The Engineering and Scientific Challenges of Environmental Justice Organizations in the US: A Qualitative Study

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Research Article

Keywords: environmental justice organizations, engineers and scientists, field of collaboration, community-based monitoring, citizen science

Posted Date: February 23rd, 2021

DOI: https://doi.org/10.21203/rs.3.rs-159784/v1

Version of Record: A version of this preprint was published at Journal of Cleaner Production on October 7th, 2022. See the published version at https://doi.org/10.1016/j.jclepro.2022.134463.

Abstract

With the goal of exploring the engineering and scientific challenges of environmental justice organizations (EJOs), we present the results of 47 interviews with representatives of US-based EJOs. Methodologically, we use a deductive-inductive approach to identifying salient categories in the interview coding process. We identify a structure of three overarching themes for potential interactions between EJOs and engineers and scientists: (1) organizational goals; (2) engineering and scientific challenges; and (3) experiences with engineers and scientists. Our findings reveal a breadth of EJO goals and myriad engineering and scientific challenges ranging from community development, clean and just energy transactions, climate change adaptation, and water and air quality monitoring. We also find activity-based opportunities for engineers and scientists like data collection, management, and analysis; online platform building; GIS mapping; and causation analyses. We find that engineers and scientists could help bridge the culture gap between them and EJOs and help build a field of collaboration by: a greater mindfulness of local contexts; building relational rapport and trust; moving beyond narrow technical solutions; identifying low-cost accessible solutions; and receiving unconscious bias training. To our knowledge, this study is unique by its provision and assemblage of—in one place—the myriad ways engineers and scientists might work with EJOs to address the challenges of environmental, energy, and climate justice.

Introduction

Little is known academically about environmental justice organizations' (EJOs) engineering and scientific challenges *and* their experiences with engineers and scientists. We do know that there are engineers and scientists (E&Ss) who are interested in and have worked with EJOs (Ottinger and Cohen 2011; Boucher et al. 2020). There are organizations like the Union of Concerned Scientists (UCS 2020) and the Engineers Without Borders' Community Engineering Corps (EWB-USA 2020a) with specific interests in community and justice issues. Professional organizations have created engagement opportunities for E&Ss to work on community issues (AAAS 2020; AGU 2020) and individual scholars have made calls for greater social responsibility (Bielefeldt 2018), more community-driven research (Pandya 2014), and a new social contract for the fields of engineering and science (Lubchenco 1998; Gallopín et al. 2001). These initiatives and calls appear to have brought greater recognition to the cause of engineering and science to address environmental justice challenges in communities.

There can be, however, limited understanding of community perspectives in these contexts. For instance, in proposing a "field of collaboration" between engineers, scientists, and community groups, Boucher et al. (2020) do not study EJOs themselves, but quantitatively survey E&Ss to understand their incentives, barriers, and potential related to community collaborations. Research conducted on Engineers Without Borders often focuses on student members, their motives and experiences (Litchfield and Javernick-Will 2015; Litchfield et al. 2016; Litchfield and Javernick-Will 2017).

To be fair, there are numerous calls for a greater understanding of a community's perspectives on their engineering and scientific challenges. For example, in the context of international development, observers have pointed to the lessons learned from community voices when community ownership of a project is not achieved (EWB-USA 2017). There are also calls for enhanced processes of "co-creation and co-design,. .. through local input" and community consultation (EWB-UK 2020) (*co-creation* and *co-design* are processes whereby concerned communities are directly involved in identifying, troubleshooting, and resolving their own challenges). Moreover, there is often a vigilance that asks whether projects are properly community-driven and whose voices are being left out (Dietrich 2014). After such repeated compromised experiences, Engineers Without Borders (EWB-USA 2020b, c) has implemented a policy whereby they do not initiate contact with communities, but require communities to first contact them. The intent of this policy is to generate longer lasting solutions to community challenges by moderating the tendency of E&Ss to approach communities in a top down or colonial fashion.

To date, the open-source, international, EJAtlas (Martinez-Alier et al. 2014; Temper et al. 2015; EJOLT 2020) is the most comprehensive, real-time collection of global EJOs available. It has been designed and defined as a tool for "activism, advocacy and scientific knowledge" (Temper et al. 2015, p. 255). However, it primarily focuses on environmental conflicts, their categorization, and their historical and political contexts. As a complement to the EJAtlas, our present study focuses on the engineering and scientific challenges of EJOs in the context of the United States (US). We also identify, from a qualitative, grassroots perspective, the goals of these EJOs and their experiences with engineers and scientists.

