just our work life.” In addition, Claudia, a stay-at-home mom with no immediate economic links to the industry (her husband works in healthcare), emphasized fracking as bringing substantial work to the community by bolstering business for “mom and pop shops” and creating employment for those who could work directly on fracking operations. Lindsay, who works for the health department and whose husband works as a miner, affirmed the dangers of fracking yet discussed it as a “necessary evil.” Though many of the women interviewed noted the dangers

fracking poses to the environment, human health, and/or workers who risk injury or death on the job, the majority described economic benefits as substantial and essential.

Rita and Lindsay invoked economic benefits as reason to dismiss or minimize environmental concerns, thus reducing cognitive dissonance. That is, although closure or even regulation of oil and gas operations could improve public health and safety, participants cognitively (and communicatively) constructed economic losses as simply too costly. As Rita noted, “[We] want to make things safe for all parties involved, but not to the point of regulating it so much that it can’t be done or used.” She thus argued that practices should be safe but only insofar as safety precautions did not infringe on the industry’s ability to frack and reap economic benefits. Rita elaborated, “[T]here comes a point where you can regulate something to death where you can no longer provide for your family. . . . if we regulate it to death, then you’re going to have a bunch of unemployed people.” Once again, the consequences of mitigating health and safety concerns were, for participants, too costly. Rita’s sentiments suggested that any concerns needed to be considered in light of economic benefits. Immediate economic livelihood took precedent over potential health and environmental impacts. Such constructions were necessary for participants to reduce dissonance, allowing them to view fracking as permissible even in the case of concerning health effects.

Minimizing Environmental Links to Reproductive Hardship

As noted earlier, pregnant women and their fetuses are particularly vulnerable to the effects of toxic chemicals, including those used for fracking (Layne, 2001; Currie et al., 2017; Whitworth et al., 2018; McKenzie et al., 2019). Though all our participants experienced some form of reproductive hardship, only one, Michelle, suspected her struggles were related to her proximity to fracking. The majority of interviewees dismissed or minimized the possibility of links between fracking and reproductive struggles. Several invoked the fact that they were originally from elsewhere as evidence that their reproductive challenges were unrelated to local fracking. Further, participants tended to elevate genetic and other personal factors as more likely than fracking to have caused reproductive challenges. Once again, these tendencies reflect CDT’s claim that uncomfortable dissonance leads individuals to cognitively reduce incongruities between cognitions or between cognitions and behaviors.

Claudia and Rita suggested that the fact that they grew up elsewhere made it unlikely that fracking in the Uintah Basin contributed to their reproductive hardship. When asked whether her experiences with miscarriage had impacted her perception of the fracking industry, Claudia replied, “I haven’t seen an impact of fracking. I also was not born and raised here. . . . So for me, no.” Rita emphasized the fact that she was originally from another area as reason to eliminate local fracking as a cause of her reproductive struggles: “I’ve dealt with reproductive issues, but I don’t think that they have anything to do with fracking. I didn’t originate here in the basin, and I haven’t always been around fracking and

natural gas and all that stuff.” Rita also believed studies conducted in the region—designed to assess potential links between fracking chemicals and health—were flawed in that the majority of study participants “didn’t originate from here . . . [and] didn’t necessarily even work in the industry.” Rita and Claudia perceived fracking as only likely to impact the health of those who grew up near operations or had direct ties to the industry.

Relatedly, numerous participants attributed their hardships to genetic and/or personal factors. After noting that she was not born and raised in the Uintah Basin, Rita stated, “So I believe that it probably has more of a . . . something to do with my genetics, and just my own personal health issues that I deal with rather than an environmental cause.” Rita further emphasized that she was considered at an advanced age during the pregnancy and also noted that her husband had been working nights, creating exhaustion. While such factors can certainly impact pregnancy, other participants echoed an emphasis on genetic factors as reason to dismiss potential environmental links to their difficulties. Angela, a nurse and mother of two, stated, “I would say in my case it’s probably more genetic,” and yet another participant suggested her miscarriage was more likely linked to genetic as opposed to environmental factors. Such perceptions confirm Layne’s (2001) finding that women tend to take personal responsibility for pregnancy loss even in cases wherein environmental factors have been clearly established as contributors to reproductive harm. While taking personal responsibility for reproductive hardship “places an inordinate moral burden on women” (Layne, 2001, p. 41), it also offers cognitive benefits to women who take such (unfair) responsibility. That is, it allows them to reduce cognitive dissonance about the possibility that such hardship might be caused by industries that support their communities and/or their own families.

Limitations

Although the themes noted in these interviews shed light on how women living near fracking operations make sense of their reproductive hardships, this study has limitations that warrant review. Miscarriage, stillbirth, birth defects, and difficulty with conception are deeply personal and even stigmatized issues, making women who have experienced such problems a population that is relatively hard to reach. Our study is thus limited in that we acquired only six participants whose insights cannot be generalized but are nonetheless informative. Further, the Uintah Basin’s economic dependence on fracking creates stigma for anyone speaking out against potential health consequences of the industry, as evidenced in the death threats received by the local midwife (Solotaroff, 2015). It is thus possible that the women interviewed *did* perceive some sort of link between fracking and their reproductive struggles but were unwilling to voice their concerns.

