World Development 183 (2024) 106719

Contents lists available at ScienceDirect

World Development

journal homepage: www.elsevier.com/locate/worlddev

Regular Research Article

Minority groups, Indigenousness and Indigeneity, and place in social perceptions of future climate interventions

Benjamin K. Sovacool [a,b,c,*], Chad M. Baum [a], Livia Fritz [a]

[a] Department of Business Development and Technology, Aarhus University, Denmark
[b] Science Policy Research Unit (SPRU), University of Sussex Business School, United Kingdom
[c] Department of Earth and Environment, Boston University, United States

ARTICLE INFO

Keywords:
Climate interventions
Climate policy
Energy policy
Geoengineering
Carbon removal
Environmental politics

ABSTRACT

Radical climate intervention technologies such as carbon dioxide removal and solar radiation management pose difficult questions as potential remedies for destructive climate change. The effect these technologies could have on Indigenous peoples and minority groups, and those living in rural areas, could be profound and potentially calamitous. Drawing on a large-scale, cross-country set of nationally representative surveys (n = 30,284 participants, with at least 1,000 in each country) in 30 countries and 19 languages, this article examines public preferences for climate intervention technologies through the three dimensions of minority groups, Indigenousness, and place. The survey explores 10 climate intervention or geoengineering technologies: stratospheric aerosol injection, marine cloud brightening, space-based geoengineering, afforestation and reforestation, soil carbon sequestration, blue carbon and marine biomass, direct air capture with carbon storage, bioenergy with carbon capture and storage, enhanced rock weathering, and biochar. Comparing the full sample of respondents with a subsample self-identifying as ethnic minorities or Indigenous peoples, it finds this latter category of respondents has greater familiarity with these technologies than non-members, are more positive about small-scale trials and have more positive attitudes towards engineered options (versus nature-based options). Those in cities also expressed stronger support for small-scale field trials. Moreover, members of Indigenous groups or ethnic minorities expressed significantly higher levels of support for small-scale trials for nearly all technologies, were more supportive of policy incentives, and, *inter alia*, less supportive of policy restrictions. Conversely, non-members of Indigenous or ethnic minority groups expressed small but significantly greater support for independent national restrictions being placed on solar radiation management and engineered forms of carbon removal.

1. Introduction

Novel and often controversial climate intervention technologies such as carbon dioxide removal and solar radiation management are attracting attention from researchers, investors, and policymakers as the adverse impacts of climate change increasingly occur (IPCC, 2022; Smith et al., 2023; Diesendorf, 2022). Negative emissions technologies, also known as carbon dioxide removal (CDR) or greenhouse gas removal (GGR), may be utilized to remove carbon dioxide from the Earth's atmosphere. These options are assigned to a varying extent an expandingly critical role within the range of strategies and trajectories that aim to reduce global temperature change or meet the longer-term targets embedded in the Paris Agreement (Masson-Delmotte et al., 2018). Some may involve novel and potentially risky engineering techniques such as Direct Air Capture with Carbon Storage of Enhanced Weathering (Low et al., 2022), others more established and nature-based techniques such as afforestation, forest conservation, and forest management (Liu et al., 2024; Piris-Cabezas et al., 2023).

By contrast, solar geoengineering technologies, also known as solar radiation management or modification (SRM) or sunlight reflection methods, seek to reflect a portion of incoming sunlight back into space before it reaches the Earth's surface. These options could serve as an emergency intervention to counteract the risk of global warming, reduce the risk of tipping points, or create a stop-gap period of adjustment that gives countries time to adapt to the impacts of climate change (Barrett and Lenton, 2014; Cherry et al., 2022; Sovacool, 2021; Corner and

* Corresponding author at: Department of Business Development and Technology, Aarhus University, Denmark.
E-mail address: benjaminso@hih.au.dk (B.K. Sovacool).

https://doi.org/10.1016/j.worlddev.2024.106719
Accepted 10 July 2024
Available online 24 July 2024

Pidgeon, 2015).

When combined into a portfolio, this collection of negative emissions and solar geoengineering interventions could (with varying degrees of confidence and efficacy) limit global temperature change to below 2 degrees Celsius (Hubert, 2016: 488), address the wicked problem of residual emissions (Buck et al., 2023; Lund et al., 2023) or emissions gaps (Höhne et al., 2020), and couple positively with the sustainable development goals or enhanced global equity, food security and poverty reduction (Enevoldsen et al., 2022; Honegger et al., 2021a; 2021b).

And yet, the impact that negative emissions and solar geoengineering deployment could have on minority groups, Indigenous peoples, and those living in rural areas could be profound and potentially calamitous—with "potential inequalities in the distribution of environmental risks, research ethics, and abuses of social power" (Whyte, 2018: 289). Pathways for limiting global warming below 1.5 °C or 2 °C would require large-scale deployment of negative emissions technologies that could affect virtually every country on the planet, with possibly major unintended consequences. Jones (2018: 24) warns that "the unintended consequences of climate mitigation efforts have [already] disproportionately been borne by already marginalized communities, and hence there is a potential for the unintended consequences [such as negative emissions] to result in environmental injustice." Larkin and colleagues (2018) add that as negative emissions deployment expands, community objections, especially those from frontline communities over equity concerns, could constitute a significant constraint on uptake. In the domain of solar geoengineering, Stephens et al. (2021a: 1161) emphasize global risks including "exacerbating international conflict" and a "highly contested and politicized landscape of global climate policy." Others caution against solar geoengineering deployment on grounds of militarization and weaponization (Sovacool et al., 2023), climate justice (Stephens et al., 2021b), and governance (Biermann et al., 2022).

But what do minority groups, Indigenous peoples, and rural members of the public think themselves about these options? Drawing on a large-scale, cross-country set of nationally representative surveys (n = 30,284 participants, with at least 1,000 in each country) in 30 countries and 19 languages, this article examines public preferences for climate-intervention technologies through the three dimensions of minority groups, Indigenousness, and place. The survey explores social perceptions of 10 climate intervention or geoengineering technologies clustered into three categories: Solar Radiation Management (three options of stratospheric aerosol injection, marine cloud brightening, space-based geoengineering); Nature-Based Carbon Dioxide Removal (afforestation and reforestation, soil carbon sequestration, blue carbon and marine biomass); and Engineered Carbon Removal (direct air capture with carbon storage, bioenergy with carbon capture and storage, enhanced weathering, and biochar). After a series of screening questions, assigning respondents to one of these three technology groups, and giving introductory background material and comprehension questions (see Supplementary Material), the bulk of our survey instrument had eight sections:

- Familiarity with technologies;
- Assessment of perceived risks/benefits;
- Ranking of risks;
- Weighing risks and benefits;
- Assessments of support for technology;
- Assessment of policy support;
- Assessment of potential covariates;
- Demographics.

The survey was then distributed to a representative sample of the public in 30 countries—Australia, Austria, Brazil, Canada, Chile, China, Denmark, Dominican Republic, Estonia, France, Germany, Greece, India, Indonesia, Italy, Japan, Kenya, Netherlands, Nigeria, Norway, Poland, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States—in 19 languages. This sample of countries was intended to capture a mix of those with large and small populations, with different political regimes and policy environments, across the Global North and Global South, and with geographic heterogeneity including island nation states, coastal states, landlocked states, Arctic states, and tropical states.

Such a diverse sample of countries was important given that social perceptions often vary among these demographic, political, economic, and geographic dimensions. Our results can lead to the identification of communities of color or place for whom the issue of climate change may be less politically charged, such as racial and ethnic minorities and members of socioeconomically disadvantaged groups (Schuldt and Pearson, 2016), represent critical audiences for bridging partisan disagreements and building consensus on policy. Although the primary objective of the paper is empirical, and it involves charting social perceptions across underexamined communities within society as well as unexamined countries in the literature, the authors genuinely encourage future researchers to make theoretical advances as well, which can build on our empirical foundations to make future conceptual frameworks more valid and robust.

2. Definitions, terms, and positionality

Given the sensitivity of the topic, some definitions and reflections on ethnic minorities, Indigenousness and Indigeneity, and place are warranted.

This study uses the term "minority group" or "ethnic minority" to refer to social groups or diasporas that are often numerically smaller than a majority group, and who share a common religious, linguistic, or ethnic heritage or identity (Baird, 2008), an interpretation also supported by research in this journal (Stevens and Pelkonen, 2023; Lazarev and Mironova, 2018). Although outdated and at times controversial, the term is still widely used in national and global policymaking, e.g. in the United States for its census (US Census, 2020) as well as the European Union Charter of Fundamental Rights (European Commission, 2021) and the World Bank (2020). Although no harmonized global dataset exists, the United Nations (2011) estimates that approximately 10–20 per cent of the world population belongs to a minority group of some kind, making that group constituent of 600 million to 1.2 billion people. Examples would be African Americans or Hispanics/Latino/Latinas in the United States, the Roma across Europe, Dalits and Muslims in India, and Afro-descendants in Colombia, or cultural groups other than the Kinh in Vietnam (DeJaeghere et al., 2022) or other than Han Chinese in China (Ouyang and Pinstrup-Andersen, 2012).

"Indigenous peoples" encompass groups who have a special connection with their territory or land, and who were often the first people to inhabit that particular place. Schlingmann and colleagues (2021: 57) classify Indigenous peoples as "groups who are descended from and identify with the original inhabitants of a region and maintain a deep connection to place and nature over generations." The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) conceptualizes Indigenous peoples as a community of people who share intergenerational ancestry and cultural aspects with original (pre-colonial) occupants of ancestral lands in a specific region of the world and recognizes the need for respective peoples to have autonomy in defining themselves as Indigenous. Another way to conceive of Indigenousness is around a set of commonalities involving experience, culture, history, and recognition. According to Abate and Kronk (2013), this conception classifies Indigenous peoples by their: (a) experience: increased vulnerability to climate change related to the location of Indigenous communities; (b) culture: a unique connection to the land for legal, spiritual or aesthetic reasons; (c) history: a shared past connected to colonization and oppression that has potentially increased vulnerability; and (d) recognition: status under public international law that there are basic rights owed to Indigenous communities. A final way of conceiving of Indigenous groups are those that have their own autonomy or sovereignty over their territories and resources, with distinct authority compared to a central government (Rayo et al., 2024). An example here would be the "tribal sovereignty" given explicitly to Native Americans in the United States which gives them authority to self-govern their own reservations (Macklem, 1993). A large part of the global Indigenous population lives in urban contexts, which determines other types of vulnerability and also affects the vulnerability of those living in traditional territories.

Following this conception, examples of Indigenous peoples include the Native Americans of the United States, First Nations communities in Canada, the Aboriginals or Traditional Owners of Australia, the Sami of the Arctic, and the Miskitu of Nicaragua. At least 370 million people worldwide identify as Indigenous peoples (about 5 % of the population) or have tenure rights over Indigenous territories, and these groups collectively speak more than 4,000 languages and manage about one-quarter of the world's land area (Ford et al., 2020). In the United States, there are more than 560 federally recognized Indigenous groups (classified as "Tribes") which are situated in every type of environment or ecosystem found within the country, with the two largest subgroups being American Indians and Alaska Natives (about 5.2 million people) and Hawaiian Natives/Pacific Islanders (1.2 million people) (Wildcat, 2013).

A closely related term that we employ is that of Indigeneity. Indigenous peoples were often identified as the First People of a specific regional area, but this terminology has colonial undertones. Being the "first" to inhabit a territory may be difficult to prove, as societies have changed over thousands of years and boundaries are often complex to define. Moreover, Indigenous peoples enjoy the right to self-identification, i.e. their recognition as such does not depend on a third party. Thus, scholars have argued it may be more important to relate the definition to colonial processes, whose origins are easier to trace. Thus, Indigeneity as a term applied to First People came into use in the 1990s, as many colonized communities fought against erasure, genocide, and forced acculturation under what they saw as oppressive and colonial regimes (Steeves, 2018). The term can both substitute for the use of Indigenous peoples, or compliment it, as it is intended to reveal communities that view themselves as distinct from other parts of societies that have settled within their territory, but with a stronger emphasis on colonialism (Brown et al., 1999).

A final term used in the study is that of "place" or "sense of place." This term is utilized to depict the relationship that people have with their spatial settings. It is often employed in the geography, urban studies, and rural studies literatures in relation to place-making or place-attachment that communities have with their geographic location or homeland (Groat, 1995; Feld and Basso, 1996).

A corpus of scientific and media literature—some of which the study will present below—depicts the disproportionate and severe impacts that climate change and energy infrastructure development have on ethnic minorities or Indigenous peoples. This framing can be implicit and complicit in presenting such groups as lacking agency and competence or depicting them in need of help or rescuing from others, especially "white outsiders" (Norton-Smith et al., 2016). Other narratives can perpetuate a false portrayal of Indigenous peoples as "noble people who live in harmony with the land," insinuating that they would not consider technologies that could benefit them, such as electricity or water provision (Tsosie, 2007). This study subscribes to neither narrative, and instead represents the viewpoints of people identifying as ethnic minorities or Indigenous in their own words, through their own stated preferences. Rather than closing down the discussion of Indigenous perceptions of climate change and climate technology, it seeks to open them up, and celebrate a diversity of viewpoints, in tandem with calls for more balanced research involving Indigenous peoples spanning many decades now (Liboiron and Cotter, 2023; Tschakert et al., 2023; Cochran et al., 2013; Berkes, 1999; Cajete, 1999; Ellen, 2000; Kimmerer, 2002). This holds true especially for solar geoengineering technologies, where rural populations and decision-makers have differing perspectives and a diversity and richness of views not often captured in existing research efforts (Sovacool, 2023; Taiwo and Talati, 2022; Delina, 2020; Winickoff et al., 2015).

3. Minority groups, Indigenousness and Indigeneity, and place in climate vulnerability and protection

This section briefly summarizes three stands of literature, drawing from the broader work on climate protection, climate intervention, and climate change mitigation, given the lack of evidence specifically on carbon removal and solar geoengineering. It involved searching for relevant studies published on Scopus within the past 25 years (1999–2023) utilizing terms such as "vulnerable group," "vulnerability," "justice," "equity," "Indigenousness," "Indigeneity," and "ethnicity" along with "climate change," "climate impact," or "climate hazard." The extant literature from this search tends to identify disparities in climate change impacts, and disparities in access or burdens related to low-carbon technology adoption, by race and ethnic status, among Indigenous peoples, and by place across urban and rural areas and the Global North/Global South divide.

3.1. Importance of minority groups, ethnic minorities and environmental racism

The literature on minority groups, race, and ethnic minorities tends to advance three different arguments about the consequences of racism, injustice, and climate protection. One relates to disparities by race or ethnic minority status to the impacts of climate change; one to disparities in concern about climate change; and one in disparities over climate interventions such as renewable energy or climate mitigation technologies.