We begin this study in Sect. 2 by reviewing what is known about the engineering and scientific challenges of EJOs. In Sect. 3, we discuss our method for analyzing 47 interviews with representatives of EJOs in the US. In Sect. 4, we describe our findings regarding EJO goals, technical challenges, and experiences with E&Ss; in Sect. 5, we discuss our findings and their relation to the literature. In Sect. 6, we conclude and offer recommendations on the constructive ways that E&Ss might collaborate with EJOs in the US.

Review Of The Literature

2.1 Defining Environmental Justice Organizations (EJOs)

We consider EJOs to be a type of community-based organization (CBO). We define *community* as a group of people—networked or otherwise—connected by a common interest or effort, or a stake in a particular resource. The CBO is itself a type of community. It may have members, staff, and persons who identify themselves as part of it. The CBO may also have legal status as an organization, like a nonprofit, and may have a particular vision or mission to address an issue in the broader community. For our purposes, the primary difference between an EJO and a CBO is the EJO's more critical focus on issues of environmental justice (EJ)—a movement (e.g., activist, academic, or legal) seeking to address the disparate social distribution of environmental benefits and burdens.

To more clearly define the key terms of this study, Fig. 1 offers a visualization of their interaction. There are two large spheres representing "the community" and "engineering and science." As we consider that much of engineering and science is not involved in addressing the environmental challenges faced by communities, we conceptualize a limited "space of interaction" where engineers and scientists might be addressing particular community challenges. We consider both the EJO and the CBO to be representatives of the larger community, but not necessarily speaking for the whole (INCITE! 2017). Though firmly embedded in the community, both the EJO and the CBO have interactions with engineering and science, but the EJO has a more concentrated focus on environmental issues.

As Martinez-Alier et al. (2014) assert, EJOs do not arise from something read in a book or a report; they arise from concrete experiences that have affected community members directly. For instance, such experiences might be public health issues due to contaminated water (Brown 1992) or locally unwanted toxic dumping (Bullard 1990). An EJO might also arise to assist a government with forest management (Davis et al. 2020) or some other type of natural resource stewardship (Abrams et al. 2016, p. 2). As the EJAtlas attests (Temper et al. 2015; EJOLT 2020), there are EJOs all across the world arising in response to environmental, climate, and energy challenges.

We identify three fundamental and entangled dimensions related to the purposes and functioning of EJOs can be identified: political, socio-environmental, and organizational. The political dimension refers to EJO struggles with powerful entities over environmental benefits and burdens; the socio-environmental dimension refers to the interaction of those benefits and burdens in a community setting; and the organizational dimension refers to the daily operations of an EJO as a type of business (e.g., organizing people, campaigns, communications, perhaps fundraising, etc.). Though this study primarily focuses on the socio-environmental dimension as this is where we perceive engineering and scientific resources might be best applied, we do not intend to be dismissive of the political and organizational dimensions. For instance, it is not uncommon for EJOs to be politically engaged in *environmental conflict* (Temper et al. 2015; EJOLT 2020)—disputes over environmental benefits and burdens—and EJO members to be considered *environmental defenders* (Ghazoul and Kleinschroth 2018; Scheidel et al. 2020). Said defenders can work under great personal threat and, internationally, some have been murdered or assassinated (UNEP 2018), like Chico Mendez in Brazil in 1988 (Martinez-Alier et al. 2014) and Berta Cáceres in Honduras in 2016 (Lakhani 2020). A review of the EJAtlas finds that 13% of the registered environmental conflicts involve assassinations (Scheidel et al. 2020, p. 5). EJOs, then, can be a threat to the daily operations of extractive industries and the governments that enable these industries. Consequently, an engineer or scientist's involvement with an EJO may be a source of tension for both the E&Ss involved and the engineering and scientific fields themselves; in other words, many E&Ss undergird the design and functioning of, for example, an extractive industry.