CONCLUSION

This study aimed to address the dearth of literature discussing women’s perceptions of reproductive hardship in relation to hydraulic fracturing operations. Through in-depth interviews, we sought to investigate how and to what extent women living in the

Uintah Basin—an area economically dependent on hydraulic fracturing—perceived their reproductive hardships as related to local fracking operations. Our findings, explained through CDT, illustrate that those interviewed played up the economic benefits of fracking at the same time that they downplayed fracking as a potential contributor to their experiences with miscarriage and other reproductive challenges. Thus, it appears that women continue to bear personal responsibility for reproduction while echoing industry rhetoric that pits jobs against environmental welfare (Estabrook et al., 2007). While such beliefs and communication patterns benefit such women in that they enable the reduction of dissonance, there is ample cause for concern in regards to health consequences caused by fracking operations. We want to conclude this paper by noting that a healthy economy is one that is sustainable in the long-term (Murphy, 2020). Rather than relying upon a toxic and tentative “boom-or-bust” economy, the United States in particular must make the move toward economies that value the ways in which human health is inextricably linked to the health of the environment.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

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ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Board, Office of Research at Utah State University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MM developed the argument, wrote the manuscript, and ensured participant payment. MS developed the idea for the study and conducted all interviews. SZ edited the manuscript and assisted with clarifying the discussion of the findings. TG served as a research assistant during the development of the manuscript and helped gather literature and identify themes in the interviews.

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Time to Listen: Children's Voice in Geoscience Education Research

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Arguably the greatest threat facing society is that posed by irreversible climate change. In tandem with mitigating the effects of climate change, we must now make decisions about issues such as renewable energy, sustainable and safe water supplies, management of renewable and non-renewable natural resources, and management of natural disasters. The current school-age generation will see the worst effects of climate change, including greater frequency and intensity of extreme weather events; shortages of water and other necessary resources; and dangers due to pollution and toxicity in human environments and the human food chain. The next generation is coming of age as difficult socio-political choices are being made at local and national levels to manage resources and mitigate environmental damage. It is therefore important to center the voices of children and young people in research aiming to address the social, political, and educational dimensions of geoscience topics, including climate change and related topics. This paper proposes the use of Children's Research Advisory Groups (CRAGs) to meaningfully include children and young people as co-researchers in geoscience-related research.

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INTRODUCTION: WHY LISTEN TO CHILDREN ABOUT GEOSCIENCE

Climate change is a vast, accelerating, and highly complex threat to human civilisation on our planet, requiring both scientific and socio-political expertise to tackle (Grundmann, 2016). Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate, leading to natural disasters, low harvests, biodiversity loss, etc, according to the UN Intergovernmental Panel on Climate Change (IPCC). These effects, already in motion, are expected to worsen over the coming years, with a well-publicised estimation in 2018 by the IPCC that we had fewer than 12 years to make the significant changes required to tackle this threat (now 10 years) (Intergovernmental Panel on Climate Change, 2018).

Therefore, significant decisions being taken today and over the next few years—on regulations, investments, and management strategies—will determine the state of the world the current cohort of school students inherit as young adults. It is the next generation that will bear the worst of the effects of unmanaged climate change, yet the decisions that determine how well those effects will be avoided or managed are being taken before the current generation of school students can vote or directly influence policy. These students have indeed been making their voices heard via protests, social media activism, and school strikes. It is vitally important to listen to them, and center the voices of children and young people in research aiming to address the social, political, and educational dimensions of climate change and related topics.

Youth Activism

It would be of benefit to both the young people and the researchers for researchers on climate change to listen to the younger generation.

Young people have been a force in environmental activism for a long time, although attention has generally focused more on young adults (particularly college students) than on minors. The first "Earth Day" in 1970 was marked by activism on college campuses (Freeman III, 2002; Rome, 2010). Individual youth activist activity during the 1990's and early 2000's led to the formation of the Youth Climate Movement in 2005 (Ogrodnik and Staggengborg, 2016; Foran et al., 2017). Compared with older generations, young people are consistently "associated with activism and with liberal politics" (Harris, 2017) (p. 296). It makes sense that younger people are more likely to challenge a conservative status quo than their parents and grandparents, who are perhaps more likely to be comfortably established within it (Flanagan and Tucker, 1999; Sloam, 2013).

It also makes sense that young people are more likely to be concerned with projections of climate devastation over the coming decades than older people who may not live long enough to see the worst effects. Wray-Lake, Flanagan, and Osgood (Wray-Lake et al., 2010) write that "today's young people will inevitably become national and global leaders with responsibility for environmental stewardship and sustainability" (p. 62).

In August 2018, teenage climate activist Greta Thunberg staged a protest outside the Swedish Riksdag (parliament), with a sign that read "Skolstrejk för klimatet" ("School strike for the climate"). She has since staged the same protest every Friday (www.fridaysforfuture.org), and has been joined by both individual strikers and mass protests in countries from Ireland to Japan to Argentina (Taylor, 2019). Reis, Ng-A-Fook, and Glithero (Reis et al., 2015) provide a table of examples of "youth who are leading the way in recent environmental action" (p. 44).

Children and young people are increasingly aware that on the current trajectory, the risks and dangers of climate change will be significantly worse by the time they come of age.

The Case for Children's Voice in Geoscience Research

Thus the intertwined issues of climate change, sustainability, pollution, etc, are of considerable importance to the next generation (Fisher, 2016). But when research is undertaken, it is conceived, designed, and enacted by adults. The lives of children and teenagers have changed drastically since current adult researchers were teenagers (Sandeen, 2008). How can adults know if they're even asking the right questions, if they have little familiarity with the world teenagers are living in now? Furthermore, teenagers and young people use language differently to older people; not just unfamiliar new slang, but pioneering new grammatical constructions (McCulloch, 2019). If they manage to ask the right questions, how can they be sure they're interpreting the answers accurately?