First, ample evidence suggests disparities by race or minority status in climate change impacts. Heatwaves and the health impacts of severe weather already affect ethnic minorities statistically more than other social groups. Several international studies have reported that individuals from ethnic minorities are at increased risk of heat-related illness or natural disasters (Lenton et al., 2023; Krieger et al., 2020; Hansen et al., 2013). Communities of color tend to be more exposed to harmful patterns of pollution from industry, heavier traffic from vehicles, and harm from civil infrastructure such as leaking water lines, flooded waterways, or unsafe bridges (Gutschow et al., 2021; Williams, 2021). For instance, in the United States, ethnic minorities constitute 57 percent of residents in a two-mile radius of hazardous facilities, and make up 60 percent of those living near to polluting facilities (Abimbola et al., 2021). Consequently, people of color in the United States experience 38 % higher concentrations of outdoor smog pollution than Whites, and at the extreme end of the range, up to 20 times the level of smog exposure as equivalent-income Whites (Clark et al., 2014). Air pollution impacts are racialized as well, with 623 million person-years of Medicare data from 73 million persons revealing that Black Americans are exposed to much higher annual levels of air pollution containing fine particulate matter than White Americans and are more susceptible to its health effects (Josey et al., 2023).

The negative social and economic impact of extreme weather events, sea level rise, and storm surges are also concentrated among groups of racial or ethnic minorities (Doherty and Clayton, 2011). In the aftermath of Hurricane Katrina in the United States, for example, African Americans were far more likely than Whites to suffer the harms from both the storm (hazard injustices) and injustices arising from recovery and emergency efforts (procedural injustices) (Sovacool et al., 2018; Laska and Morrow, 2006; Doherty and Clayton, 2011). In Europe it is the Roma who were most susceptible to flooding risks given their precarious housing conditions (Baird, 2008). Racism consequently shapes the delivery of aid to minority households and communities in response to and in the aftermath of floods, forest fires, hurricanes and other climate-induced disasters (Abimbola et al., 2021). Gutschow and colleagues (2021: 3) conclude, "Climate change worsens health injustices rooted in centuries of inequitable policies and practices, including structural racism." Tilley and colleagues similarly write (2023: 3) that "communities of color have consistently been disproportionately blighted by … climate change–related floods, droughts, wildfires, and other extreme weather events." Baird (2008: 15) agrees and noted that:

> "minorities tend to live in the more marginal areas, exposed areas, that seem to be seeing more climate changes and are more susceptible to climate impacts because they have got less, and get less, from governments.… It is a characteristic of all the studies that I have seen, that the ethnic communities are the people who suffer most from climate impacts and are the most vulnerable."

Second, opinion polls and surveys of public attitudes consistently reveal a gap in relation to race or ethnic minority status vis-à-vis concern about environmental destruction and climate change. In the United States, it is African Americans and Latinos who express greater concerns about climate change, and greater levels of support for climate and energy policy, than those who are Caucasian/White (Pearson et al., 2017; Pearson et al., 2018; Dietz and Whitley, 2018). This difference has been confirmed in longitudinal research over large population sizes, such as a *meta*-analysis of ten years of representative polls from Gallup in the United States, and was also confirmed when other variables were controlled for including gender, age, income, education, political affiliation and religious views (McCright and Dunlap, 2011a). Cross-sectional analysis of Gallup survey responses from 1990, 2000, and 2010 even found this trend to be strengthening over time (Guber, 2013). Schuldt and Pearson (2016) evidenced that public opinion about climate change in the United States is less politically polarized for racial and ethnic minorities than majority groups; they also noted that political ideology was far less predictive of the climate beliefs of non-Whites than of Whites.

Other work has found that the issue of climate change ranks the highest, or higher than other environmental concerns, among minorities including localized issues such as air pollution related to urban transport emissions or traffic congestion (Macias, 2016a, 2016b). Sociologists have posited the reason for these views stems from the fact that minority communities tend to suffer disproportionately from a wide range of hazards in the environment, even when compared to other social groups of similar economic status (Jones and Rainey, 2006). There is even a theory in sociology and psychology, known as "environmental deprivation theory," which posits that exposure to environmental hazards and harm leads to greater concern about the environment and increased support for protective measures and behaviors (Whittaker et al., 2005). Additionally, research studying a "White male effect" in perceptions of risks has evidenced the ways that gender, race, and political orientation can predict beliefs about climate change and support for mitigation policy (Pearson et al., 2017).

For instance, conservative White males are significantly more likely than other groups in the United States to deny the existence of climate change, or to oppose the perceived liberal values that are associated with climate change and climate action (McCright and Dunlap, 2013; McCright et al., 2016). Some researchers have even surmised that environmental beliefs, including skepticism about climate change, can serve an "identity-protective" function to protect the status afforded by advantaged group memberships (Kahan et al., 2012). Consistent with this hypothesis, individuals from elite or privileged groups, as well as those who are more likely to perceive prevailing group hierarchies as just and fair (e.g., typically conservative White males), tend to oppose efforts that reduce environmental risks and also tend to perceive them as more personally threatening to their values (McCright and Dunlap, 2011b; Feygina et al., 2010). Conversely, Asians and Latinos in the United States frequently express the greatest environmental concern (Jones et al., 2014; Leiserowitz and Akerlof, 2010). Studies in other countries like New Zealand have also confirmed this trend, showing that cultural orientations among minority groups that prioritize social harmony, respect, and concern for family or community also view climate change as a greater concern to them (Lovelock et al., 2013; Holloway et al., 2009). Additional research has suggested that environmental attitudes of minority groups may be grounded in familial concerns and motivations to leave a sustainable world to future generations (Speiser and Krygsman, 2014; Satterfield et al., 2004). Even communication about climate change concerns can promote racism and defensive behaviors or threats from majority or conservative groups (Uenal et al., 2021).

Third, research has demonstrated racial and ethnic disparities in both access to and the impacts of climate technologies, including renewable energy, and efforts towards climate protection. As one study put it succinctly, structural racism shapes the policy responses to climate change itself (Kantack and Paschall, 2023). Numerous studies have found that symbolic racism, the belief that minorities are receiving unfair advantage, is a strong predictor of support for environmental remediation (Benegal, 2018; Chanin, 2018; Dietz et al., 2018). Part of this finding is connected to the tendency for energy wealth and resources to be rooted in previous colonial relations of dependency, which contributes towards lock-in of certain technologies, and even patterns of precariousness and predation that consolidate wealth among actors who are historically white, colonialist and majoritarian (Sealey-Huggins, 2018; Godfrey, 2012). Moreover, ongoing low-carbon transitions have highly uneven impacts in terms of equality of access, equality of benefits, and equality of risks. This can include racial disparities in terms of those who experience energy poverty or insecurity as well as have access to renewable energy or other innovations (Newell, 2021; Memmott et al., 2021), notably rooftop solar photovoltaics (Sunter et al., 2019) or utility-scale solar (Stock and Sovacool, 2023). These dynamics can also be visible in who manages renewable energy programs; in Canada, community renewable energy efforts largely consist of those driven by affluent white men, with serious disadvantages for minority inclusion or social legitimacy (Tarhan, 2022). The expansion of oil palm and other biofuel plantations has also had a calamitous effect on ethnic minorities and forest dwellers due to land grabbing and dispossession of territories (Baird, 2008).

3.2. Importance of colonialism, Indigeneity and Indigenousness

Like the above, research exploring Indigeneity and the perspectives of Indigenous groups has identified disparities in both climate change impacts as well as in climate interventions, largely the result of patterns of previous colonialism and exploitation (Sultana, 2022). Abimbola and colleagues (2021) term this the "perverse paradox" of climate colonialism, namely that it was resources extracted from colonized territories that largely led to the very industrialization and carbon emissions that are now harming Indigenous peoples.

Indigenous peoples exercise some degree of control or autonomy over about 30 % of the word's land surface (Garnett et al., 2018). Their livelihoods are dependent on natural resources, forests, and land use activities, which are greatly impacted by climate change (Ford et al., 2020). In the Asia Pacific, this includes small-scale farmers, small-scale fishers, or artisanal hunters, or those engaged in animal husbandry, or even those that depend on weaving, woodwork, carving, and blacksmithing (Shaffril & Mohamed, 2020). Indigenous farmers must confront rising temperatures, growing irrigation costs, changing planting schedules, reduced water supply, and alterations in the patterns of pest outbreaks; Indigenous fishers, meanwhile, confront extreme waves and winds, and higher costs of fueling their vessels; hunters confront bush fires, wildfires, and changing patterns of animal migration. The impacts of these climate change-related consequences on Indigenous groups are acute, particularly to the 15 % of them who are considered as extremely poor as they have a high reliance on the stability of nature for their livelihood (Shaffril & Mohamed, 2020). One comprehensive and systematic review of the climate impacts, and responses to climate change, across 1,851 Indigenous communities found that two-thirds occurred in natural resource-dependent sectors of livelihood, especially agriculture and livestock management (45 %) and fishing or aquaculture (38 %) (Schlingmann et al., 2021). However, it also cautioned that only 13 % of those dependent on agriculture or livestock and only 5 % dependent on fishing or aquaculture had coping strategies in place to address climate risks.

Moreover, climate change is exacerbating food insecurity and aggravating environmental degradation among Indigenous groups (FAO, 2021). In North and South America, drought is placing stress throughout Indigenous lands, where without adequate access to water, food insecurity will rise (FAO et al., 2021), or nutritional inadequacies and food insecurity will be worsened by climate change (Deaconu et al., 2021). Native Americans in the United States face forced displacement and resettlement due to erosion and sea-level rise on the coasts, and reductions in rainfall and extended drought in the interior (Norton-Smith et al., 2016). Abimbola et al. (2021: 31) concluded that "communities of Indigenous Peoples in the Global North are among the worst affected by climate change owing to centuries of exclusion and marginalization." Climate change is also transforming the knowledge base that Indigenous groups rely on for their culture and identity, given that sense of place evolves or degrades as the environment does. In Alaska, sea-level rise and temperature increases are accelerating the melting of permafrost and coastal erosion, making it difficult for entire Indigenous communities to remain where they are (Abimbola et al., 2021). Pacific Island Indigenous peoples face changes to the productivity of their fisheries or fishing activities, the degradation of coral reefs, and in low-laying areas even the loss of their homes (Tsosie, 2007).

Even climate technologies have the potential to concentrate negative impacts among Indigenous peoples, given they are often shaped by, and help solidify, patterns of settler colonialism (Whyte, 2016; Whyte, 2020; Wildcat, 2013). The uranium needed to fuel commercial nuclear power plants, considered one significant tool for climate change mitigation, generates a multitude of environmental and social hazards among Native Americans; the erection of large hydroelectric dams in Canada and the Pacific Northwest has also severely impacted the ability of Indigenous peoples to fish, to use water resources, or to access tribal lands (Tsosie, 2007). Wind farms and solar projects encroach on Indigenous lands, often proceeding without consent (Calzadilla and Mauger, 2018), and pipelines transporting ethanol or biofuel have a disproportionate number of spills on Indigenous lands (Datta and Hurlbert, 2020). Owen et al. (2023: 4) mapped the material and mineral resource needs for a low-carbon transition globally, and concluded that "more than half of the energy transition metal resource base is located on or near the lands of Indigenous and peasant peoples." Other examples of colonialism or unfair distribution of impacts to Indigenous peoples come from historical experiences with the Clean Development Mechanism, REDD+, and voluntary carbon markets in driving projects of unclear additionality and/or low-quality credits (Carton et al., 2021; Purdon, 2015), the introduction of growing carbon stocks and concerns over land grabbing (Dooley and Kartha, 2018) to food vs. fuel dynamics and dispossession (Seo and Rodriguez, 2012).

Some novel and recent research even focuses intently on the potential of carbon removal or geoengineering to unfairly impact Indigenous groups. One study cautions that the substantial scaling of carbon removal technologies could concentrate and exacerbate negative impacts in black, brown, and Indigenous communities (Batres et al., 2021). Jaschke and Biermann (2022) warn that negative emissions options could interfere with Indigenous land uses and risk land grabbing and the clearance of tropical forests. Kartha and Dooley (2016) add that because negative emissions options can displace natural ecosystems and existing land uses, these have the potential to interfere with subsistence production and local livelihoods in smallholder farming communities and among Indigenous peoples. Other research on afforestation and Bioenergy with Carbon Capture and Storage has noted strong opposition from Indigenous leaders, Indigenous women in particular, over concerns that such projects would disrupt household and community livelihoods (McElwee, 2023), with a summary of negative impacts shown in Table 1.

Table 1
Problems identified in the literature from deployment of negative emissions technologies facing Indigenous peoples.

Dimension	Composite risks	Risks facing Indigenous groups	Specific technologies implicated
Land and oceans	– Unclear definition of marginal lands or seascapes for models – Impacts of displacement of existing land uses – Regional locations of NETs deployment – Risks of uncertainty around land tenure or fisheries	– Land tenure conflicts – Land grabbing – Elite capture of land resources- Colonial histories and path dependencies – Exclusion from fishing in Marine Protected Areas	BECCS, afforestation, blue carbon and marine biomass
Capital	– Unclear carbon prices and their incentivization of NETs – Sources of funding (private vs public) – Overall costs of action over time – Risk of failures- Role of govt subsidies	– Role of financial speculation – Complications of measurement and verification – Transparency of contracting- Smallholder rights and costs	BECCS, enhanced weathering, soil carbon sequestration, afforestation, biochar
Labor	– Types and quality of labor – Length of contracts – Gender issues- Risks to investors of labor violations	– Lower demands for labor due to mechanization – Stability of employment- Demands for migrant labor	BECCS, afforestation, biochar
Rural politics	– Equity in benefit sharing – Perceptions of risks- Impacts on food security	– Procedural and recognition justice – Uneven benefit distribution – Conflicts over benefits- Rural coalitions and organization building in opposition	BECCS, afforestation

Source: Modified from McElwee (2023). NETs = negative emissions technologies. BECCS=bioenergy with carbon capture and storage.

3.3. Importance of space and place-identity

Literatures on place, space and spatial justice have identified a final collection of climate intervention disparities between urban and rural communities, and between the Global North and Global South (Baum et al., 2024). This collection of evidence advances the notion that support for low-carbon interventions will differ spatially by political regimes, geographies, and economic conditions, thus varying both across and within countries (Kilbourne et al., 2002). This is not only due to variation in socioeconomic or demographic variables across space—but also variations in access to energy and mobility services, geographical conditions and climate, population density, and consumer lifestyles, attitudes and values (Lenzena et al., 2006; Meinherz et al., 2020; Devine-Wright et al., 2015).

For instance, frequency of use of low-carbon infrastructures such as mass transit are correlated with the size of urban areas, with more densely populated municipalities having better (i.e., more equitable or affordable) access to public transport (Abenoza et al., 2017). In the United Kingdom, living in a rural place is still significantly associated with higher emissions even after controlling for income, and the strongest effect is for household emissions, which are 16 % higher for rural than for urban households (Büchs et al., 2013). Population density, land morphology, and policy regimes can all shape low-carbon interventions—including peoples' awareness and knowledge of them, as well as the distribution of costs and benefits (Raven et al., 2017; Wesseling, 2016).