2.2 In what sectors might engineering and science interact with EJOs?

In a typological analysis of 2,743 environmental conflicts registered in the EJAtlas, Scheidel et al. (2020, p. 6) find that 21% of the conflicts are related to mining; 17% related to energy and climate issues; 15% related to biomass and land uses; and 14% related to water management. Figure 2 illustrates the "occurrence of types of environmental conflicts across world income regions" (Scheidel et al. 2020, p. 7) and suggests that environmental conflicts—and therefore EJOs—in the US (as a high-income country; bottom row) may be related to energy and climate issues, infrastructure projects, industrial zones, mining, and nuclear power. In a type of complement to this typology, the Community Engineering Corps (CECorps) primarily works on issues of water supply, structures, civil works, energy, and agriculture (EWB-USA 2020a). These areas, though, are not framed as related to "environmental conflict," but what the CECorps (2019) calls "community-driven projects." Moreover, these projects are primarily initiated by non-profit organizations (secondarily by local utilities and thirdly by municipalities) and, aside from their staff, the CECorps is an all-volunteer organization. There are also documented case studies of technical experts' encounters in environmental justice and their potential for scientific transformations due to community interactions in issues of health, energy systems, pollution exposure, risk assessments, and pesticides (Ottinger and Cohen 2011).

2.3 The socio-environmental dimension: Community-based monitoring and citizen science

From a very limited selection of the socio-environmental dimension, we define the EJO as the space where people are affected by and consequently react to the *experience* of an environmental hazard or burden. This experience can be cited as the issue that brought the EJO into existence (Martinez-Alier et al. 2014). An example of this in the US can be found in EJOs like the Center for Environmental Health and Justice (CHEJ 2019), an organization that grew out of the Love Canal disaster. The CHEJ was mostly founded by Lois Gibbs who started organizing residents after learning that her children were not the only ones who were sick from living in an area contaminated by toxic waste (Gibbs 2002, 2011; Livesey 2003; CHEJ 2019). Another example of an EJO originating from environmental experience is Moms Clean Air Force. "Moms" define themselves as "a community of moms and dads united against air pollution. .. to protect our children's health" (MCAF 2020). They work on issues created by fracking and methane release, smog, and asthma, to name only a few. They also fight against contamination caused by other toxic chemicals and related health issues. Much of their work is in the political (e.g., voting, lobbying, and policy) dimension. However they also work in education, creating and disseminating fact sheets, and, with chapters across the US, they also work in community organizing (MCAF 2020).

Notably, there is a large and associated area of the literature that engages scientific and engineering knowledges that is referred by different names: citizen science, community-based ecological (or environmental) monitoring or, for short, community-based monitoring (CBM). As this literature primarily recounts approaches to environmental monitoring that are not initiated by the community (Conrad and Hilchey 2011), we find the acronym CBM more accommodating than citizen science, which tends toward the recruitment of public participants to be involved in research projects initiated by others (Kruger and Shannon 2000; Conrad and Hilchey 2011).

There have been numerous reviews of this large and unwieldy literature [37, 39–42]. For instance, regarding ecosystem impact assessments, Conrad and Hilchey (2011, p. 276) identify three types—status assessments, impact assessments, and adaptive management—which can apply to different aspects of an ecosystem, like species diversity or a nutrient cycle. Regarding focal points of citizen science, Kullenberg and Kasperowski (2016) identify three areas: (1) biology, conservation, and ecology (e.g., data collection); (2) geographic information research; and (3) social sciences and epidemiology.

Njue et al. (2019) review 71 articles (from 2001 to 2018) regarding monitoring in hydrology and find that it mostly focuses on water levels/flow, water quality, and precipitation; monitoring *approaches*, though, mostly involve data collection. However, the studies reviewed differed in their "scale, scope and degree of citizen involvement” (Njue et al. 2019, p. 1). Njue et al. (2019) also argue for more co-created projects between researchers and publics in order to augment the “sustainability of monitoring networks.” Notably, CBM can be used for educational purposes (Bonney et al. 2009), but proper training in the science of monitoring—related to a particular issue—is critical to data quality (Sharpe and Conrad 2006; Aceves-Bueno et al. 2017). There is also evidence of data management issues due to the volumes of collected and available data (Sharpe and Conrad 2006; Newman et al. 2011). These can pose a particular challenge to organizations that desire to both make sense of their data and share it with a spectrum of interested networks and concerned stakeholders. Finally, scholars (Sharpe and Conrad 2006; Buckland-Nicks et al. 2016) have noted the qualities of successful CBM groups and emphasize the importance of adequate long-term funding, strong communications, and a supportive volunteer program.