The United Nations Convention on the Rights of the Child (UNCRC) says that children should have meaningful input on

issues that affect them. This must include research undertaken on these issues, particularly where the goal of the research is to inform policy.

Research undertaken that will directly or indirectly affect the lives of young people should be informed by the experiential expertise of young people themselves. The following section will explain one method of centering children's voice by including representative students as co-researchers during the research process (Broström, 2012).

HOW TO LISTEN TO CHILDREN ABOUT GEOSCIENCE

James (James, 2007) catalogs the ways in which children's voices can be used in research, along with the common problems and pitfalls: "Giving voice to children is not simply or only about letting children speak; it is about exploring the unique contribution to our understanding of and theorizing about the social world that children's perspectives can provide" (p. 262).

In order to incorporate children's and young people's voices in matters that affect them, it is useful to follow the principles laid out in the UNCRC. Giving children the opportunity to speak is not enough; there are four elements that must be present for their voice to be meaningfully incorporated. These are: Space, that is, the opportunity and time to express their views; Voice, including ensuring they have the requisite vocabulary; Audience, meaning that someone will listen to their views; and Influence, or the potential to actually enact change or progress (Lundy, 2007). The last of the four elements is crucial - there is no point listening to, e.g., student climate activists, if their opinions and preferences will not have an effect on the decisions being taken on policy (Welty and Lundy, 2013). While efforts have been made to involve children in problematising climate change (Arts, 2019), expanding the focus to geoscience more broadly would provide young people with a deeper understanding of the myriad factors affecting their future.

The Research Advisory Group

The Children's Research Advisory Groups (CRAGs) method centers children's or students' voice in research (Lundy et al., 2011; Murphy et al., 2013). Representative groups of children act as expert co-researchers, giving their opinions derived from their experiential expertise on "children similar to themselves" (for example, their peers, classmates, siblings, etc). This method was first described by Lundy and McEvoy (Lundy and McEvoy, 2009), then called a Children's Advisory Group.

As Lundy and McEvoy (ibid) describe, school is likely to be the most convenient location to hold a CRAG, however, it's important that the students don't feel like the CRAG is "schoolwork" or that they have to participate, or have to provide a "right answer". In order to minimise this, CRAGs are conducted in a manner that isn't like ordinary school, and the young co-researchers are consulted or given control over many aspects of the CRAG. For example, Lundy and McEvoy (ibid) suggest the CRAG not take place in the students' usual classroom (preferably in an unconventional room such as the art room) and proceedings kept informal. Young co-researchers choose their own system for pseudonyms, if pseudonyms will be used.