The literature also finds that geography and space can be a proxy for culture, or at least for the existence of cultural variation, whereby differences in prevailing value and belief systems can explain low-carbon adoption and behavior for alternate fuel vehicles (Pettifor et al., 2017a), renewable electricity generators (Sovacool, 2009), smart homes (Furszyfer Del Rio et al., 2021), or low-carbon household retrofits (Sovacool and Griffiths, 2020). Cultural differences across Europe can account for varying preferences for the design features of different innovations, including price, performance, size, and power (De Mooij et al., 2002). Culture, namely in relation to energy systems, can also explain why low-carbon ambitions vary significantly across countries as diverse as China, Denmark, India, and Russia (Stephenson et al., 2021). Culture can mediate social influences on low-carbon choices, with consumers in the United States more susceptible to appeals rooted in status and materialism, whereas consumers in China may be more susceptible to appeals rooted in community wellbeing and longer-term gain (Pettifor et al., 2017b).

Finally, place and space can also serve as mechanisms that create disparities in the access to climate intervention technologies, in the same way that race and Indigenousness do. Svobodova and colleagues recently critique how while many urban areas in the Global North will benefit from low-carbon energy transitions, the negative impacts will predominantly befall those in rural areas in the Global South (Svobodova et al., 2022). They calculate that community disruption and pollution from mining, due to the phase-in of solar panels, wind farms, electric vehicles and other innovations, will place some 115.7 million people in rural mine-town systems at risk (Svobodova et al., 2022). Paprocki (2018) shows how low-carbon pathways for climate adaptation come to be employed more in social, economic, or geographically peripheral areas, which are envisioned as laboratories or experimental spaces where technical elites can pilot new, novel, or risky technologies, pointing to Bangladesh as an example. Spatial inequities abound in urban communities as well, specifically concerning electric vehicle adoption, which impinges on many of the spaces needed for other forms of green mobility, including bicycle tracks, bus lanes, and walking paths (Henderson, 2020), not to mention given that planners are using EV adoption as an excuse to build new roads, even in restricted or sensitive areas, into rural areas (Sovacool et al., 2019). In Germany, increased electricity prices due to the feed-in-tariffs used to support construction of solar panels are even argued to increase energy poverty, especially in densely populated urban areas, where inhabitants have little possibility to install subsidized solar (or wind) energy installations (Weber and Cabras, 2017). A similar strand of work argues specifically that solar geoengineering research and deployment needs to become more inclusive in terms of its governance and to involve a greater number of actors from the Global South (Stephens et al., 2021a, 2021b). Biermann and Möller (2019) argue against a bias for unilateral deployment or research in the Global North, and Biermann et al. (2021) advocate for better knowledge integration as well as effective and enforceable political control over geoengineering by the Global South.

4. Research design

To explore the intersecting importance of ethnic minorities, Indigenousness, and place, this paper presents findings from a large-scale, cross-country set of surveys (n = 30,284 participants, with at least 1,000 in each country) of the public perceptions of CDR and SRM technologies in 30 countries and 19 languages (see Fig. 1). The surveys were nationally representative in terms of age, gender, and geographic region of countries, along with quotas set for income and education so that both higher than median and lower than median groups were adequately represented. By conducting surveys with such scale and scope, this exercise helps to provide a global baseline of SRM and CDR perceptions. The study was designed to deliver insights on risk and benefit perceptions and levels of support, notably how these vary across countries and between individuals with different characteristics and experiences. Indeed, the sample includes representatives from many continents, including, for the first time, several in Africa and South America as well as one small island developing state.

4.1. Details of the survey instrument

The survey instrument examined ten technologies, broken down into three technology categories. Participants were randomly assigned to one of the following: *SRM* (stratospheric aerosol injection, marine cloud brightening, space-based geoengineering); *nature-based CDR* (afforestation and reforestation, soil carbon sequestration, marine biomass and blue carbon); *engineered CDR* (direct air capture with carbon storage (DACCS), bioenergy with carbon capture and storage (BECCS), enhanced weathering, biochar).[1] As participants were asked to evaluate multiple technologies within a technology category, this approach enables us to gain insights into relative preferences between technologies. Also, by asking members of the public for the first time in a survey on climate-intervention technologies about their support for different policy options, we can draw a distinction between the level and nature of policy support among the two broad categories of CDR and SRM as well as seen to be desirable by those belonging to indigenous or ethnic minority groups versus others.

In addition to the standard questions about demographics, the survey did explicitly ask respondents if they "would consider yourself to be a member of an ethnic minority or Indigenous group" – individuals could choose to answer "Yes", "No", or "Prefer not to say", thereby not forcing them to respond if the question was deemed sensitive in any way. In total, 2053 respondents (or 6.8 % of the total) opted for this latter response and were not included in the ensuing analysis – of the remaining 28,231 respondents, 5038 (16.6 % of effective sample) self-identified as a member of ethnic minority or indigenous group, with Fig. 2 offering more detail. By considering responses of this group, this study can differentiate responses from those self-identifying as members of Indigenous or ethnic minority groups versus others. Although it does rely upon a self-reported classification of ethnic minority or Indigenous status, such an approach is in accordance with principles in energy and climate justice of *recognition* (Martin et al., 2016; Honneth, 2004; Fraser, 1999), respecting how an individual identifies and classifies their own heritage.

For extensive details about our research design, see Appendices I and II in our Supplementary Information.

In terms of limitations, we did conflate whether respondents self-identified as both an ethnic minority or an Indigenous person, making it impossible to disaggregate between the two. Furthermore, there is potential for "composition bias" to the extent that the populations of some countries are likely to be over-represented. Countries vary

[1] Even if the distinction between *nature-based CDR* and *engineered or chemical CDR* might be imperfect, we defend it on the basis that the categories entail different kinds of resource and energy demands as well as how space is used, such that these differences may be significant across geographies and polities. While we use these categories for the presentation of our findings, we strictly avoided introducing any of the approaches to the survey participants as more or less natural, as engineered or nature-based, thus attending to a potential framing effect or biasing related to "naturalness".

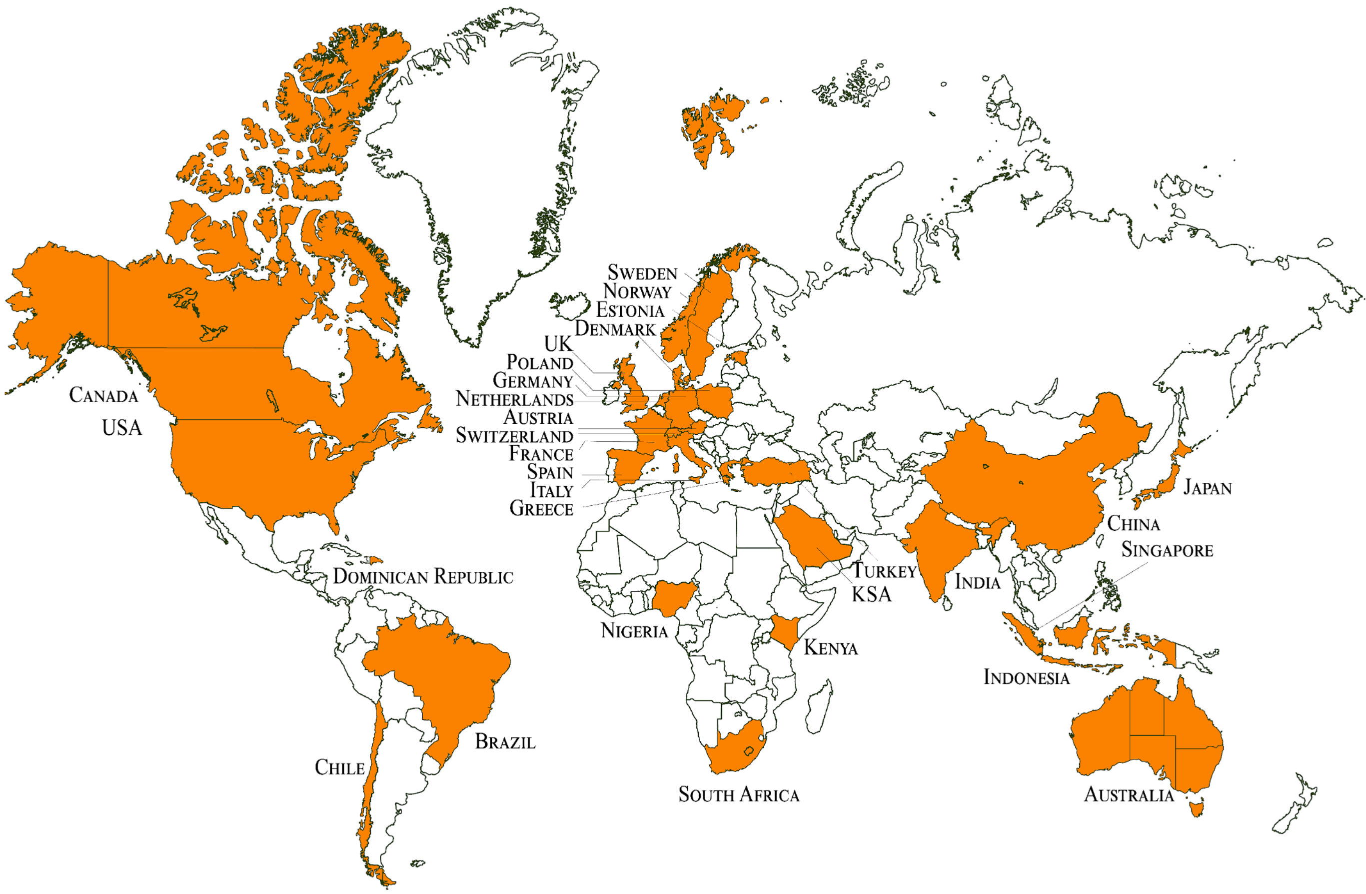

Fig. 1. Geographic Outline of Survey Countries (N = 30). .
Source: Authors

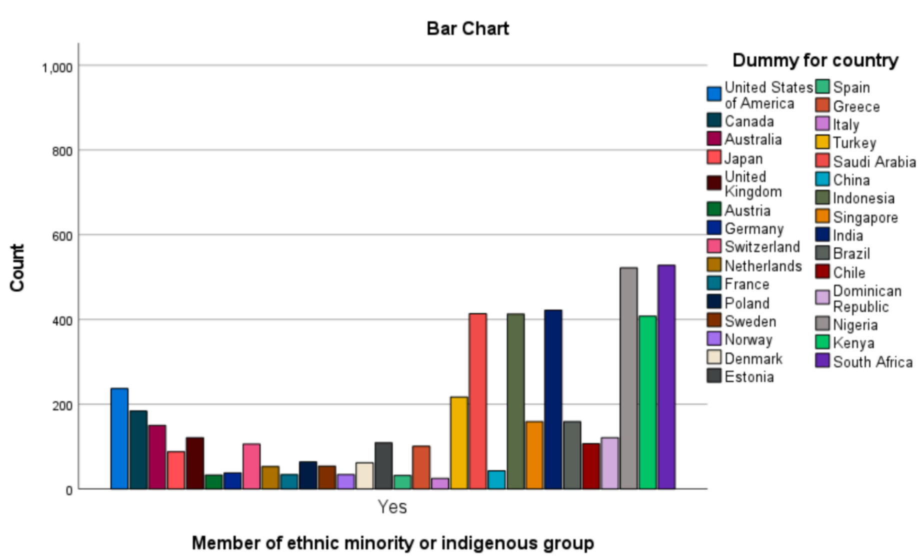

Fig. 2. Subsample of respondents self-identifying as a member of an ethnic minority or Indigenous group (N = 5,038).

regarding how many of their citizens belong to an ethnic minority or Indigenous group.[2] Notably, at least 40 % of the sample in India, Indonesia, Kenya, and Saudi Arabia and 50 % in South Africa and Nigeria self-identify as belonging to an indigenous group and/or ethnic minority versus only 3 % in many European countries – there is also a "middle-tier" of "immigrant" countries such as Canada, US, Australia, and Brazil (as well as Turkey and Singapore) that register 15–20 %. Overall, the percentage of participants identifying as ethnic minorities or indigenous stands at 31.5 % in Global South countries versus 9.8 % in Global North countries. Also, though a brief definition and introduction of CDR and SRM measures was provided to participants, these may not have been comprehensive enough to ensure the understanding and potential implications and risks held by respondents.

Finally, we recognize that publics' familiarity and knowledge of climate-intervention technologies is generally low (Corner and Pidgeon, 2015; Merk et al., 2019; Cox et al., 2020; Baum et al., 2024). As public discourse and understanding of such technologies evolve in the coming years, it could be that perceptions prove malleable in contact with ongoing reality (Fischhoff & Fischhoff, 2002). Being presently founded on principally hypothetical experiences, such perceptions may come to better reflect "pseudo-opinions" (Bishop et al., 1980). This offers reason to interpret the survey results with caution; however, given the urgent need to inform and integrate publics into discussions and debates of the potential research and deployment of climate-intervention technologies, our results also provide key insights on where perceptions among the public are at present.

4.2. Statistical analysis

Data were analysed using SPSS v28.0. Descriptive statistical analysis included analysis of frequency distributions and (pairwise) comparison of groups using parametric and nonparametric testing. Significance testing for differences in the means and medians of group cohorts used independent-samples (two-tailed) Mann Whitney U and independent-samples (two-tailed) Kruskal-Wallis H testing. We also employed independent-samples (two-tailed) t testing in the context of significant differences in the level of policy support (see Section 5.3) across technology categories – this was done in order to calculate (Cohen's d) effect sizes to better understand if such differences were meaningful. Whenever more than two groups were compared, i.e., when looking at differences between *indigenous/minority* groups and *others* vis-à-vis policy support across the technology categories (SRM, engineered CDR, and nature-based CDR) and differences in support for small-scale field trials of technologies contrasting those living in *rural, suburban or small- to mid-sized city* and *large city* areas, differences were assessed in a pairwise manner (for each pair of group cohorts). Given that such analysis entailed multiple comparisons, adjustments to the significance levels have been made using the stepwise step-down method in SPSS (Campbell and Skillings, 1985). This procedure for dealing with multiple comparisons identifies statistically "homogenous" subsets (of cohort groups or technology categories) that do not significantly differ from one another. Crucially, this procedure (unlike the Bonferroni method) of adjusting for multiple comparisons is stated (e.g., by Campbell and Skillings, 1985) to be able to be better control for Type 1 error levels (i.e., false positives) while having superior power for pairwise comparisons.

[2] Count data for Estonia is not indicative of the share of its (sample) population identifying as ethnic minorities or indigenous, which was almost 45%. Due to tensions around the Russian-Ukraine War, this item was prompting significant negative comments among those surveyed; we therefore decided to remove it, resulting in only 247 people providing responses in Estonia.

5. Results and discussion

This Section presents and discusses our results, organized thematically across the four core dimensions of the survey instrument: awareness and perceptions of risks and benefits, experiments and preferences for policy, trust, and spatial identity.

5.1. Awareness and enhanced perceptions of risks and benefits

Perceived familiarity was assessed (using nonparametric independent-samples (two-tailed) Kruskal-Wallis H testing) to be significantly higher across all technologies for those self-identifying as a member of an Indigenous group or ethnic minority (Table 2). Except for afforestation and reforestation, however, familiarity was generally perceived to be quite low.