2.4 Undone science and experiences with engineers and scientists

CBM has the capacity to produce engineering and scientific knowledge in areas that might otherwise not exist and this engages another area of the literature called “undone science”: areas of science and engineering that have been, purposefully or not, glossed over and unfunded (Hess 2007; Frickel et al. 2010). Frickel et al. (2010, p. 445) argue that these undone areas are the result of an “institutional politics of knowledge” where funded endeavors are politically constructed in accord with the powers that dominate research priorities that serve commercial actors in a narrow, for-profit marketplace (Mirowski 2011; Lave 2012). Such “dominating powers and priorities” have already been evidenced in the global EJO database and the environmental conflicts reviewed in the EJAtlas (Temper et al. 2015; Scheidel et al. 2020). Regarding market dynamics, then, critical research and technological development of “potentially broad social benefit” are left unidentified (Frickel et al. 2010, p. 445). Here, we presume is where EJOs and CBM groups are making efforts to fill these knowledge and social benefit “gaps” and we venture that engineers and scientists ought to be more engaged in these efforts. We are aware though that most engineers and scientists are wholly captured within their particular niche of work in this dominant, for-profit marketplace of knowledge (Mills 1956; Kunda 2009). The NSF (2017) posits that over 70% of engineers and scientists in the US are employed in business or industry.

This “market gap” then may help explain why there is very little literature on the experiences of EJOs with E&Ss, e.g., their engagements, collaborations, and recounted experiences. In other words, views from what the literature calls “community perspective.” There are two studies though—from the EJO/community perspective that evaluate experiences with E&Ss—and both emphasize the importance of mutual trust; respect of local culture and knowledge; clear communications; and community involvement in the interpretation and dissemination of data (Pivik and Goelman 2011; Lesen et al. 2019). Lesen et al. (2019, p. 1) also mentioned the importance of meeting communities at their level; staying aware of power dynamics; and “incorporating theories and practices that center critical reflection.” Pivik and Goelman (2011, p. 271) added the importance of having adequate time; regular meetings; a shared commitment in decision making and goals; and a memorandum of understanding is also helpful to enhancing researcher interactions with community-based groups.

2.5 Research questions

This review gives insight into the engineering and scientific challenges confronting EJOs, globally, and some responses via environmental monitoring in the US. However, as much of this literature is based on research that was not initiated from a community base, it only partially illuminates those engineering and scientific challenges. Consequently, there is something of a knowledge-gap regarding the EJO perspective on their engineering and scientific challenges, and such knowledge might form the basis of a new approach and/or tools for collaborations. Thus, we ask: What are the goals *and* the engineering and scientific challenges of EJOs in the US, and what have EJO experiences working with engineers and scientists?

Methods And Data

Informed by these literatures, we conducted a US-wide search for EJOs, broadly construed (i.e., environmental, energy, or climate justice organizations), with the aim of exploring what engineers and scientists could learn from these organizations: about their goals, engineering and scientific challenges, and their experiences with E&Ss. We tried not to focus on one particular issue area, but broadly surveyed in order to identify areas for possible engineering and scientific collaborations.

First, we identified EJOs working on EJ issues and compiled a database through three methods: internet searches, institutional networks (like the National Environmental Justice Conference and the Office of Environmental Justice at the US EPA), and snowball sampling. We also used an IRS search for registered 501(c)(3) organizations using the terms “environmental justice,” “climate justice,” and “energy justice.” After this, we had over 3,000 potential contacts.