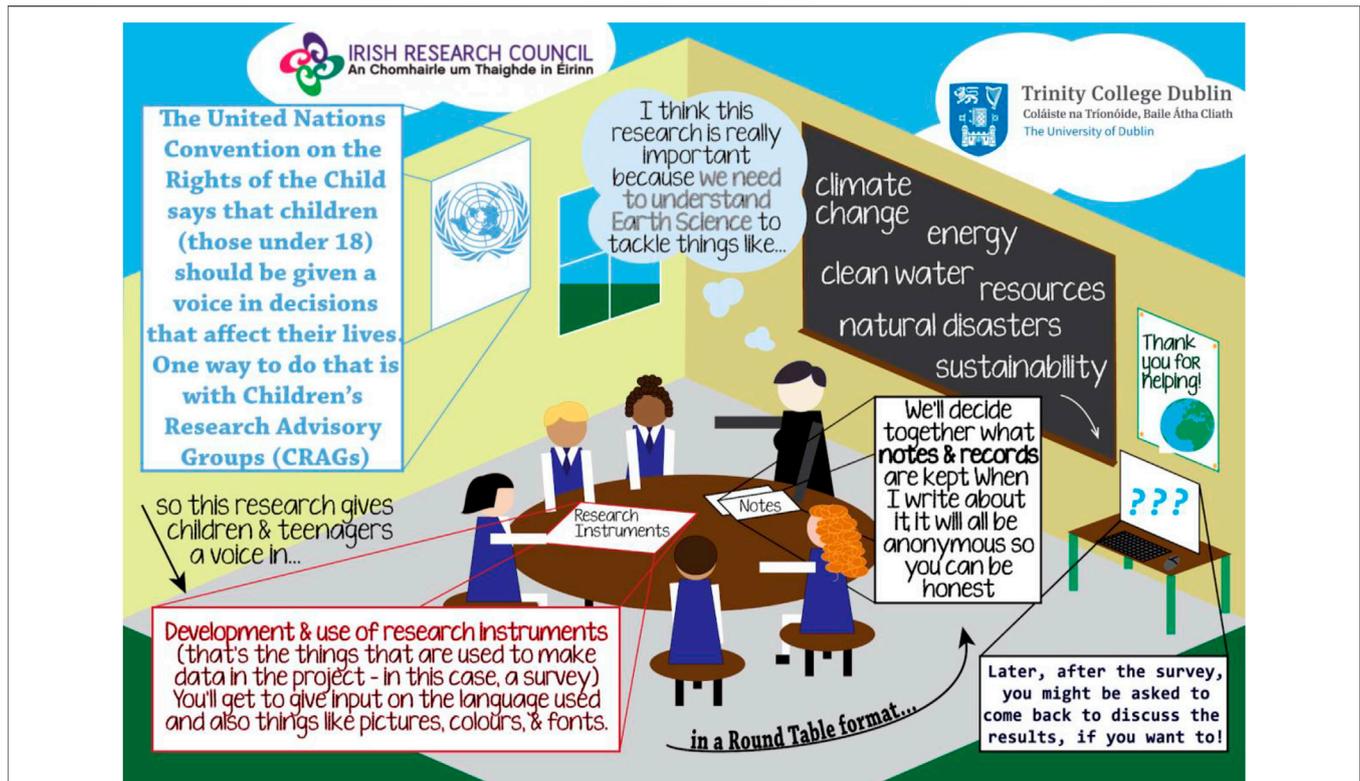


FIGURE 1 | Children's Research Advisory Groups: An excerpt (edited for clarity) from the information sheet given to student co-researchers as part of an ongoing geoscience education research project undertaken by the authors (Artist is EN).

Perhaps most importantly, young co-researchers jointly determine how the CRAGs proceed, how the discussion is framed, and how records are kept. As can be seen in **Figure 1**, the Research Advisory Group method is particularly useful for topics where there is a high degree of student engagement, as is the case with climate change and environmental issues. Although multifaceted and multidimensional in their nature, these problems can be tackled by the advisory groups through longer or repeated engagements. As well as helping them to express their views, capacity-building activities can aid children in familiarising themselves with issues they may not have encountered before and applying the views they form to situations other than their own experiences [ibid]. To make such a process feasible, a CRAG facilitator visiting a school needs the support and backing of both school and teacher.

DISCUSSION

Let Students Improve Geoscience Education

There is a need to address the place of geoscience in formal education (Lewis and Baker, 2010; Neenan and Roche, 2016). Children's lives are framed around school from as young as four years old until typically their late teens. It is unsurprising that the teenage-driven climate change protest has focused on school strikes. Students ask why they should go to school if they are

not being prepared for climate change, and instead are being taught skills and knowledge that may not be useful in a rapidly changing world.

Placards with slogans such as "Why bother with school when you won't listen to the educated?" and "This generation got no destination" are brandished by frustrated school students (**Figure 2**).

Student activist groups in several countries have explicitly called for climate change to be addressed in schools. For example, the Irish student-led activist group Schools' Climate Action Network Ireland has called for "reform of the education system to address the need for ecological literacy" (O'Sullivan and Kelleher, 2019). In many countries, climate change, natural resources, natural disasters, and sustainability are touched on as part of subjects such as Science, Geography, and Social Science, but there are increasing calls globally for climate change to be covered in more depth and detail in the formal education system. A YouGov poll commissioned by Oxfam in the United Kingdom found that 69% of teachers agreed there should be more emphasis on climate change in schools, but that three-quarters of teachers did not feel they had received adequate training to be able to deliver climate change content in lessons. This research didn't address students' opinions, nor is students' knowledge of the system usually drawn upon in curriculum reform.

One theory of the purpose of formal education is to prepare children for the future. It is increasingly clear that the impacts of climate change will significantly affect current students' futures,



FIGURE 2 | In Their Own Words: Signs by students expressing frustration at the first major School Strike For Climate march in Ireland, on Friday the March 15, 2019 (Photographer is EN).

and the formal education system must take this into account. Using CRAGs in education research is relatively time-consuming and requires a lot of work from the school(s) as well as from the researcher(s). However, it is potentially an invaluable tool for education reform at all levels.

Let Underrepresented Groups Improve Inclusion and Access

The geosciences in Western countries have long been dominated by white men, at the loss of the expertise and perspectives of women, people of other races and ethnicities, disabled people, queer people, etc. (Holmes et al., 2008; Atchison and Martinez-Frias, 2012; Bernard and Cooperdock, 2018). Matters are improving, particularly with regard to gender, but slowly, and success with diversity and inclusion programs has been mixed (Dobbin and Kalev, 2016; Huntoon, 2016). Research on barriers and obstacles to inclusion, and programs and initiatives to diversify a field, are most effective when underrepresented groups have input from the very beginning (Abu-Amsha et al., 2019; Young et al., 2019). In order to attract and retain more female, Black or minority ethnic, disabled, queer, working class, and other underrepresented geoscientists tomorrow, involve children and teenagers in the research on diversity and inclusion today.

CONCLUSION: BY LISTENING TO CHILDREN AND YOUNG PEOPLE, WE GIVE THEM POWER

Given the recent trends towards greater participant-driven research, crowdsourcing, and citizen science, it is important to

make visible and clear the full context of how power is being returned to the participants in a system (Woolley and et al., 2016; Roche et al., 2020). Even aside from ethical or moral considerations of returning power to participants in research, children and young people have expertise on their own experience, which can be leveraged to improve data collection and analysis. With enough qualitative and quantitative data collection, the Research Advisory Group method could inform policy recommendations. In the context of geoscience education, this could lead to children's input being explicitly integrated into formal education systems, while the underlying CRAG method could be readily adapted to different disciplines and educational contexts.

In order to balance the power in a researcher-participant interaction, care must be taken at every stage of the process. Eitzel et al. (Eitzel et al., 2017) show that even the terminology itself should be chosen carefully, and its usage explained for all participants. Aspects such as the language used or the space in which the discussion takes place must be considered and, if necessary, reworked. This is a process that costs time and effort, but that results in better data, and data that is arguably generated more ethically.