When participants were asked to make a summary assessment of the balance of risks to benefits (Table 3, Fig. 3), according to nonparametric independent-samples (two-tailed) Kruskal-Wallis H testing, those identifying as members of an Indigenous group or ethnic minority were significantly more positive about SRM and engineered CDR: $p < 0.001$ for stratospheric aerosol injection; $p < 0.001$ for marine cloud brightening; $p < 0.001$ for space-based geoengineering; $p < 0.001$ for DACCS; $p < 0.001$ for BECCS; $p < 0.001$ for enhanced weathering; $p = 0.011$ for biochar. In any case, both groups tended to be generally neutral about the overall balance of benefits to risks for stratospheric aerosol injection, space-based geoengineering, and enhanced weathering – though this

Table 2
Significant Differences ($p < 0.05$) between Expressed Familiarity (mean) with Technologies depending on Indigenous or Ethnic Minority Self-Identification (1–5 scale: 1 = Not at all (never heard of it), 5 = Very familiar; different letters in columns indicate significant differences between group cohorts).

	Total	Self-Identify as Indigenous or Ethnic Minority	Other
	(N = 10,084)	(N = 1,727)	(N = 7,680)
Stratospheric aerosol injection	1.72 (1.19)	2.28^a(1.49)	1.60^{b}1.08)
Marine cloud brightening	1.69 (1.18)	2.31^a(1.52)	1.56^b(1.05)
Space-based geoengineering	1.81 (1.23)	2.37^a(1.52)	1.69^b(1.13)
	(N = 10,105)	(N = 1,700)	(N = 7,703)
Afforestation and reforestation	3.33 (1.40)	3.64^a(1.43)	3.28^b(1.39)
Soil carbon sequestration	2.24 (1.32)	2.80^a(1.51)	2.12^b(1.25)
Marine biomass and blue carbon	2.05 (1.26)	2.68^a(1.50)	1.93^b(1.17)
	(N = 10,095)	(N = 1,611)	(N = 7,810)
DACCS	1.99 (1.32)	2.62^a(1.55)	1.88^b(1.24)
BECCS	2.05 (1.30)	2.66^a(1.52)	1.95^b(1.23)
Enhanced weathering	1.82 (1.25)	2.53^a(1.53)	1.69^b(1.14)
Biochar	1.96 (1.28)	2.60^a(1.54)	1.84^b(1.19)

Note: 2053 participants opted to answer "Prefer not to say" and were categorized as "missing data" for this analysis. This explains the differences between the total sample and the two sub-samples. Standard deviations are in parentheses. If different letters are present for columns of a given row (e.g., "a" versus "b"), this indicates that significant differences exist regarding expressed levels of familiarity for a given technology ($p < 0.05$), according to pairwise, independent-samples (two-tailed) Kruskal-Wallis H testing.

Table 3
Significant differences ($p < 0.05$) in the Perceived Balance of Benefits to Risks across Technologies (1–5 scale: 1 = Risks far outweigh benefits; 3 = Benefits and risks about the same; 5 = Benefits far outweigh risks; different letters in columns indicate significant differences between group cohorts).

	Self-Identify as Indigenous or Ethnic Minority (N = 1,727)	Other (N = 7,680)
Stratospheric aerosol injection	2.94ᵃ(1.28)	2.68ᵇ(1.18)
Marine cloud brightening	3.16ᵃ(1.26)	2.84ᵇ(1.18)
Space-based geoengineering	3.00ᵃ(1.34)	2.72ᵇ(1.28)
	(N = 1,700)	(N = 7,703)
Afforestation and reforestation	3.78ᵃ(1.28)	3.89ᵇ(1.18)
Soil carbon sequestration	3.57ᵃ(1.26)	3.61ᵃ(1.14)
Marine biomass and blue carbon	3.46ᵃ(1.29)	3.55ᵃ(1.15)
	(N = 1,611)	(N = 7,810)
DACCS	3.27ᵃ(1.30)	3.10ᵇ(1.20)
BECCS	3.21ᵃ(1.26)	3.10ᵇ(1.15)
Enhanced weathering	3.06ᵃ(1.32)	2.83ᵇ(1.20)
Biochar	3.31ᵃ(1.24)	3.24ᵇ(1.17)

Note: 2053 participants opted to answer "Prefer not to say" and were thus categorized as "missing data" for this analysis; uneven distribution of such respondents across treatment groups explains why the sample sizes vary slightly. Standard deviations are in parentheses. If different letters are present for columns of a given row (e.g., "a" versus "b"), this indicates that significant differences exist regarding the perceived balance of benefits to risks for a given technology ($p < 0.05$), according to pairwise, independent-samples (two-tailed) Kruskal-Wallis H testing.

tended towards perceiving slightly more risks than benefits for those not self-identifying as minority or indigenous. At the same time, things were reversed for afforestation and reforestation, with members of Indigenous or ethnic minority groups seeing a relatively lower benefit-risk ratio, $p = 0.009$. For the other two nature-based CDR options, perceptions were found not to significantly differ: $p = 0.919$ for soil carbon sequestration; and $p = 0.080$ for marine biomass and blue carbon.

Fig. 4 breaks down results within all Indigenous and ethnic minority respondents. Panel A shows how in some countries, such as Turkey, the United States, India, Kenya, Nigeria, Brazil, South Africa, Chile, Indonesia, Saudi Arabia, and the Dominican Republic, more than 10 % of the entire subsample of Indigenous groups stated their support for climate intervention technologies in the form of carbon removal. Panel B shows the data for solar geoengineering, where more than 10 % of the subsample of Indigenous groups in Turkey, India, Indonesia, Saudi Arabia, Nigeria and Spain stated their support. Interestingly, solar geoengineering options are much less supported than carbon removal options in Norway and Sweden than in Denmark, perhaps due to the SCoPEx experiment that was scrapped due to Saami pressure in Sweden (Low et al., 2022b).

By means of nonparametric statistical analysis (independent-samples (two-tailed) Mann-Whitney U (for continuous variables) or independent-samples (two-tailed) Kruskal-Wallis H testing (for discrete variables)), we identified significant differences between respondents that do and do not identify as members of indigenous or ethnic minority groups for various climate change and environmental beliefs (Table 4). These helpfully inform why those who self-identify as members of such groups might be relatively more positive about SRM and engineered CDR options. Results highlighted that *negative emotions about climate change* (anger, fear, sadness, worry), $p < 0.001$, levels of *perceived climate harm*, $p < 0.001$, *personal experience with major natural disasters*, $p = <0.001$, and beliefs in *science and technology as solution to climate change*, $p < 0.001$, are all significantly higher among members of indigenous or ethnic minority groups. Notably, whereas 60 % of such individuals have experienced a major natural disaster such as flood or wildfire in the last three years, this drops to about one-third for those not identifying as such. Conversely, members of Indigenous or ethnic minorities reported both greater *aversion to tampering with nature*, $p < 0.001$, and perceptions of *environmental identity*, $p < 0.001$.

To an extent, this indicates that there is some conflict between the different factors, since such individuals seem to place high value on the environment and nature, while also confronting substantial climate risks. In part, this might be why members of ethnic minorities or indigenous groups are not relatively more positive than others about nature-based CDR options, even somewhat less so for afforestation and reforestation. It could be proposed that such options, maybe even owing to their greater familiarity, are not radical enough for the task at hand – though this could also be a reflection of indigenous communities having served as the site of such activities, and having had to bear the negative consequences, e.g., under the auspices of the Reducing Emissions from Deforestation and Forest Degradation (REDD+) program (Skutsch and Turnhout, 2020; Gupta et al., 2012; Schroeder and McDermott, 2014). Even so, it must be emphasized that afforestation and reforestation is still the most positively assessed option across both groups, and that all

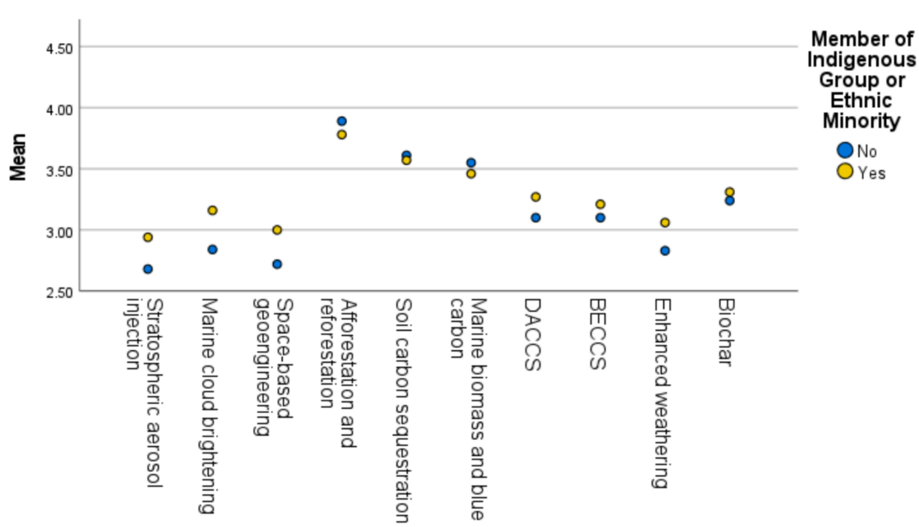

Fig. 3. Differences between Members versus Non-Members of Indigenous and Minority Groups in the Perceived Balance of Potential Benefits to Risks (1–5 scale: 1 = Risks far outweigh benefits; 3 = Benefits and risks about the same; 5 = Benefits far outweigh risks).

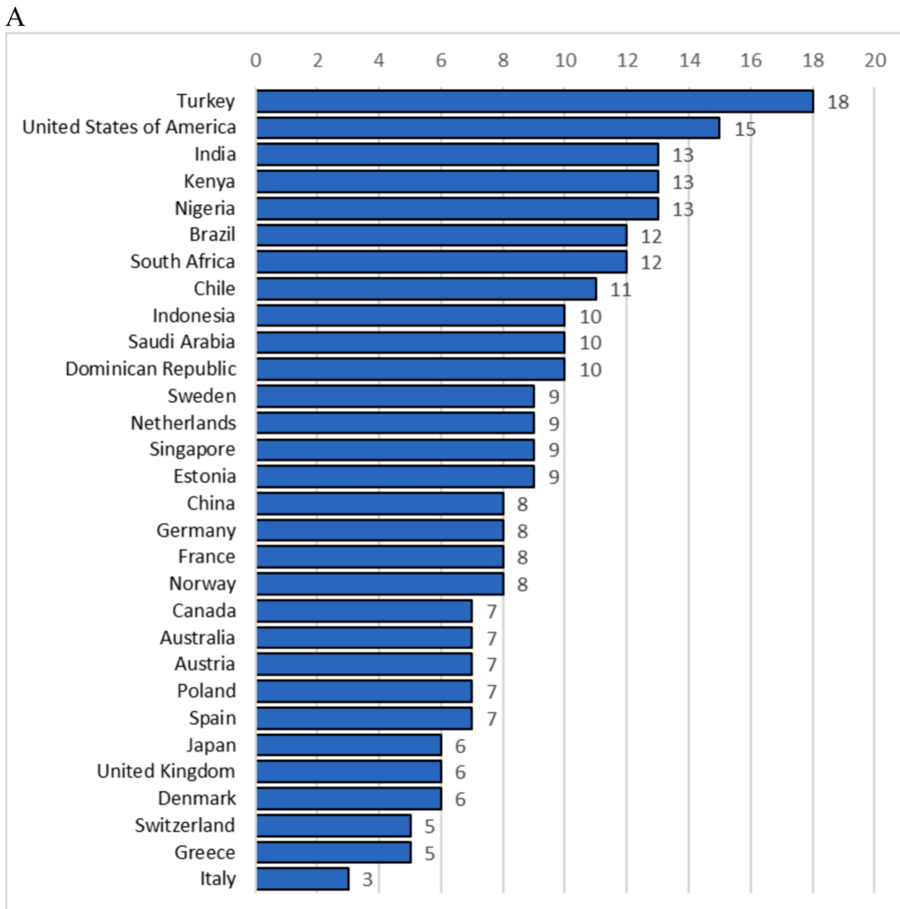

Fig. 4. Percentage of respondents self-identifying as Ethnic Minority or Indigenous supporting or strongly supporting carbon removal technologies (panel A) or solar geoengineering options (panel B) as a percentage of the entire subsample (N = 5,038). Note: A=Carbon Removal options, B = Solar Geoengineering options. The diagram depicts respondents who rated their support or preference for carbon removal and/or solar geoengineering technologies as a 5, 6, or 7 on a 7-point Likert scale. See Supplementary Materials for more details.

evaluations of all nature-based CDR options were more positive than those of any other grouping.

5.2. Experiments and policy preferences

Participants were asked how much they would support small-scale field trials for a given technology, again for the three or four climate-interventions in the category to which they were randomly assigned. Reflecting their greater positivity regarding the balance of benefits to risks (Table 5, Fig. 5), members of Indigenous groups or ethnic minorities expressed significantly higher levels of support for small-scale trials for nearly all technologies, according to independent-samples (two-tailed) Kruskal-Wallis H testing ($p < 0.001$) – the exception is afforestation and reforestation, $p = 0.317$. Again, alignment between the two groups centers around afforestation, which is also the most popular of the options (Table 5, Fig. 5). Even though support for small-scale trials is higher among members of minority and indigenous groups for the other nature-based CDR options, it is notable that the extent of such differences is much smaller than for the other two categories. Whereas minority and indigenous respondents were somewhat supportive of trials being done for all options, preferences for the other respondents were more oriented toward nature-based CDR options and some engineered CDR options, particularly biochar. While such individuals are still more supportive than not of small-scale field trials, we establish by means of Cohen's d that the gap between their support and those of members of minority and indigenous groups is largest for SRM options, even if these effect sizes are still characterized as being "small" in nature (Cohen, 1988): Cohen's $d = 0.344$ for stratospheric aerosol injection; $d = 0.339$ for marine cloud brightening; $d = 0.336$ for space-based geoengineering. Similarly, "small" effect sizes are established for the differences between the groups for three of the engineered CDR options (i.e., not biochar): Cohen's $d = 0.244$ for DACCS; $d = 0.215$ for BECCS; and $d = 0.258$ for enhanced weathering. In total, these findings signal that, although identifying as a member of an indigenous or minority group has a significant impact on the support for small-scale field trials of climate-intervention technologies (except for afforestation and reforestation), the size of this effect is, even at its largest (i.e., for SRM and engineered CDR), still small in nature.