We then selected groups using several criteria. First, we determined whether the group’s focal areas and mission included EJ. We did this by reviewing their websites, social media pages, and affiliated materials. Groups who did not substantially focus on the disproportionate impacts of environmental problems on different populations were not included. For example, our search often included conservation groups who were concerned about biodiversity conservation, which we did not classify as EJ when it did not connect to human impacts. Secondly, we delimited groups by their status, active or inactive. Using the same review of materials, websites and social media, we looked for the latest posts, updates, or changes. If they were older than three years, we assumed the group was no longer active. Thirdly, we parsed the EJOs into four types: small, medium, or large non-profit, and community group. These designations were determined by the group’s incorporation as a non-profit and the size of the organization (based on interview questions). For example, small non-profits have five (5) or less paid staff, medium have between 6–20, and large have more than 20 paid staff. Lastly, we emailed the listed persons/contacts at least three times. Those who responded were asked if they could sign up for an interview where they consented via electronic and verbal formats. After this initial process, our database was narrowed to 426 groups and with a $75 incentive, we conducted interviews with 47 different groups between October 2018 and May 2019. Interviews lasted between 30 and 90 minutes, were conducted by phone, and recorded for analysis. We conducted semi-structured interviews that focused on key questions (see Appendix).

Regarding coding, we used a deductive-inductive approach to categorize organizational goals and challenges into broad focal areas where engineering and scientific expertise might be desired. This deductive portion aligns with what some call a Framework (Srivastava and Thomson 2009; Gale et al. 2013) or Template (Brooks et al. 2015) Analysis. We then “filled in” these templated areas by coding in the manner of Grounded Theory (Glaser and Strauss 1967;

Strauss 1987). A team of three analysts coded the interviews and a code book was created. As our ultimate goal with this study is to connect these and all EJOs with desired engineering and scientific resources, we also categorize EJO experiences with E&Ss to explore questions about future collaborations. In reporting our results, we use the gender-neutral terms “them/their.”

Notably, a particular narrative script may contain more codes than one. In other words, there are many times that codes are related to others and are categorized in multiple ways. Regarding limitations, as with most qualitative studies, these findings are not broadly generalizable though they offer a rich insight in the particulars of our sample.

Results

Before reviewing the qualitative results of our interviews (*n* = 47), we first review some descriptive statistics of the sample. Table 1 assembles some of the more pertinent self-identified attributes of the EJOs that participated in this study. As Table 1 is fairly detailed and self-explanatory, we only call attention to some more salient attributes: that (1) the great majority of EJOs (about 81%) identified and were registered as non-profit organizations—primarily 501(c)(3); 47% of our respondents identified as the Executive Director; and 41% of these EJOs resided in the Northeast region of the US. Notably, the term *Community Group* (in this instance) is used for the EJOs that were not registered non-profits and respondents identified them as: a “community group/organization,” “a coalition,” “a task force,” or “a grassroots campaign.”

Table 1
Descriptive frequency data for interviewed environmental justice organizations (EJO; *n* = 47).

Attribute	**Frequency**	**Sample Count**
Type of EJO		
Small Non-profit	32%	*n* = 15
Medium Non-profit	32%	*n* = 15
Large Non-profit	17%	*n* = 8
Community Group	17%	*n* = 8
Other	2%	*n* = 1
Respondent Role		
Executive Director	47%	*n* = 22
Manager/Director	21%	*n* = 10
Organizer	19%	*n* = 9
Communications	6%	*n* = 3
Other	6%	*n* = 3
US Region		
Northeast	40%	*n* = 19
Pacific	23%	*n* = 11
Southeast	19%	*n* = 9
Midwest	13%	*n* = 6
Rocky Mountain	4%	*n* = 2
Sample Totals	100.0%	*n* = 47

4.1 Organizational goals

In Table 2, we categorize the sociopolitical goals—main issue areas—of the (n = 47) EJOs. These are listed in descending order of count, i.e., if mentioned by an interviewee. These categories seemed to appropriately cluster and signify the EJO’s main issue areas (as scripted by our respondents). The issues listed in parentheses more specifically represent the responses from our respondents themselves. This is the same format for all the following tables below. As seen, the sociopolitical goals in Table 2 run a range of issues from environmental, climate, and social justice to community building and political engagement. Notably, some goals overlap with some of the others and EJOs often have multiple goals, which is why the total count of goals is larger than the number of EJOs themselves.