“Honoring young children's rights to express their views creates more effective policy and it fosters stronger, more cohesive and inclusive communities. In these ways it contributes to a healthy democracy which recognises that children's rights are the human rights of any citizen” (MacNaughton et al., 2007) (p. 9).

“Those who will be affected the hardest are already suffering the consequences. But their voices are not heard” (Thunberg, 2019).

This doesn't just apply to young people: it applies to coastal and island villages, subsistence farmers, Indigenous populations, and many others. But the further someone is from their life expectancy, the greater the threat of climate change. Young people must be given a seat at the table when the future of the planet 10, 20, 30 years from now is being discussed (O'Brien and Political agency, 2015).

Students are experts on their own experiences and the realities of the worlds they live in; classrooms, family homes, family farms, student activist circles, clubs and sports, their local area. That expertise can and should be tapped into, especially when the stakes for the planet have never been higher.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Trinity College Dublin Research Ethics

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AUTHOR CONTRIBUTIONS

EN carried out the CRAGs and led the writing of the paper. JR and LB contributed to the conceptual design, writing, and editing.

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Farmers' Perception of Climate Change: A Review of the Literature for Latin America

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Global climate is changing rapidly, and it is not clear if agricultural producers in developing countries will be able to adapt fast enough in order to mitigate its negative effects. In order to be willing to take adaptation measures, farmers need to perceive that the climate is changing or could change, and they need to attribute enough weight to this perception to take action. During the last two decades, the literature that examines farmers' perception of climate change has gained ground, but it is still scant. This is particularly true for Latin America, which is highly vulnerable to climate change. Based on a review of original research articles published between 2000 and 2020, this article presents the status of knowledge about the topic in the region to identify research gaps and inform future research. The review found that the available research has been based mostly on qualitative analyses of case studies for a few countries. More research that identifies causal relationships is necessary. Data from surveys that are representative at the national or subnational levels, as well as longitudinal data, will be very helpful to better understand farmer's perceptions. Finally, the use of field experiments and choice experiments can complement the use of observational data.

Keywords: perception, climate change, adaptation, Latin America, farmer, agriculture

INTRODUCTION

Throughout human history, farmers have adapted to changing environmental, social and economic conditions (Kurukulasuriya and Rosenthal, 2013). Nonetheless, it is not clear if agricultural producers will be able to keep up with the unprecedented speed at which climate is expected to change in the coming years (Jones et al., 2012). The negative effects of these changes will be higher for agricultural producers that practice rainfed agriculture, as well as for those with limited access to credit and insurance, and those that are disconnected from regional or national markets (Skoufias et al., 2011; Quiroga et al., 2015; IFAD, 2016; Castells-Quintana et al., 2018). In order to ameliorate these negative effects, public policies and interventions to promote and facilitate adaptation will be needed (Howden et al., 2007; Kumar et al., 2020). Nonetheless, in order to be willing to implement adaptation measures, farmers need to be aware of climate change (Silvestri et al., 2012; Simelton et al., 2013; Meldrum et al., 2018). In that sense, the perception that farmers have about climate change not only informs their planting decisions, but also determines the adoption of adaptation measures (Meldrum et al., 2018; De Matos Carlos et al., 2020). Therefore, understanding farmers' perceptions about climate change can be seen as a condition for the design and successful implementation of

adaptation policies in agriculture (Hansen et al., 2004; Silvestri et al., 2012; De Matos Carlos et al., 2020).

The number of studies that focus on understanding farmers' climate change perception has been increasing, but it is still scant. This is particularly true for Latin America (Dang et al., 2019; Karki et al., 2020), a region highly vulnerable to climate change (López-Feldman and Hernández Cort). This phenomenon is expected to have serious negative impacts on the income, consumption and health of agricultural producers in the region (Reyer et al., 2017; IPCC et al., 2018), leading to increases in poverty and inequality (Skoufias et al., 2011; Harvey et al., 2018; López-Feldman and Mora Rivera, 2018). Given this scenario, the lack of research on the determinants of climate change perception is worrisome. The objective of this work is to present an overview of the studies on this topic available for Latin America while identifying research gaps and potential paths for future research.

CLIMATE CHANGE PERCEPTION

Climate change perception is a complex process that encompasses a range of psychological constructs such as knowledge, beliefs, attitudes and concerns about if and how the climate is changing (Whitmarsh and Capstick, 2018). Perception is influenced and shaped, among other things, by the individuals' characteristics, their experience, the information that they receive, and the cultural and geographic context in which they live (van der Linden, 2015; Whitmarsh and Capstick, 2018). Therefore, measuring climate change perception and trying to find its determinants is not an easy task.

The variability that local weather can have from one day to the other, from one season to the next, and between years, is one of the many challenges that a person faces when trying to distinguish between normal short-run variations and climate change manifestations (Hansen et al., 2012). In fact, local short-term variations tend to be more salient than long-term trends and hence can have a key impact on the formation of climate change perceptions (Lehner and Stocker, 2015). Although the perception of those that directly depend on the weather for at least part of their income, such as farmers, tend to be more accurate than that of their counterparts, they might still have problems using their own experience with weather variables to correctly interpret changes as being big enough as to feel worried and compelled to do something about it (Weber, 2010; Whitmarsh and Capstick, 2018).