Participants were also asked which of a list of seven policies or activities they would support before climate-intervention technologies were utilized. From this list (Table 6), presented in terms of policies taking place at domestic or international level, they could choose as many or as few as they deemed necessary – or "None of the above" if none were seen as necessary. In contrast to their support for small-scale field trials, participants were here invited to evaluate policies for each the technology categories: SRM, nature-based CDR, or engineered CDR. Across all categories and for those belonging to indigenous and ethnic minority groups and others, an overarching preference ordering emerges. Notably, the highest support is assigned to national-level government funding for public and private research and development, closely followed by information and engagement campaigns with the public for two technology categories (engineered CDR, SRM). Then

B

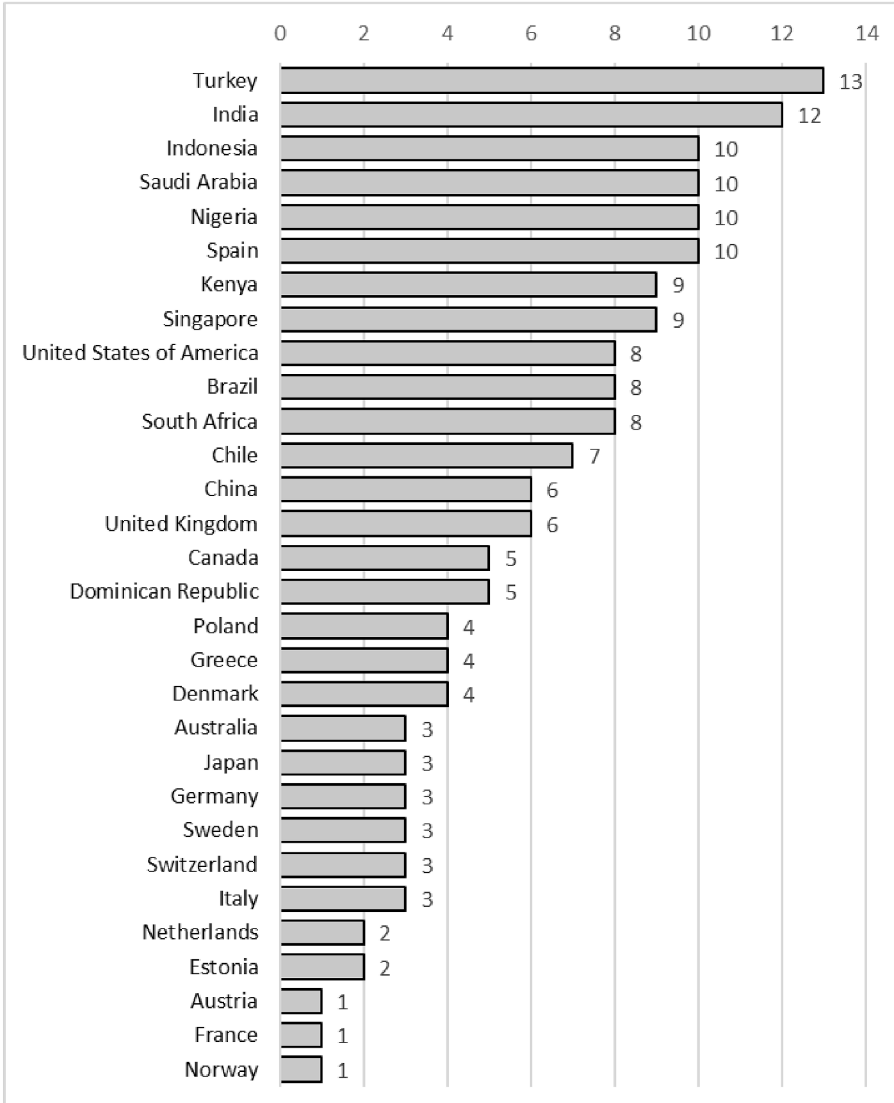

Fig. 4. (*continued*).

comes an intermediate grouping of international-level policies and activities: establish international organization for oversight and setting standards; create new international scientific agency to explore technologies and start testing and development; and (for SRM) generating a special report at international level (e.g., by IPCC) to evaluate and assess technologies. Policies receiving least support, typically no more than one-third of each group, entailed some kind of restriction at domestic or international levels (i.e., independent national government policies that restrict the use of technology (e.g., to ban or how to regulate) or the use of an international ban or moratorium on technologies deemed risky) as well as (for the two CDR categories) a global-level market for trading carbon credits and/or offsets. On the whole, this illustrates a preference for public engagement on climate-intervention technologies along with support for early-stage research and development to be undertaken at the national level – in contrast, there is more narrow support for placing restrictions and limitations at this stage.

Focusing on Indigenous and ethnic minority groups, we identified (using independent-samples (two-tailed) Kruskal-Wallis H testing) significant differences in support for all policy options vis-à-vis SRM ($p < 0.001$), with members of such groups more supportive – except for international bans or moratoria, where the two group cohorts were unified in their limited interest in such an option ($p = 0.070$). Indeed, the lack of any difference between the groups also holds for CDR as well ($p = 0.566$ for nature-based CDR, $p = 0.328$ engineered CDR) – in the case of engineered CDR, like SRM, this was the only policy option for which no significant difference could be established ($p = 0.002$ for national-level government support, $p = 0.003$ for information and public engagement campaigns, $p < 0.001$ for the rest). Regarding the potential use of restrictions, it must however be stressed that such policies ranked among the least preferred options across both groups – any difference between the groups thereby reflects that those not belonging to ethnic minority or Indigenous groups support such policies to an even lesser extent. In general, the findings for engineered CDR and SRM mirror one another, both in terms of the significant differences that exist and tendency towards greater support among indigenous and minority groups for almost all policies. Conversely, there are similar levels of support (or the lack thereof) between the groups, regarding nature-based CDR, for national-level government support ($p = 0.056$) and information and engagement campaigns ($p = 0.112$) – with both policies receiving the highest-level of overall support. Both groups identify such policies as the most commendable for ongoing development of nature-based CDR options.

Another interesting point of difference for Indigenous and ethnic

Table 4
Significant differences ($p < 0.001$) between group cohorts in Means of Environmental and Climate Change Beliefs (different letters in columns indicate significant differences between group cohorts).

	Self-Identify as Indigenous or Ethnic Minority (N = 5,038)	Other (N = 23,193)
Aversion to tampering with nature (1–7 scale: 7 = Strongly agree)	4.94[a](1.31)	4.66[b](1.17)
Environmental identity (1–7 scale: 7 = Strongly agree)	4.89[a](1.06)	4.48[b](1.010)
Negative emotions about climate change (1–5 scale: 5 = Extremely (worried))	3.60[a](1.03)	3.44[b](0.99)
Perceived climate harm (1–4 scale: 4 = A great deal)	3.21[a](0.88)	2.91[b](0.90)
Personal experience with major natural disaster in last three years(percentage answering "Yes")	60.24 %[a]	37.04 %[b]
	(N = 4,961)	(N = 22,530)
Belief in science and technology as solution to climate change (1–5 scale: 5 = Strongly agree)	3.87[a](1.16)	3.45[b](1.09)

Note: Standard deviations are in parentheses. If different letters are present for columns of a given row (e.g., "a" versus "b"), this indicates that significant differences exist between the two cohort groups ($p < 0.001$), according to pairwise, independent-samples (two-tailed) Mann Whitney U (for continuous variables) and independent-samples (two-tailed) Kruskal-Wallis H testing (for discrete variables). Means (not mean ranks, on which tests are based) are reported. Smaller sample sizes for *science and technology as solution to climate change* reflect the exclusion of those answering "don't know" to this question.

Table 5
Significantly Greater Support ($p < 0.05$) for Small-Scale Field Trials of Multiple Climate-Intervention Technologies among those Self-identifying as Indigenous or Ethnic Minority (1–5 scale: 1 = Strictly reject, 5 = Fully support; different letters in columns indicate significant differences in technology support between group cohorts).

	Self-Identify as Indigenous or Ethnic Minority	Other
Stratospheric aerosol injection (N = 1692; N = 7460)	3.86[a](1.21)	3.43[b](1.24)
Marine cloud brightening (N = 1695; N = 7475)	3.99[a](1.14)	3.59[b](1.12)
Space-based geoengineering (N = 1684; N = 7438)	3.88[a](1.24)	3.45[b](1.29)
Afforestation and reforestation (N = 1679; N = 7539)	4.47[a](0.89)	4.47[a](0.84)
Soil carbon sequestration (N = 1672; N = 7493)	4.33[a](0.96)	4.25[b](0.94)
Marine biomass and blue carbon (N = 1676; N = 7471)	4.29[a](0.96)	4.22[b](0.94)
DACCS (N = 1571; N = 7595)	4.10[a](1.08)	3.83[b](1.12)
BECCS (N = 1572; N = 7585)	4.07[a](1.10)	3.83[b](1.08)
Enhanced weathering (N = 1575; N = 7579)	3.92[a](1.23)	3.61[b](1.21)
Biochar (N = 1579; N = 7595)	4.11[a](1.09)	3.95[b](1.06)

Note: Sample sizes excluded those who opted to answer "Prefer not to say", which is why the numbers differ slightly. Standard deviations in parentheses. If different letters are present for columns of a given row (e.g., "a" versus "b"), this indicates that significant differences exist between the two cohort groups ($p < 0.05$), according to pairwise, independent-samples (two-tailed) Kruskal-Wallis H testing; if values in columns have the same letter (as for "afforestation and reforestation"), the difference between the means is not statistically significant.

minority individuals is the extent to which SRM is distinguished from CDR. Namely, using independent-samples (two-tailed) t tests, we determined that non-members of Indigenous or ethnic minority groups expressed a significantly greater preference for independent national restrictions being placed on SRM (and engineered CDR) versus nature-based CDR ($t(15381) = 2.57$, $p = 0.031$, Cohen's $d = 0.035$). Speaking to lower policy support for SRM, such individuals deemed it to merit less national-level government support than CDR ($t(23191) = 17.09$, $p < 0.001$, Cohen's $d = 0.238$), along with being less open to information and public engagement campaigns for SRM versus nature-based CDR ($t(15381) = 4.45$, $p < 0.001$, Cohen's $d = 0.072$). Even at the international level, non-members were less supportive for SRM versus CDR of a special report for assessment and evaluation of technologies ($t(15381) = 5.53$, $p < 0.001$, Cohen's $d = 0.089$) or setting up an organization for conducting oversight and setting standards ($t(15381) = 8.35$, $p < 0.001$, Cohen's $d = 0.135$). In total, at domestic and international level, this speaks to lower levels of support for SRM vis-à-vis CDR (nature-based CDR specifically) among those not self-identifying as belonging to indigenous or ethnic minority groups – although it should be noted that only the effect size for national-level government support can be considered "small", with the others more trivial (albeit significant) in nature.

Nevertheless, the above findings provide a contrast to those for individuals belonging to Indigenous or ethnic minority groups. For this group, we identified minimal differences of significance concerning the perceived necessity of policies according to technology category. The only differences centered on the more limited importance of national-level government support for SRM vis-à-vis CDR ($t(5036) = 4.26$, $p < 0.001$, Cohen's $d = 0.126$) together with less need for an international special report on SRM vis-à-vis nature-based CDR ($t(3425) = 3.04$, $p = 0.001$, Cohen's $d = 0.104$). Thus, the scope of policy differences between SRM and CDR is more limited for members of ethnic minorities or indigenous groups. Recalling Table 4, prospective explanations would include significantly stronger perceptions for individuals in such groups of science and technology as a solution to climate change, along with possibly the greater urgency of climate change that can be expected to attend greater experience with and exposure to major natural disasters and perceptions of climate harm.

5.3. *Trust in actors and institutions*

Interesting differences between those which do and do not identify as members of Indigenous groups or ethnic minorities also emerged for levels of trust in various groups and institutions. Members of Indigenous groups and/or ethnic minorities broadly express significantly higher levels of trust in all kinds of actors, according to independent-samples (two-tailed) Kruskal-Wallis H testing (Table 7): $p < 0.001$ for industry and corporations in the field of climate technology; $p < 0.001$ for universities and scientific research institutes; $p < 0.001$ for national governments and official agencies; $p < 0.001$ for international government institutions such as the United Nations; and $p < 0.001$ for nongovernmental organizations (NGOs) like climate and environmental and climate groups. Such individuals expressed at least moderate levels of trust in all actors and institutions, in contrast to the more neutral views of majority individuals in, notably, industry and corporations and international government institutions as well as the tendency towards distrust in national governments and official agencies. Overall, the groups were in agreement on the trust rankings across actors, with universities and scientific research institutes at the top – indeed, the difference of the mean ratings was lowest for this actor.

5.4. *Place and spatial identity*

Place emerges as a distinguishing feature of support for climate-intervention technologies (Table 8). We determined, through pairwise, independent-samples (two-tailed) Kruskal-Wallis H testing, that the

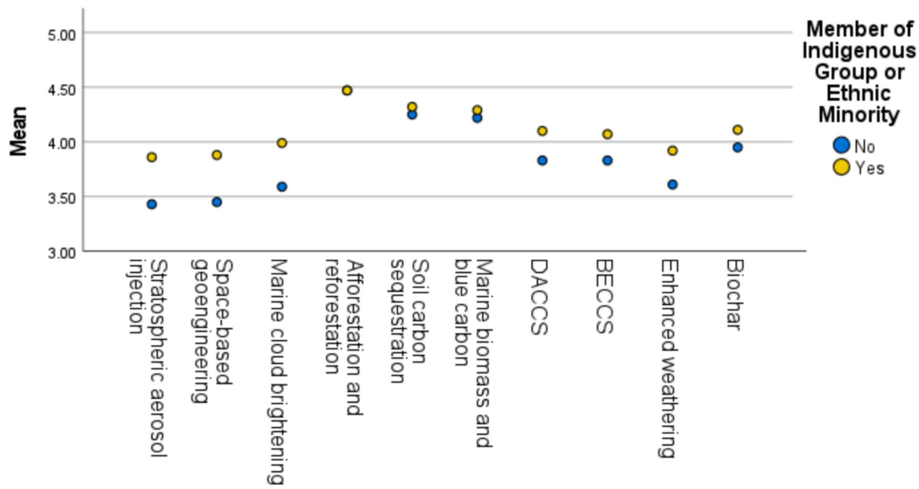

Fig. 5. Differences between Members versus Non-Members of Indigenous and Minority Groups in Support of Small-scale Field Trials of Climate- Intervention Technologies (1–5 scale: 1 = Strictly reject, 5 = Fully support).

level of support is significantly different ($p < 0.001$) across the types of regions (rural areas, suburban or small to mid-sized cities, and large cities). In specific, those living in large cities consistently provide the greatest support, followed by those in suburban areas or small to mid-sized cities, whereas those in rural areas are least supportive. The only exceptions center on the nature-based CDR options, where not only are there no significant differences between those in rural areas vis-à-vis suburban areas or small to mid-sized cities but also the extent of the differences between those living in such areas is smaller – even while remaining statistically significant. Such findings thus reflect the generally stronger greater agreement in relation to the nature-based CDR options.

In addition, we explored the intersection between place and Indigeneity. To do so, we separated those members of Indigenous or ethnic minority individuals who live in large urban versus rural areas, to compare the levels of support for small-scale field trials with the various technologies with each other and with non-members of such groups (see Table 9). According to pairwise, independent-samples (two-tailed) Kruskal-Wallis H testing, indigenous individuals in rural areas are not found to significantly differ ($p < 0.05$) from non-members for eight of the technologies – in contrast, they express lower support for afforestation and reforestation and higher support for BECCS. While afforestation and reforestation still rate the highest across all technologies in terms of overall support, the relatively lower support among indigenous and/or minority individuals in rural areas is notable, given that such groups have tended to bear the negative consequences of efforts such as REDD+.