Table 2
Sociopolitical Goals (n = 47)

Sociopolitical Goals	Count
Environmental and Climate Justice (e.g., combatting fracking, cleanup and restoration, clean energy)	23
Community Building (e.g., providing practical resources and services to our communities)	20
Political Engagement (e.g., lobbying, encouraging votership, policy making)	14
Organizing (e.g., establishing organizational presence, membership, local and national engagement)	12
Social Justice (e.g., reproductive justice, accessible food, immigration justice, workers' rights)	11
Education (e.g., environmental and climate science, watershed education, presentations on climate change)	10
Research (e.g., shale gas monitoring, particulate pollution health impacts, annual polling)	9
Total	99

When analyzing the goals of these EJOs, we identified a difference between an end-goal and a means to that end, and sometimes an overlap between the two. For instance, many talked about education as a goal, but it was also a means toward a greater goal like raising the consciousness of their community stakeholders. Consequently, we coded items like ends and means as goals if respondents did mention them as such.

We also note that a majority of goals were not related to the more traditional understandings of engineering and science, but more toward issues like community development, political engagement, and community organizing. These types of goals, then, might be a better fit for community organizers, educators, lawyers, lobbyists, fundraisers or some other form of resource-based support.

4.2 Engineering and scientific challenges

Table 3 and Table 4 depict our categorizations of the engineering and scientific challenges identified by our respondents. In a more topical categorization (Table 3), our respondents said that their engineering and scientific challenges were primarily in the areas of community development, food and agriculture, public and environmental health, clean and just energy transitions and others. In Table 4, we recategorize the same set of engineering and scientific challenges with a focus on the methods and activities to address these challenges, which are useful independent of topical matter. As seen, these can include activities like data collection, online platform building, data dissemination, data analysis and mapping. These types of activities can be helpful to organizations independent of whether the data, for instance, is related to air or water testing, or climate change or land use issues.

Table 3
Topical categorization of respondent identified engineering and scientific challenges (n = 47).

Topical Areas	Count
Community Development (e.g., economic development, education, engagement)	40
Food and Agriculture (e.g., access to healthy foods, hemp farming support, agricultural contamination)	37
Public and Environmental Health (e.g., environmental justice dashboards for cities, health impacts, lead testing)	34
Clean and Just Energy Transitions (e.g., energy burden, microgrids, and energy storage)	32
Climate Change: Adaptation and Resilience (e.g., emergency preparedness, heat resilience, natural disaster risk)	32
Computer Science and Programming (e.g., user conscious interface, apps for data collection, online platform building)	28
Water Quality (e.g., coal ash contamination, resource use)	27
Air Quality (e.g., greenhouse gas emissions, fugitive emissions, air monitoring)	26
Urban Planning and Infrastructure (e.g., brownfield redevelopment, traffic engineering, stormwater management)	22
Land and Soil Quality (e.g., site cleanups, soil testing, landfill impact analysis)	15
Environmental Sciences (e.g., ecology, marine science, bioremediation)	12
Fossil Fuel Infrastructure (e.g., clean-up of mining, mountaintop removal, superfund sites)	9
Environmental Restoration (e.g., reforestation, coral restoration, coastal plant restoration)	6
Waste Management (e.g., recycling, waste auditing, zero waste)	4
Other Topical Areas (e.g., Indigenous issues, advocacy, and lobbying)	37

Table 4
Engineering and scientific challenges categorized by generalized methods of work and activity (n = 47).

Methods and Activities	**Count**
Data Collection (e.g., collecting evidence, quantitative data collection, qualitative data collection)	37
Online Platform Building (e.g., building online data portals, website, and developing user interfaces)	25
Data Dissemination (e.g., sharing data, publishing data, making data publicly accessible)	25
Data Analysis (e.g., assessment tools, data interpretation, sample analysis)	23
Mapping (e.g., fracking, zoning changes, air quality)	22
Research formulation and framing (e.g., creating a study, participatory action research, distilling literature)	21
Complexity Analysis (e.g., intersectional energy burdens, disproportionate impacts,)	18
Causation and correlation analysis (e.g., understanding evidence, use of independent labs and researchers, uncovering root causes)	12
Data Management (e.g., running a database, management tools, accessible data)	10
Mobile Application Development (e.g., web-based air monitoring, community resources, citizen engagement)	8
Expert Witness Testimony (e.g., expert evidence, expert support in court, expert endorsement)	8
Social Scientific Analysis (e.g., related to poverty and environmental justice, religion and environmental justice, race, and health outcomes)	6
Technical Needs Evaluation (e.g., evaluating unknown impacts, proactive testing, needs analysis)	4

Although the categorization of goals and challenges confronting an EJO is helpful to identify potential areas of collaboration or undone science, such categorization—as a sorting process—comes with the shortcomings of “forcing” issues into categories of which they may not “perfectly” fit, and may thus offer too simplistic a view of an issue and especially the multidimensionality of an issue area. We illustrate this dynamic with two quotes:

First, the Director of Capacity Building at a mid-sized, Northeast non-profit describes how history, air-and-water quality issues, land uses, GIS mapping, health, and a shortage of human capacities intersect with each other.