Life experiences influence perception, individuals who have been directly affected by extreme climatic events tend to report that the probability of such event happening again is relatively high (Patt and Schröter, 2008; De Matos Carlos et al., 2020). Furthermore, the perception that a person has about climate change can be influenced or modified by the information that she receives (Weber, 2010). Finally, it should be noted that perception is in part a subjective phenomenon, therefore, different people in the same locality might construct different perceptions of climate change even though they experience the same weather patterns (Simelton et al., 2013).

THE LINK BETWEEN PERCEPTION AND ADAPTATION TO CLIMATE CHANGE

In order to protect the livelihoods of the population that directly depends on agriculture, adaptation of the agricultural sector to the adverse effects of climate change is crucial (Asfaw et al., 2016). In a world with perfect information, complete markets, and adequate incentives, the decision to adopt or implement a particular adaptation measure would simply be a matter of evaluating the net benefits of said measure. That is certainly not the setting in which small and subsistence farmers in developing countries operate (Castells-Quintana et al., 2018). Therefore, the adoption of adaptation measures is not an automatic or smooth process, quite the contrary. The evidence has shown that factors like inadequate access to insurance or credit, limited information about adaptation alternatives, and incomplete property rights, constitute barriers that small and subsistence farmers face in relation to technology adoption (Asfaw et al., 2016). Furthermore, the decision to adopt a new technology or production method frequently entails cognitive processes, like mental accounting (Thaler, 1999), loss aversion (Kahneman and Tversky, 1979), and hyperbolic discounting (Laibson, 1997), which can lead to suboptimal levels of adoption (Zilberman et al., 2012). This is particularly relevant for adaptation to climate change, as even farmers with access to weather information and climate forecasts face considerable levels of uncertainty (Silvestri et al., 2012). Under these conditions, the perception that farmers have about climate change is a key component to understanding their adaptation decisions (Clarke, et al., 2012).

Adaptation requires not only that individuals perceive that something is changing or could change, but also that they attribute enough weight to this perception to be willing to take action and try to do something about it (Eakin et al., 2014). In this sense, perceiving that the climate is changing can be seen as a pre-condition for the adoption of agricultural adaptation measures (Simelton et al., 2013; Makuvaro et al., 2018). Furthermore, the successful implementation of public policies aimed towards the promotion of adaptation requires, among many other things, the cooperation and participation of the intended beneficiaries. If their perception about the consequences or immediacy of climate change is different from that of the policy makers, then it is likely that the implementation of the policy will fail (Patt and Schrö).

CLIMATE CHANGE PERCEPTION OF FARMERS IN LATIN AMERICA

Hansen et al. (2004) were the first to analyze the climate perceptions of farmers in a Latin American country (Argentina). The literature on this topic has slowly grown since then, although it is still scarce compared to that from Africa and South-East Asia (Altea, 2020; Karki et al., 2020). Here we briefly summarize some of the main findings of the studies about Latin America published, in either English or Spanish, during the period 2000–2020. The articles' selection process was based on some of the steps used in systematic reviews,

TABLE 1 | Basic information for studies regarding climate change perception in Latin America.

Authors	Methods	Climate related variables	Sample size	Study area	Language
Hansen et al. (2004)	Qualitative analysis (Mental models)	Temperature, precipitation, <i>el Niño</i> and <i>la Niña</i>	215 farmers (200 in Argentina and 15 in the US)	Argentina	English
Boillat and Berkes (2013)	Qualitative analysis (Semi-structured interviews)	Temperature, precipitation and wind	28 households	Bolivia	English
Jacobi et al. (2015)	Qualitative analysis (Focus groups)	Temperature (extreme heat) and droughts	30 farmers and 5 experts	Bolivia	English
Meldrum et al. (2018)	Quantitative analysis (Focus groups and multifactor analysis)	Temperature, precipitation, hail and frost	193 households	Bolivia	English
Valdivia et al. (2010)	Qualitative analysis (Participatory research)	Temperature, precipitation, droughts, floods, hail and frost	330 households	Bolivia	English
De Matos Carlos et al. (2020)	Quantitative analysis (Logit)	Temperature, precipitation and droughts	289 farmers	Brazil	English
Funatsu et al. (2019)	Quantitative analysis (Descriptive statistics and bivariate analysis)	Precipitation	747 households	Brazil	English
Roco et al. (2015)	Quantitative analysis (Probit)	Temperature, precipitation and droughts	274 farmers	Chile	English
Barrucand et al. (2017)	Qualitative analysis (Structured and semi-structured interviews)	Temperature, precipitation and wind	37 households	Colombia	English
Leroy (2019)	Qualitative analysis (Structured and semi-structured interviews)	Water Scarcity, temperature, and precipitation	56 farmers (24 Venezuela y 32 Colombia) and 17 strategic actors	Colombia and Venezuela	English
Pinilla et al. (2012)	Qualitative analysis (Structured and semi-structured interviews)	Precipitation	487 farmers	Colombia	Spanish
Eakin et al. (2014)	Qualitative analysis (Descriptive statistics)	Droughts, torrential rainfall and hurricanes	1,267 households (Costa Rica:399; Guatemala:399; Honduras:161; Mexico:164)	Costa Rica, Guatemala, Honduras, and Mexico	English
VanderMolen (2011)	Qualitative analysis (Semi-structured interviews)	Temperature and precipitation	90 farmers	Ecuador	English
López-García and Manzano (2016)	Qualitative analysis (Semi-structured interviews)	Temperature, precipitation and droughts	35 persons	Mexico	Spanish
Meli et al. (2015)	Qualitative analysis (Participatory research, semi-structured interviews)	Temperature and precipitation	93 persons (57 ejidatarios, 14 elders and 22 local authorities)	Mexico	English
Orduño et al. (2019)	Quantitative analysis (ANOVA, Principal Component analysis)	Precipitation, droughts, floods and frost	370 farmers	Mexico	English
Sánchez-Cortés and Lazos (2011)	Qualitative analysis (Semi-structured interviews)	Temperature and precipitation	69 persons	Mexico	English
Quiroga et al. (2015)	Quantitative analysis (Ordered probit)	Water available for irrigation	274 farmers	Nicaragua	English
Altea (2020)	Qualitative analysis (Semi-structured interviews)	Temperature, precipitation, hail and frost	23 farmers and 13 regional institutions	Peru	English
Gurgiser et al. (2016)	Quantitative analysis (Semi-structured and narrative interviews)	Precipitation	37 farmers, 16 representatives of communities and 26 representatives of public institutions and NGOs	Peru	English
Fourment et al. (2020)	Qualitative analysis (Semi-directed interviews)	Precipitation (with strong winds)	38 winegrowers and 3 technical advisors	Uruguay	English