Aside from these two technology options, however, levels of support turn out to be broadly similar between rural individuals self-identifying as members of Indigenous or ethnic minority groups versus non-members. In contrast, urban individuals identifying as indigenous or ethnic minorities expressed significantly higher support across all technologies – although their support for biochar is not found to significantly differ from rural indigenous individuals. In sum, it is the indigenous and ethnic minority individuals living in urban areas who emerge as the most supportive of climate-intervention technologies. In fact, the lowest rating of this group is that of stratospheric aerosol injection which, at 4.00, still represents that they are broadly at least "somewhat" supportive.

6. Conclusion

Belonging to ethnic minority or Indigenous groups, as well as place and the kind of geographic region in which one lives, shape social perceptions of and levels of support for climate-intervention technologies. Those self-identifying as a member of an Indigenous group, minority group or ethnic minority express significantly greater familiarity with these technologies than non-members as well as more positive attitudes towards engineered (but not nature-based) CDR options. Members of Indigenous groups or ethnic minorities, furthermore, express significantly higher levels of support for small-scale trials for nearly all technologies, were more supportive of policy incentives in a variety of forms, particularly for SRM, and consistently less supportive of policy restrictions.

That members of Indigenous groups or ethnic minorities are more open to considering novel climate-intervention technologies, despite ample evidence of heightened vulnerability shown in Section 3.1 and 3.2, might suggest that the risks related to insufficient climate action are weighted higher. Complementing similar findings on emerging public perceptions in the Global South (Baum et al., 2024; Fritz et al., 2024), our results suggest that this greater openness to climate interventions is correlated with direct personal experience of climate impacts. It is correlated with greater fears about climate change and a correspondingly stronger sense of urgency to act among those identifying as indigenous or ethnic minorities.

These concerns, however, do not seem to translate into more positive attitudes towards nature-based CDR. Here, our results uncover ambiguities that might be related to prior negative experiences among indigenous and rural communities with afforestation for example under the REDD+ programme and legitimate worries over land use conflicts as well as reflecting specific values regarding human-nature relations and local place attachments. Place emerges here as a notable intervening factor for support for climate-intervention technologies, with those living in large cities consistently stating the strongest support for small-scale field trials, followed by those in suburban areas or small to mid-sized cities, whereas it is those in rural areas who are least supportive. The significant differences in risk perceptions and policy preferences across the population groups studied underscore the need for developing inclusive governance arrangements that account for the diversity of perspectives and lived experiences in varied local contexts.

Our study points the way towards future research gaps as well. Although we have examined 30 countries, many for the first time, more than 100 are actively considering geoengineering or carbon removal deployment. Moreover, deeper examination of the intersectional importance of ethnicity, Indigenousness or Indigeneity, and place together with other attributes (e.g., gender, age, income) would be fruitful and should be complemented by inquiries into the diversity within ethnic minority and Indigenous groups within and across

Table 6
Significant Differences ($p < 0.05$) in Percentage of Respondents Expressing Support of a Policy Option between Members of Ethnic Minorities or Indigenous Groups versus Others, assessed by Technology Category (different numbers in the cell of a given column indicate significant differences in support for a policy option between group cohorts; different letters between columns of a given row reflect significant (pairwise) differences in level of policy support by technology category for a given group cohort).

		SRM	Engineered CDR	Nature-based CDR
Independent national government policies restricting technology	*Indigenous/ Minority*	36.94 %[1a]	37.93 %[1a]	35.59 %[1a]
	Others	28.19 %[2a]	28.62 %[2a]	26.64 %[2b]
National-level government support for public and private R&D	*Indigenous/ Minority*	58.31 %[1a]	61.89 %[1b]	66.82 %[1c]
	Others	49.25 %[2a]	57.62 %[2b]	64.38 %[1c]
Information and engagement campaigns to consult public	*Indigenous/ Minority*	57.96 %[1a]	58.78 %[1a]	58.94 %[1a]
	Others	53.27 %[2a]	54.79 %[2a]	56.84 %[1b]
International ban or moratorium on technologies deemed risky	*Indigenous/ Minority*	36.54 %[1a]	36.69 %[1a]	33.65 %[1a]
	Others	34.24 %[1a]	35.40 %[1a]	34.38 %[1a]
Establish international organization for oversight and setting standards	*Indigenous/ Minority*	52.06 %[1a]	54.69 %[1ab]	56.06 %[1b]
	Others	46.60 %[2a]	50.15 %[2b]	53.32 %[2c]
Create international scientific agency to engage in testing and development	*Indigenous/ Minority*	53.04 %[1]	.	.
	Others	47.07 %[2]		
Global-level market for trading carbon credits and/or offsets	*Indigenous/ Minority*	.	35.07 %[1a]	36.06 %[1a]
	Others		27.22 %[2a]	29.99 %[2b]
Generate special report at international level to evaluate/assess technologies	*Indigenous/ Minority*	51.13 %[1a]	53.01 %[1ab]	56.29 %[1b]
	Others	44.06 %[2a]	47.98 %[2b]	48.50 %[2b]
None of the above	*Indigenous/ Minority*	4.11 %[1a]	4.16 %[1a]	3.59 %[1a]
	Others	9.48 %[2a]	9.17 %[2a]	7.24 %[2b]

Note: For "Indigenous/Minority" group, N = 1727 for SRM, N = 1700 for nature-based CDR, and N = 1611 for engineered CDR For "Others" group, N = 7680 for SRM, N = 7703 for nature-based CDR, and N = 7810 for engineered CDR. Means (rather than mean ranks, on which the tests are based) are reported. If numbers are different in the cell of a given column (i.e., "2" appears in corresponding line for "Others"), this indicates significant differences exist ($p < 0.05$) regarding the scope of support within the two cohort groups for a policy option vis-à-vis the relevant technology category, according to pairwise, independent-samples (two-tailed) Kruskal-Wallis *H* testing. If different letters are present in the columns of a particular row (policy option), this indicates significant differences ($p < 0.05$) in the percentage of respondents (of a given group cohort) expressing support for a policy option depending on the technology categories, according to pairwise, independent-samples (two-tailed) Kruskal-Wallis *H* testing, with adjustments using the stepwise step-down method available in SPSS (Campbell and Skillings, 1985) which identifies statistically "homogenous" subsets (of technology categories) which do not significantly differ from one another. If letters are the same (i.e., only "a" appears), no significant differences exist. If two letters appear (e.g., "ab"), as for "engineered CDR" in row "generate special report at international level to evaluate/assess technologies", this indicates that perceptions do not significantly differ from the either two technology categories, though these differ from one another.

Table 7
Significant Differences ($p < 0.001$) between group cohorts in Trust (mean) in Actors and Institutions (1–6 scale: 1 = No trust, 6 = Very high trust; different letters in columns indicate significant differences between group cohorts).

	Self-Identify as Indigenous or Ethnic Minority (N = 5,038)	Other (N = 23,193)
Industry and corporations in the field of climate technology	4.24[a](1.50)	3.62[b](1.42)
Universities and scientific research institutes	4.73[a](1.29)	4.44[b](1.25)
National governments and official agencies	3.99[a](1.62)	3.33[b](1.44)
International government institutions (e.g., United Nations)	4.36[a](1.52)	3.68[b](1.45)
Nongovernmental organizations (e.g., environmental, climate groups)	4.43[a](1.44)	3.86[b](1.41)

Note: Standard deviations are in parentheses. If different letters are present for columns of a given row (e.g., "a" versus "b"), this indicates that significant differences exist between the two cohort groups ($p < 0.001$), according to pairwise, independent-samples (two-tailed) Kruskal-Wallis *H* testing. Means (not mean ranks, on which tests are based) are reported.

Table 8
Significant Differences in Support ($p < 0.05$) for Small-Scale Field Trials of Climate-Intervention Technologies, according to Geographic Region (1–5 scale: 1 = Strictly reject, 5 = Fully support; different letters in columns indicate significant (pairwise) differences in technology support between the group cohorts).

	Rural	Suburban or small to mid-sized city	Large city
	(N ≈ 1,400)	(N ≈ 4,000)	(N ≈ 4,390)
Stratospheric aerosol injection	3.16[a](1.31)	3.43[b](1.25)	3.66[c](1.21)
Marine cloud brightening	3.32[a](1.27)	3.58[b](1.19)	3.82[c](1.15)
Space-based geoengineering	3.18[a](1.33)	3.44[b](1.28)	3.70[c](1.25)
	(N ≈ 1,365)	(N ≈ 4,030)	(N ≈ 4,430)
Afforestation and reforestation	4.43[a](0.89)	4.43[a](0.86)	4.49[b](0.85)
Soil carbon sequestration	4.19[a](0.97)	4.23[a](0.95)	4.29[b](0.94)
Marine biomass and blue carbon	4.16[a](0.96)	4.20[a](0.96)	4.25[b](0.94)
	(N ≈ 1,370)	(N ≈ 3,955)	(N ≈ 4,450)
DACCS	3.64[a](1.19)	3.80[b](1.11)	4.00[c](1.09)
BECCS	3.68[a](1.15)	3.80[b](1.09)	4.00[c](1.05)
Enhanced weathering	3.47[a](1.26)	3.59[b](1.21)	3.78[c](1.20)
Biochar	3.81[a](1.13)	3.93[b](1.07)	4.06[c](1.03)

Note: Approximate numbers given for sample sizes, as totals may differ slightly (by no more than twenty) due to excluding those who opted to answer "Prefer not to say". Total sample sizes for each group are N = 4,304 for rural areas, N = 12,377 for suburban or small- to mid-sized cities, and N = 13,603 for urban areas. If different letters are present in the columns of a particular row (technology), this indicates significant differences ($p < 0.05$) exist between pairs of groups for a given technology, according to pairwise, independent-samples (two-tailed) Kruskal-Wallis *H* testing, which identifies statistically "homogenous" subsets (of cohort groups) which do not significantly differ from one another. If letters are the same (i.e., only "a" appears), no significant differences exist. If letters are the same (i.e., only "a" appears), no significant differences exist.

countries. For instance, how strong is the role of ethnicity compared to that of other socio-demographic variables or even of country fixed-effects? Given the differing perceptions of ethnic minority and Indigenous individuals in rural versus urban areas, particularly the greater support of the latter for nearly all technologies, it will be crucial to understand the factors and motivations which lie at the root of such differences. The current research demonstrates the importance of centering the perceptions and experiences of Indigenous groups and

Table 9
Significant Differences ($p < 0.05$) in Support for Small-Scale Field Trials of Climate-Intervention Technologies, assessed for Intersection of Geographic Region and Membership of Ethnic Minority or Indigenous Group (1–5 scale: 1 = Strictly reject, 5 = Fully support; different letters in columns indicate significant (pairwise) differences in technology support between the group cohorts).

	Non-Member (all regions)	Rural × self-identify as Indigenous or Ethnic Minority	Urban × self-identify as Indigenous or Ethnic Minority
	(N ≈ 7,460)	(N ≈ 130)	(N ≈ 970)
Stratospheric aerosol injection	3.43^{a}(1.24)	3.59^{a}(1.35)	4.00^{b}(1.12)
Marine cloud brightening	3.59^{a}(1.20)	3.61^{a}(1.35)	4.10^{b}(1.08)
Space-based geoengineering	3.45^{a}(1.29)	3.51^{a}(1.39)	4.03^{b}(1.16)
	(N ≈ 7,500)	(N ≈ 140)	(N ≈ 950)
4	4.47^{a}(0.84)	4.28^{b}(1.01)	4.53^{c}(0.84)
Soil carbon sequestration	4.25^{a}(0.94)	4.18^{a}(1.01)	4.37^{b}(0.93)
Marine biomass and blue carbon	4.22^{a}(0.94)	4.17^{a}(0.98)	4.30^{b}(0.98)
	(N ≈ 7,590)	(N ≈ 120)	(N ≈ 900)
DACCS	3.83^{a}(1.12)	3.87^{a}(1.13)	4.21^{b}(1.04)
BECCS	3.83^{a}(1.08)	3.99^{b}(1.17)	4.15^{b}(1.06)
Enhanced weathering	3.61^{a}(1.21)	3.75^{a}(1.32)	4.03^{b}(1.19)
Biochar	3.95^{a}(1.06)	4.00^{ab}(1.20)	4.17^{b}(1.02)

Note: Approximate numbers are given for sample sizes, as totals may differ slightly (by no more than five for indigenous individuals or forty for non-member individuals) due to excluding those who opted to answer "Prefer not to say". Those self-identifying as members of ethnic minorities and/or indigenous groups and living in suburban areas (N = 650) or small to medium-sized cities (N = 1116) are omitted from analysis. If different letters are present in the columns of a particular row (technology), this indicates significant differences ($p < 0.05$) exist between pairs of groups for a given technology, according to pairwise, independent-samples (two-tailed) Kruskal-Wallis H testing, with adjustments using the stepwise step-down method available in SPSS (Campbell and Skillings, 1985) which identifies statistically "homogenous" subsets (of cohort groups) which do not significantly differ from one another. If letters are the same (i.e., only "a" appears), no significant differences exist. If letters are the same (i.e., only "a" appears), no significant differences exist. If two letters appear (e.g., "ab"), as for column "Rural and self-identify as Indigenous or Ethnic Minority" and row "biochar", this indicates that perceptions do not significantly differ from the other group cohorts, though these differ from one another.

ethnic minorities, albeit on a quite high level; the next, fundamentally necessary step is to engage with such individuals in their diversity.

Consequently, research building on these questions, and providing deeper and more situated insights around the diverse conceptions of ethnicity, Indigenousness, and spatial identity, could help speed the development of innovative technological and policy solutions urgently needed to meet key carbon reduction targets – or, equally importantly, unfair burdens being imposed on some groups over others. Such social groups represent critical new audiences for potentially bridging partisan disagreements and building consensus on climate and energy policy.

CRediT authorship contribution statement

Benjamin K. Sovacool: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Chad M. Baum:** and **Livia Fritz:** Writing – review & editing, Writing – original draft, Visualization, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the European Research Council (ERC) Grant Agreement No. 951542-GENIE-ERC-2020-SyG, "GeoEngineering and NegatIve Emissions pathways in Europe" (GENIE). The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed herein lies entirely with the author(s). Also, the project was approved by the Institutional Review Board at Aarhus University 2021-13 as well as by the Ethics Committee at the European Research Council. The authors also thank Dr. William Lamb for his help in designing some of the diagrams and visualizations used in the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.worlddev.2024.106719.

References

Abate, R. S., & Kronk, E. A. (2013). Chapter 1: Commonality among unique indigenous communities: An introduction to climate change and its impacts on indigenous peoples. *Climate change and indigenous peoples*. Cheltenham, UK: Edward Elgar Publishing.

Abenoza, R. F., et al. (2017). Travel satisfaction with public transport: Determinants, user classes, regional disparities and their evolution. *Transportation Research Part A, 95*, 64–84.

Abimbola, O., Kwesi, J., & Tselane, A. (2021). *Makhesi-Wilkinson, Erin Roberts, racism and climate (in)justice: How racism and colonialism shape the climate crisis and climate action*. Washington, DC: Heinrich Böll-Stiftung.

Baird, R. (2008). *The impact of climate change on minorities and indigenous peoples, briefing paper*. London: Minority Rights Group International.

Barrett, S., Lenton, T. M., Millner, A., Tavoni, A., et al. (2014). Climate engineering reconsidered. *Nature Climate Change, 4*, 527–529.

Batres, M., Wang, F. M., Buck, H. J., Kapila, R., Kosar, U., Licker, R., Nagabhushan, D., Rekhelman, E., & Suarez, V. (2021). Environmental and climate justice and technological climate removal. *The Electricity Journal, 34*(7), Article 107002.

Baum, C. M., Fritz, L., Low, S., & Sovacool, B. K. (2024). Public perceptions of climate intervention technologies across the global north and south. *Nature Communications, 15*, 2060.

Berkes, F. (1999). *Sacred ecology: Traditional ecological knowledge and resource management*. Philadelphia: Taylor & Francis.

Benegal, S. D. (2018). The spillover of race and racial attitudes into public opinion about climate change. *Environmental Politics, 27*(4), 733–756.

Biermann, F., & Möller, I. (2019). Rich man's solution? Climate engineering discourses and the marginalization of the Global South. *International Environmental Agreements, 19*, 151–167. https://doi.org/10.1007/s10784-019-09431-0

Biermann, F., Oomen, J., Gupta, A., Ali, S. H., Conca, K., Hajer, M. A., Kashwan, P., Kotzé, L. J., Leach, M., Messner, D., Okereke, C., Persson, Å., Potočnik, J., Schlosberg, D., Scobie, M., & VanDeveer, S. D. (2022). Solar geoengineering: The case for an international non-use agreement. *WIREs Climate Change, 13*(3), e754.

Bishop, G. F., Oldendick, R. W., Tuchfarber, A. J., & Bennett, S. E. (1980). Pseudo-opinions on public affairs. *Public Opinion Quarterly, 44*(2), 198–209.

Brown, J. N., & Sant, P. M. (Eds.). (1999). *Indigeneity: Construction and re/presentation*. Hauppauge, NY: Nova Science.

Büchs, M., et al. (2013). Who emits most? Associations between socio-economic factors and UK households' home energy, transport, indirect and total CO2 emissions. *Ecological Economics, 90*, 114–123.

Buck, H. J., Carton, W., Lund, J. F., et al. (2023). Why residual emissions matter right now. *Nature Climate Change, 13*, 351–358.

Cajete, G. (1999). *Native science: Natural laws of interdependence*. Santa Fe, NM: Clear Light Books.

Calzadilla, P. V., & Mauger, R. (2018). The UN's new sustainable development agenda and renewable energy: The challenge to reach SDG7 while achieving energy justice. *Journal of Energy & Natural Resources Law, 36*(2), 233–254.

Campbell, G., & Skillings, J. H. (1985). Nonparametric stepwise multiple comparison procedures. *Journal of the American Statistical Association, 80*, 998.

Carton, W., Lund, J. F., & Dooley, K. (2021). Undoing equivalence: Rethinking carbon accounting for just carbon removal. *Frontiers in Climate*. https://doi.org/10.3389/fclim.2021.664130

Chanin, J. (2018). The effect of symbolic racism on environmental concern and environmental action. *Environmental Sociology, 4*(3), 1–13.

Cherry, T. L., Kroll, S., McEvoy, D. M., Campoverde, D., & Moreno-Cruz, J. (2022). Climate cooperation in the shadow of solar geoengineering: An experimental investigation of the moral hazard conjecture. *Environmental Politics*. https://doi.org/10.1080/09644016.2022.2066285

Clark, L. P., Millet, D. B., & Marshall, J. D. (2014). National patterns in environmental injustice and inequality: Outdoor NO air pollution in the United States. *PLoS One, 9*, Article e94431.

Cochran, P., Huntington, O. H., Pungowiyi, C., Tom, S., Chapin, F. S., Huntington, H., Maynard, N., & Trainor, S. (2013). Indigenous frameworks for observing and responding to climate change in Alaska. *Climatic Change, 120*(3), 557–567.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Abingdon, UK: Routledge.

Corner, A., & Pidgeon, N. (2015). Like artificial trees? The effect of framing by natural analogy on public perceptions of geoengineering. *Climatic Change, 130*(3), 425–438. https://doi.org/10.1007/s10584-014-1148-6

Cox, E., Spence, E., & Pidgeon, N. (2020). Public perceptions of carbon dioxide removal in the United States and the United Kingdom. *Nature Climate Change, 10*(8), 744–749.

Datta, R., & Hurlbert, M. A. (2020). Pipeline spills and indigenous energy justice. *Sustainability, 12*(1), 47.

de Mooij, M., & Hofstede, G. (2002). Convergence and divergence in consumer behavior: Implications for international retailing. *Journal of Retailing, 78*, 61–69.

Deaconu, A., Ekomer, Mercille, G., et al. (2021). Promoting traditional foods for human and environmental health: Lessons from agroecology and Indigenous communities in Ecuador. *BMC Nutrition, 7*, 1. https://doi.org/10.1186/s40795-020-00395-y

DeJaeghere, J., Wiger, N. P., Le, H., Luong, P., Ngo, N. T. H., Vu, T. T., & Lee, J. (2022). Why do aspirations matter for empowerment?: Discrepancies between the A-WEAI domains and aspirations of ethnic minority women in Vietnam. *World Development, 159*, Article 106057.

Delina, L. L. (2020). Potentials and critiques of building a southeast asian interdisciplinary knowledge community on critical geoengineering studies. *Climatic Change, 163*, 973–987. https://doi.org/10.1007/s10584-020-02921-0

Devine-Wright, P., Price, J., & Leviston, Z. (2015). My country or my planet? Exploring the influence of multiple place attachments and ideological beliefs upon climate change attitudes and opinions. *Global Environmental Change, 30*, 68–79.

Diesendorf, M. (2022). Scenarios for mitigating CO2 emissions from energy supply in the absence of CO2 removal. *Climate Policy, 22*(7), 882–896.

Dietz, T., Duan, R., Nalley, J., & Van Witsen, A. (2018). Social support for water quality: The influence of values and symbolic racism. *Human Ecology Review, 24*(1), 51–70.

Dietz, T., & Whitley, C. T. (2018). Environmentalism, norms, and identity. *Proceedings of the National Academy of Sciences, 115*(49), 12334–12336.

Doherty, T. J., & Clayton, S. (2011). The psychological impacts of global climate change. *American Psychologist, 66*(4), 265–276. https://doi.org/10.1037/a0023141

Dooley, K., & Kartha, S. (2018). Land-based negative emissions: Risks for climate mitigation and impacts on sustainable development. *International Environmental Agreements, 18*, 79–98.

Ellen, R. (2000). *Indigenous environmental knowledge and its transformations: Critical anthropological perspectives* (Vol. 5). New York: Routledge.

Enevoldsen, P., Baum, C. M., Low, S., Sovacool, B. K. (2022). Examining the synergies and trade-offs of net-zero climate protection with the sustainable development goals. Science Progress 105(4), 1-26.

European Commission. (2021). Racial and ethnic origin. Brussels, available at http://fra.europa.eu/en/themes/racial-and-ethnic-origin.

FAO. (2021). The white/wiphala paper on indigenous peoples' food systems. Rome. doi: 10.4060/cb4932en.

FAO, IFAD, UNICEF, WFP and WHO. (2021). The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, FAO. Retrieved June 19, 2022 from: https://doi.org/10.4060/cb4474en.

Feld, S., & Basso, K. H. (1996). *Senses of place*. New Mexico: Santa Fe.

Feygina, I., Jost, J. T., & Goldsmith, R. E. (2010). System justification, the denial of global warming, and the possibility of "system-sanctioned change". *Personality and Social Psychology Bulletin, 36*, 326–338.

Fischhoff, B., & Fischhoff, I. (2002). Publics' opinions about biotechnologies. *AgBioForum, 4*, 155–162.

Ford, J. D., King, N., Galappaththi, E. K., Pearce, T., McDowell, G., & Harper, S. L. (2020). The resilience of indigenous peoples to environmental change. *One Earth, 2*(6), 532–543.

Fraser, N. (1999). Social justice in the age of identity politics: Redistribution, recognition, and participation. *Culture and Economy after the Cultural Turn, 1*, 25–52.

Fritz, L., Baum, C. M., Low, S., & Sovacool, B. K. (2024). Public engagement for inclusive and sustainable governance of climate interventions. *Nature Communications, 15*(1), 4168.

Furszyfer Del Rio, D. D., Sovacool, B. K., & Griffiths, S. (2021). Culture, energy and climate sustainability, and smart home technologies: A mixed methods comparison of four countries. *Energy & Climate Change, 2*, 1–19, 100035.

Garnett, S. T., et al. (2018). A spatial overview of the global importance of Indigenous lands for conservation. *Nature Sustainability, 1*, 369–374.

Godfrey, P. C. (2012). Introduction: Race, gender & class and climate change. *Race, Gender & Class, 19*(1/2), 3–11.

Groat, L. (Ed.). (1995). *Giving places meaning: Readings in environmental psychology*. San Diego: Academic Press.

Guber, D. L. (2013). A cooling climate for change? Party polarization and the politics of global warming. *American Behavioral Scientist, 57*, 93–115.

Gupta, J., van der Grijp, N., & Kuik, O. (Eds.). (2012). *Climate change, forests and REDD: Lessons for institutional design* (1st ed.). Routledge.

Gutschow, B., Gray, B., Ragavan, M. I., Sheffield, P. E., Philipsborn, R. P., & Jee, S. H. (2021). The intersection of pediatrics, climate change, and structural racism: Ensuring health equity through climate justice. *Current Problems in Pediatric and Adolescent Health Care, 51*(6), Article 101028.

Hansen, A., Bi, L., Saniotis, A., & Nitschke, M. (2013). Vulnerability to extreme heat and climate change: Is ethnicity a factor? *Global Health Action, 6*, 1. https://doi.org/10.3402/gha.v6i0.21364

Henderson, J. (2020). EVs are not the answer: A mobility justice critique of electric vehicle transitions. *Annals of the American Association of Geographers, 110*(6), 1993–2010. https://doi.org/10.1080/24694452.2020.1744422

Höhne, N., et al. (2020). Emissions: World has four times the work or one-third of the time. *Nature, 579*, 25–28.

Holloway, R. A., Waldrip, A. M., & Ickes, W. (2009). Evidence that a simpatico self-schema accounts for differences in the self-concepts and social behavior of Latinos versus Whites (and Blacks). *Journal of Personality and Social Psychology, 96*, 1012–1028.

Honegger, M., Michaelowa, A., & Pan, J. (2021;). Potential implications of solar radiation modification for achievement of the Sustainable Development Goals. *Mitigation and Adaptation Strategies for Global Change*, 26.

Honegger, M., Michaelowa, A., & Roy, J. (2021). Potential implications of carbon dioxide removal for the sustainable development goals. *Climate Policy, 21*, 678–698.

Honneth, A. (2004). Recognition and justice. *Acta Sociologica, 47*(4), 351–364.

Hubert, A.-M., et al. (2016). Geoengineering: Code of conduct for geoengineering. *Nature, 537*(7621).

IPCC, 2022. Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, doi:10.1017/9781009325844.001.

Jaschke, G., & Biermann, F. (2022). The policy discourse on negative emissions, land-based technologies, and the Global South. *Global Environmental Change, 75*.

Jones, N. (2018). Safeguarding against environmental injustice. *Carbon & Climate Law Review, 12*(1), 23–30.

Jones, R. E., & Rainey, S. A. (2006). Examining linkages between race, environmental concern, health, and justice in a highly polluted community of color. *Journal of Black Studies, 36*, 473–496.

Jones, R. P., Cox, D., & Navarro-Rivera, J. (2014). Believers, sympathizers, and skeptics: Why Americans are conflicted about climate change, environmental policy, and science. Findings from the PRRI/AAR Religions, Values, and Climate Change Survey.

Josey, K. P., et al. (2023). Air pollution and mortality at the intersection of race and social class. *The New England Journal of Medicine, 388*, 1396–1404. https://doi.org/10.1056/NEJMsa2300523

Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., et al. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change, 2*, 732–735.

Kantack, B. R., & Paschall, C. E. (2023). Perceptions of policy problems and solutions: Climate change and structural racism. *Public Understanding of Science, 32*(2), 247–256.

Kartha, S., & Dooley, K. (2016). The risks of relying on tomorrow's 'negative emissions' to guide today's mitigation action. *Stockholm Environment Institute*.

Kilbourne, W. E., Beckmann, S. C., & Thelen, E. (2002). The role of the dominant social paradigm in environmental attitudes: A multinational examination. *Journal of Business Research, 55*, 193–204.

Kimmerer, R. W. (2002). Weaving traditional ecological knowledge into biological education: A call to action. *BioScience, 52*(5), 432–438.

Krieger, N. (2020). Climate crisis, health equity, and democratic governance: The need to act together. *Journal of Public Health Policy, 41*(1), 4–10.

Larkin, A., Kuriakose, J., Sharmina, M., & Anderson, K. (2018). What if negative emission technologies fail at scale? Implications of the Paris Agreement for big emitting nations. *Climate Policy, 18*(6), 690–714. https://doi.org/10.1080/14693062.2017.1346498

Laska, S., & Morrow, B. H. (2006). Social vulnerabilities and Hurricane Katrina: An unnatural disaster in New Orleans. *Marine Technology Society Journal, 40*, 16–26.

Lazarev, E., & Mironova, V. (2018). The economic consequences of political alienation: Ethnic minority status and investment behavior in a post-conflict society. *World Development, 106*, 27–39.

Leiserowitz, A., & Akerlof, K. (2010). *Race, ethnicity, and public responses to climate change. Yale Project on Climate Change*. New Haven, CT: Yale University and George Mason University.

Lenton, T. M., Xu, C., Abrams, J. F., et al. (2023). Quantifying the human cost of global warming. *Nature Sustainability*. https://doi.org/10.1038/s41893-023-01132-6

Lenzena, M., Wierb, M., Cohenc, C., Hayamid, H., Pachauri, S., & Schaeffer, R. (2006). A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan. *Energy, 31*, 181–207.

Liboiron, M., & Cotter, R. (2023). Review of participation of Indigenous peoples in plastics pollution governance. *Cambridge Prisms: Plastics, 1*, E16. https://doi.org/10.1017/plc.2023.16

Liu, B., Roopsind, A., & Sohngen, B. (2024). Overlapping extractive land use rights increases deforestation and forest degradation in managed natural production forests. *World Development, 174*, Article 106441.