Source: Own elaboration.

in particular we followed Karki et al. (2020) and Dang et al. (2019). For our search, we used the following combinations of keywords or closely related words: *climate change* (climate, climate variability, global warming, temperature, rainfall), *extreme weather events* (droughts, hurricanes, tropical storms), *perception* (understanding), *Latin America* (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico,

Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela, North America, Central America, South America), *family farms* (farms, small producers, farmers, subsistence farms, household, communities, villages), *indigenous* (indigeneity). In our search, in addition to *Science Direct* and *Web of Science*, we also used *Google Scholar*. It has been shown that *Google Scholar* has a very good coverage in areas where *Web of Science* does not (Martín-Martín, et al., 2018), therefore, by using these three

databases we have a comprehensive coverage of the literature. The title and abstract of 112 published papers that resulted from the search were analyzed to check if at least one of the objectives of the paper was to empirically analyze the climate change perceptions of farmers in a Latin American country; if that was the case, the paper was included in the revision. We focused on research published in peer-reviewed journals, the only exception was (Hansen et al., 2004) which was published as a technical report and was the first study to analyze the topic in a Latin American country. At the end of this procedure, 21 scientific articles met the pre-established criteria.

As **Table 1** shows, the existing studies come from a limited number of countries in the region; Mexico being the country with the highest number of studies available with five. Case based analysis was conducted for most, allowing for a more in depth understanding of local actors and weather (Funatsu et al., 2019), while excluding generalizations at greater scales. Only two studies (Eakin et al., 2014; Leroy 2019), covered more than one Latin American country. The studies are based on small samples; the average sample size of the papers included in **Table 1** is 240, with a range of 23–1,267 observations. Most of the studies are qualitative, only three use an econometric approach as part of the analysis. Latin America's diversity in terms of ecosystems, climate, and agricultural production systems is reflected in the studies. The papers in **Table 1** analyze farmers in settings that go from semiarid environments to high mountain ecosystems, intertropical alpine ecosystems (*páramos*), and tropical forests, and, although the majority of them are of subsistence farmers, there are also studies that look at small commercial farmers, such as winegrowers. Coffee is the crop that farmers were planting in most of the studies, followed by maize, banana, cacao, potatoes, sugar cane, beans, tomatoes, and cocoa.

The papers reviewed look at the perception that farmers have about changes in, among other climate and weather-related variables, temperature, precipitation, and droughts. Results show that most of the farmers have in fact perceived changes in these variables. A common approach used in many of the studies is to compare farmers perceptions with the actual measured variations in the respective variables. In this way, in addition to testing if farmers perceive changes in climate-related variables, it is also possible to test if farmers perceptions coincide with actual changes. The reported results are mixed, in some cases there is a clear correspondence between changes reported by farmers and actual changes (Pinilla et al., 2012; Roco et al., 2015; Fourment et al., 2020), while in other contexts, farmers' perceptions are less aligned with observed changes (Valdivia et al., 2010; Gurgiser et al., 2016; Funatsu et al., 2019). However, even in those cases where farmers disagree in the direction in which weather variables are changing (e.g., more or less precipitation), they tend to agree in reporting that there is more variability and in mentioning that a less reliable and more unpredictable weather complicates their farming related decisions (Eakin et al., 2014; Meli et al., 2015; López-García and Manzano, 2016). Nonetheless, in some cases even when farmers perceive climate variability, they do not attribute it to climate change as they see it as a future and long-term issue (Fourment et al., 2020).

Even though the focus of this review was not farmers' adoption of adaptation practices, the articles that do look at adoption show that, in general, farmers try to adapt to the changing environmental circumstances that they are facing (Eakin et al., 2014; Jacobi et al., 2015; Gurgiser et al., 2016; Meldrum et al., 2018; De Matos Carlos et al., 2020). Particularly relevant for the focus of this review is the result reported by De Matos Carlos et al. (2020) showing that there is a positive correlation between the adoption of adaptation practices and perceiving a change in climate.