Lovelock, B., Jellum, C., Thompson, A., & Lovelock, K. (2013). Could immigrants care less about the environment? A comparison of the environmental values of immigrant and native-born New Zealanders. *Society & Natural Resources, 26*, 402–419.

Low, S., Baum, C.a. M., & Sovacool, B. K. (2022). Rethinking Net-Zero systems, spaces, and societies: "Hard" versus "soft" alternatives for nature-based and engineered carbon removal. *Global Environmental Change, 75*, Article 102530.

Low, S., Baum, C.a. M., & Sovacool, B. K. (2022). Taking it outside: Exploring social opposition to 21 early-stage experiments in radical climate interventions. *Energy Research & Social Science, 90*(2022), Article 102594.

Lund, J. F., Markusson, N., Carton, W., & Buck, H. J. (2023). Net zero and the unexplored politics of residual emissions. *Energy Research & Social Science, 98*, Article 103035.

Macias, T. (2016). Environmental risk perception among race and ethnic groups in the United States. *Ethnicities, 16*, 111–129.

Macias, T. (2016). Ecological assimilation: Race, ethnicity, and the inverted gap of environmental concern. *Society & Natural Resources, 29*, 3–19.

Macklem, P. (1993). Distributing sovereignty: Indian nations and equality of peoples. *Stanford Law Review, 45*(5), 1311–1367.

Martin, A., Coolsaet, B., Corbera, E., Dawson, N. M., Fraser, J. A., Lehmann, I., & Rodriguez, I. (2016). Justice and conservation: The need to incorporate recognition. *Biological Conservation, 197*, 254–261.

Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., et al. (Eds.). IPCC, 2018. Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways. In: the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (Cambridge University Press, 2018).

McCright, A. M., & Dunlap, R. E. (2011). Cool dudes: The denial of climate change among conservative white males in the United States. *Global Environmental Change, 21*, 1163–1172.

McCright, A. M., & Dunlap, R. E. (2011). The politicization of climate change and polarization in the American public's views of global warming, 2001–2010. *Sociological Quarterly, 52*, 155–194.

McCright, A. M., & Dunlap, R. E. (2013). Bringing ideology in: The conservative white male effect on worry about environmental problems in the USA. Journal of Risk Research 16, 211–226.

McCright, A. M., Dunlap, R. E., & Marquart-Pyatt, S. T. (2016). Political ideology and views about climate change in the European Union. *Environmental Politics, 25*, 338–358.

McElwee, P. (2023). Advocating afforestation, betting on BECCS: Land-based negative emissions technologies (NETs) and agrarian livelihoods in the global South. *The Journal of Peasant Studies, 50*(1), 185–214. https://doi.org/10.1080/03066150.2022.2117032

Meinherz, F., Fritz, L., & Schneider, F. (2020). *How values play into sustainability assessments: Challenges and a possible way forward* (pp. 65–86). Cambridge, New York: Sustainability assessment of urban systems. Cambridge University Press.

Memmott, T., Carley, S., Graff, M., & Konisky, D. M. (2021). Socioeconomic disparities in energy insecurity among low-income households before and during the COVID-19 pandemic. *Nature Energy, 6*, 186–193.

Merk, C., Klaus, G., Pohlers, J., Ernst, A., Ott, K., & Rehdanz, K. (2019). Public perceptions of climate engineering: Laypersons' acceptance at different levels of knowledge and intensities of deliberation. *GAIA – Ecological Perspectives for Science and Society, 28*(4), 348–355. https://doi.org/10.14512/gaia.28.4.6

Newell, P. (2021). Race and the politics of energy transitions. *Energy Research & Social Science, 71*, Article 101839.

Norton-Smith, K., Lynn, K., Chief, K., Cozzetto, K., Donatuto, J., Hiza Redsteer, M., Kruger, L. E., Maldonado, J., Viles, C., Whyte, K. P. (2016). Climate change and indigenous peoples: a synthesis of current impacts and experiences. Gen. Tech. Rep. PNWGTR-944. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Ouyang, Y., & Pinstrup-Andersen, P. (2012). Health inequality between ethnic minority and Han populations in China. *World Development, 40*(7), 1452–1468.

Owen, J. R., Kemp, D., Lechner, A. M., et al. (2023). Energy transition minerals and their intersection with land-connected peoples. *Nature Sustainability, 6*, 203–211. https://doi.org/10.1038/s41893-022-00994-6

Paprocki, K. (2018). Threatening dystopias: Development and adaptation regimes in Bangladesh. *Annals of the American Association of Geographers, 108*(4), 955–973.

Pearson, A., Ballew, M., Naiman, S., & Schuldt, J. Race, class, gender and climate change communication. 2017. Oxford Research Encyclopedia of Climate Science.

Pearson, A. R., Schuldt, J. P., Romero-Cayas, R., Ballew, M. T., & Larson-Konar, D. (2018). Diverse segments of the US public underestimate the environmental concerns of minority and low-income Americans. *Proceedings of the National Academy of Sciences, 115*(49), 12429–12434.

Pettifor, H., Wilson, C., Axsen, J., Abrahamse, W., & Anable, J. (2017). Social influence in the global diffusion of alternative fuel vehicles – a meta-analysis. *Journal of Transport Geography, 62*, 247–261.

Pettifor, H., Wilson, C., Edelenbosch, O., & McCollum, D. (2017). Modelling social influence and cultural variation in global low-carbon vehicle transitions. *Global Environmental Change, 46*, 76–87.

Piris-Cabezas, P., Lubowski, R. N., & Leslie, G. (2023). Estimating the potential of international carbon markets to increase global climate ambition. *World Development, 167*, Article 106257.

Purdon, M. (2015). Opening the black box of carbon finance "additionality": the political economy of carbon finance effectiveness across Tanzania, Uganda, and Moldova. World Development 74, 462–478.

Raven, R., et al. (2017). Unpacking sustainabilities in diverse transition contexts: Solar photovoltaic and urban mobility experiments in India and Thailand. *Sustainability Science, 12*, 579–596.

Satterfield, T. A., Mertz, C. K., & Slovic, P. (2004). Discrimination, vulnerability, and justice in the face of risk. *Risk Analysis, 24*, 115–129.

Rayo, G. A., Mosinger, E. S., Thaler, K. M., 2024. Statebuilding and indigenous rights implementation: Political incentives, social movement pressure, and autonomy policy in Central America. World Development 175, 106468.

Schlingmann, A., Graham, S., Benyei, P., Corbera, E., Sanesteban, I. M., Marelle, A., Fard, R. S., & García, V. R. (2021). Global patterns of adaptation to climate change by Indigenous Peoples and local communities. A systematic review. *Current Opinion in Environmental Sustainability, 51*, 55–64.

Schroeder, H., & McDermott, C. (2014). Beyond carbon: Enabling justice and equity in REDD+ across levels of governance. *Ecology and Society, 19*(1), 31.

Schuldt, J. P., & Pearson, A. R. (2016). The role of race and ethnicity in climate change polarization: Evidence from a US national survey experiment. *Climatic Change, 136*, 495–505.

Sealey-Huggins, L. (2018). The climate crisis is a racist crisis: Structural racism, inequality and climate change. In A. Johnson, R. Joseph-Salisbury, & B. Kamunge (Eds.), *The fire now: Anti-racist scholarship in times of explicit racial violence* (pp. 99–113). London: Zed Books.

Seo, K., & Rodriguez, N. (2012). Land grab, food security, and climate change: A vicious cycle in the global South. In N. Chhetri (Ed.), *Human and social dimensions of climate change*. Rijeka, Croatia: InTechOpen.

Shaffril, H. A., Mohamed, N. A., Samsuddin, S. F., Samah, A. A., & Hamdan, M. E. (2020). Systematic literature review on adaptation towards climate change impacts among indigenous people in the Asia Pacific regions. *Journal of Cleaner Production, 258*, Article 120595.

Skutsch, M., & Turnhout, E. (2020). REDD+: If communities are the solution, what is the problem? *World Development, 130*, Article 104942.

Smith, S. M., Geden, O., Nemet, G., Gidden, M., Lamb, W. F., Powis, C., Bellamy, R., Callaghan, M., Cowie, A., Cox, E., Fuss, S., Gasser, T., Grassi, G., Greene, J., Lück, S., Mohan, A., Müller-Hansen, F., Peters, G., Pratama, Y., Repke, T., Riahi, K., Schenuit, F., Steinhauser, J., Strefler, J., Valenzuela, J. M., and Minx, J. C. (2023). The State of Carbon Dioxide Removal. 1st Edition. The State of Carbon Dioxide Removal. doi: 10.17605/OSF.IO/W3B4Z.

Speiser, M., & Krygsman, K. (2014). American climate values 2014: Insights by racial and ethnic groups. Washington, DC: Strategic Business Insights and ecoAmerica.

Sovacool, B. K. (2009). The cultural barriers to renewable energy in the United States. *Technology in Society, 31*(4), 365–373.

Sovacool, B. K. (2021). Reckless or righteous? Reviewing the sociotechnical benefits and risks of climate change geoengineering. *Energy Strategy Reviews, 35*, Article 100656.

Sovacool, B. K., Low, S., & Baum, C. (2023). The next climate war? Statecraft, security, and weaponization in the geopolitics of a low-carbon future. *Energy Strategy Reviews, 45*, 1–16, 101031.

Sovacool, B. K. (2023). Expanding carbon removal to the Global South: Thematic concerns on systems, justice, and climate governance. *Energy & Climate Change, 4*, 1–16, 100103.

Sovacool, B. K., Tan-Mullins, M., & Abrahamse, W. (2018). Bloated bodies and broken bricks: Power, ecology, and inequality in the political economy of natural disaster recovery. *World Development, 110*, 243–255.

Sovacool, B. K., Kester, J., Noel, L., & de Rubens, G. Z. (2019). Energy injustice and Nordic electric mobility: Inequality, elitism, and externalities in the electrification of vehicle-to-grid (V2G) transport. *Ecological Economics, 157*, 205–217.

Sovacool, B. K., & Griffiths, S. (2020). Culture and low-carbon energy transitions. *Nature Sustainability, 3*, 685–693.

Steeves, P. F. (2018). "Indigeneity." Oxford Handbook of Philosophy. Oxford. November. Available at 10.1093/OBO/9780199766567-0199.

Stephens, J. C., Kashwan, P., McLaren, D., & Surprise, K. (2021). The risks of solar geoengineering research. *Science, 372*(6547), 1161.

Stephens, J. C., Kashwan, P., McLaren, D., & Surprise, K. (2021). The dangers of mainstreaming solar geoengineering: A critique of the National Academies Report. *Environmental Politics*. https://doi.org/10.1080/09644016.2021.1989214

Stephenson, J., Sovacool, B. K., & Inderberg, T. H. J. (2021). Energy cultures and national decarbonisation pathways. *Renewable & Sustainable Energy Reviews, 137*, 1–15, 110592.

Stevens, D. d. l. F., Pelkonen, P. (2023). Economics of minority groups: Labour-market returns and transmission of indigenous languages in Mexico. World Development 162, 106096.

Stock, R. B., & Sovacool, K. (2023). Left in the dark: Colonial racial capitalism and solar energy transitions in India. *Energy Research & Social Science, 105*, Article 103285.

Sultana, F. (2022). The unbearable heaviness of climate coloniality. *Political Geography, 99*. https://doi.org/10.1016/j.polgeo.2022.102638

Sunter, D. A., Castellanos, S., & Kammen, D. M. (2019). Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity. *Nat Sustain, 2*, 71–76.

Svobodova, K., Owen, J. R., Kemp, D., Moudry, V., Lèbre, E., Stringer, M., Sovacool, B. K. (2002). Decarbonization, population disruption and resource inventories in the global energy transition. Nature Communications 13, 7674, pp. 1-16.

Taiwo, O., & Talati, S. (2022). Who are the engineers? Solar geoengineering research and justice. *Global Environmental Politics, MIT Press, 22*(1), 12–18.

Tarhan, D. (2022). Community renewable energy's problematic relationship with social justice: Insights from Ontario. *Local Environment*. https://doi.org/10.1080/13549839.2022.2077713

Tilley, L., Ranawana, A. M., Baldwin, A., & Tully, T. M. (2023). Race and climate change: Towards anti-racist ecologies. Politics, (in press 2023). doi:10.1177/02633957221127166.

Tschakert, P., Parsons, M., Atkins, E., Garcia, A., Godden, N., Gonda, N., Henrique, K. P., Sallu, S., Steen, K., Ziervogel, G. (2023). Methodological lessons for negotiating power, political capabilities, and resilience in research on climate change responses. World Development 167, 106247.

Tsosie, R. (2007). Indigenous people and environmental justice: The impact of climate change. *University of Colorado Law Review, 78*(4), 1625–1678.

Uenal, F., Sidanius, J., & Roozenbeek, J. (2021). Sander van der Linden, Climate change threats increase modern racism as a function of social dominance orientation and ingroup identification. *Journal of Experimental Social Psychology, 97*, Article 104228.

United Nations. (2011). United Nations Guide for Minorities. Available at https://www.ohchr.org/en/minorities/united-nations-guide-minorities.

US Census. (2020). U.S. Population More Racially and Ethnically Diverse Than Measured in 2010. Washington, DC: August. Available at https://www.census.gov/library/stories/2021/08/2020-united-states-population-more-racially-ethnically-diverse-than-2010.html.

Weber, G., & Cabras, I. (2017). The transition of Germany's energy production, green economy, low-carbon economy, socio-environmental conflicts, and equitable society. *Journal of Cleaner Production, 167*, 1222–1231.

Wesseling, J. H. (2016). Explaining variance in national electric vehicle policies. *Environmental Innovation and Societal Transitions, 21*, 28–38.

Wildcat, D. R. (2013). Introduction: Climate change and indigenous peoples of the USA. *Climatic Change, 120*, 509–515. https://doi.org/10.1007/s10584-013-0849-6

Whittaker, M., Segura, G. M., & Bowler, S. (2005). Racial/ethnic group attitudes toward environmental protection in California: Is "environmentalism" still a white phenomenon? *Political Research Quarterly, 58*, 435–447.

Whyte, K. P. (2018). Indigeneity in geoengineering discourses: Some considerations. *Ethics, Policy & Environment, 21*(3), 289–307.

Whyte, K. (2016). Indigenous experience, environmental justice and settler colonialism. *Environmental Justice and Settler Colonialism, 25*, 2016).

Whyte, K. (2020). Too late for indigenous climate justice: Ecological and relational tipping points. *Wiley Interdisciplinary Reviews: Climate Change, 11*(1), e603.

Williams, J. (2021). *Climate change is racist: Race, privilege and the struggle for climate justice*. New York: Icon Books.

Winickoff, D. E., Flegal, J. A., Asrat, A. (2015). Engaging the global south on climate engineering research. Nature Climate Change 5, 627–634.

World Bank. (2020). Everyone Equal: Making Inclusive Growth a Priority for Ethnic Minorities. Washington, DC: World Bank Group, July 13. Available at https://www.worldbank.org/en/news/feature/2020/07/13/everyone-equal-making-inclusive-growth-a-priority-for-ethnic-minorities.