The literature for Africa and Asia has shown that factors such as age, gender, education, and culture, play an important role in the processes that determine farmers' perception of climate change (Karki et al., 2020). This seems to be the case in Latin America as well. Results for Chile show that younger and more educated household heads tend to have a perception of climate change that is more aligned with the observed changes in weather variables than the perception of their older and less educated counterparts (Roco et al., 2015). Nonetheless, there is also evidence showing that, in other contexts, farmers might have similar perceptions of climate change irrespective of their age; that is the case for Southern Mexico (Meli et al., 2015). Meanwhile, results for Brazil (Funatsu et al., 2019), Peru (Altea, 2020), and Mexico (Sánchez-Cortés and Lazos, 2011; Orduño et al., 2019) show that women are less involved than men in agricultural activities and in general in decision making. Furthermore, they tend to be less perceptive of climate change, and, at least according to the evidence for Brazil and Peru, when they perceive it, they do not think of it as an anthropogenic phenomenon. Similarly, some indigenous farmers in Bolivia see climate change as a punishment of God to inappropriate human behavior (Boillat and Berkes, 2013). Results from an analysis of indigenous farmers in Mexico, show another relevant cultural aspect behind climate change perception; the Zoques in Chiapas use biological indicators (e.g., ants, birds and some plants), in addition to their observation of weather variables, to explain perceived changes in climate variability (Sánchez-Cortés and Lazos, 2011).

In addition to the aforementioned characteristics, agroclimatic conditions can also play a relevant role as a determinant of climate change perception (Karki et al., 2020). In Chile, for example, farmers living in dryland areas, where rainfall is always marginal, seem to be more aware of climate change than those located in places where irrigation infrastructure is widely available (Roco et al., 2015). Something similar, although less conclusive, is reported for Ecuador (VanderMolen, 2011). Altea (2020) presents evidence suggesting that in Peru perception of climate change varies with the altitude in which the agricultural land is located. Meanwhile, in the case of Brazil, although droughts affect farmers located in the tropical rainforest as well as those living in shrubland areas (characterized by low and irregular levels of precipitation), rainforest farmers seem to be less aware of the effects of climate change (De Matos Carlos et al., 2020). Farmers' location can be related to perception for another reason: access to meteorological information. This seems to be the case of Chilean farmers, those located close to the regional capital are more aware of the actual changes in weather

(Roco et al., 2015). Finally, perception could be affected by recent experience with climate events. Barrucand et al. (2017) report that the perception of changes in precipitation could be biased upwards when farmers have been recently affected by a weather phenomenon; La Niña occurred a few months before farmers participating in their case study were interviewed.

DISCUSSION, RESEARCH GAPS AND OPPORTUNITIES FOR FUTURE RESEARCH

The “finite pool of worry” hypothesis proposes that climate change concern is a finite resource, that is, it diminishes as other worries rise in prominence (Weber, 2006; Weber, 2015). Other than the work from Hansen et al. (2004), this is something that has not been carefully studied for Latin American farmers. Understanding how the presence of more immediate threats (e.g., violence) might hinder concern, and therefore action, about the implications of climate change is crucial in a region with high levels of poverty, inequality and social unrest. In particular, it has been shown that exposure to violence can induce higher levels of risk aversion, which in turn hampers productive investments (Moya, 2018). Given the relatively high levels of violence experienced by rural populations in many Latin American countries, understanding the effects that exposure to violence can have on climate change perceptions, as well as on adaptation decisions, is crucial for the successful adaptation of farmers in the region.

The studies available for Latin America are mostly qualitative in nature and based on case studies and small samples. While these studies provide abundant information in terms of the local context, it is desirable to complement them with quantitative studies, in particular with econometric studies. Econometric studies have the potential to identify the main factors behind climate change perceptions as well as the relationship between perception and adaptation. Furthermore, given the adequate data and the correct identification strategy, econometric tools can help establish causal relationships. Moreover, data from surveys that are representative at the national or sub-national levels are necessary to obtain results that can be generalized and used to scale-up adaptation policies and programs. Ideally, these data should be longitudinal in order to better understand how information and the occurrence of extreme climatic events affect perception and adaptation over time. The national statistical offices of all Latin American countries should regularly collect information on perception of climate change and adoption of adaptation mechanisms.

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The use of *field experiments* and *choice experiments* is an alternative approach which can complement the use of observational data. These tools are used widely in behavioral, environmental and experimental economics, among other disciplines. The use of hypothetical scenarios, a characteristic of these two methods, allows for the construction of mental simulations of the negative effects of climate change. By being based on hypothetical scenarios, these methods have an important advantage over observational studies: they can be used to analyze policies before they are actually implemented. These methods could also be useful to test how successful different policies might be in terms of promoting adoption of adaptation measures. Furthermore, they can help us analyze the effect that different approaches to communicate climate change information has on perception. The issue of the perception of climate change in a context where concern is in fact a finite resource could also be analyzed using these methods. Applying field and choice experiments to study perception and adaptation to climate change in Latin America is a very promising agenda from a purely academic perspective, but, more importantly, it could be very relevant in terms of providing valuable information that could aid in the design and successful implementation of public policies.

The complexity behind the analysis of farmers' climate change perception implies that the collaboration between researchers from different disciplines, such as economics, geography, meteorology, psychology, and sociology, among others, is almost a necessity. If such collaboration is successfully achieved, the results could generate recommendations for the design of adaptation policies that are better tailored to local conditions, less costly, more efficient, and conducive to rural development.

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All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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