GIS is a really critical thing to really demonstrate,. .. even historical injustice, if you overlay maps of redlining for housing and capital and financing. Those are the same exact neighborhoods that are experiencing the concentration of brownfield issues, lack of wealth, high concentrations of poverty, high concentrations of preventable health issues related to air quality, water, quality exposure to environmental contaminants, things like that. So, the GIS capacity is tremendous. And cities just vary in their capacity to do GIS. Some have a department. Some have one guy or one woman.

In this next quote, the Community Education and Outreach Coordinator from a Midwest, community coalition relates how another collection of issues and challenges intersect in their city.

I think related to the air monitoring over the last twenty years,. .. the community has requested more air monitors in a variety of situations. .. Not only air quality but noise and road quality and dirty land, all of that environmental agenda. .. we lead the state. .. We’re the epicenter of childhood asthma in the state. .. Pollution causes diabetes and other issues. Black women are losing babies at a rate of a Third World country here in the city. .. They did a report about a year and a half ago and parsed-out different industries or facilities and their impact.. .. But the impact analysis from the data and from both pollution data and health data, the impact,. .. is equivalent to $1.2 million in health effects per year.

In these two excerpts, these respondents script examples of multidimensional challenges—beyond a traditional or simple understanding of an engineering or scientific issue—and these excerpts also show how their qualitative categorization is itself a challenge.

4.3 Experiences with engineers and scientists

In this section, we review three inductively identified themes and 13 categories regarding our respondent’s narrated experiences with engineers and scientists. This section is outlined in Table 5 where we have also included the count that these categories occur in the (n = 47) interviews.

Table 5
Descriptive frequency data for coded categories from interviews.

Categories	*Sample Count*
1. *Advantages of working with engineers and scientists*	*n* = 47
a. Experts share technical resources and information	*n* = 44
b. Social networking	*n* = 28
c. Engineers and scientists strengthen the validity of data	*n* = 15
2. *Challenges of working with engineers and scientists*	*n* = 47
a. Need to pay for services/funding issues	*n* = 42
b. Time challenges and scheduling issues	*n* = 35
c. Cultural bias	
d. Science communication	*n* = 33
e. Restrictions on politically charged language/ideology and salience of scientific evidence	*n* = 16
3. *Better practices for collaboration with EJOs*	*n* = 42
a. Mindful of local contexts; start where people are	*n* = 30
b. A built relationship, community rapport, trust, commitment, dialogue and feedback	*n* = 29
c. Moving beyond technical solutions	*n* = 23
d. Identifying low-cost accessible solutions	*n* = 7
e. Unconscious bias training	*n* = 5
Sample Total	*n* = 47

4.3.1 Advantages of working with engineers and scientists

Experts share technical resources and information. There were many times that respondents recounted the advantages of working with engineers and scientists; this theme was present in all of our interviews. We have parsed this theme into three main categories. The most salient of these categories is the way engineers and scientists (or particular sorts of experts) are seen as a source of information and technical resources. This can include insights on an issue or policy; providing scarce skills, tools, and best practices; community mentoring and the training of citizen scientists; information on possible funding and grant opportunities; causation analyses; and being an expert witness in court. Some of these types of resources can be identified in the quotes we have provided below.

For instance, the Chief Venture Officer of a large, Northeast non-profit explained some of their relations with area universities and institutes by saying, “We definitely have experts in the field that have given us white papers, have even come to present [to us], and we know [the] recommendations of what needs to happen.” In a longer quote, an organizer of a large, Northeast non-profit recounts the importance of a soil expert and even the right testing equipment to educate city residents living in contaminated areas. There is also mention of supporting a community in “figuring out how they go through their own fight.”

different agencies who do soil testing for folks,. .. [we] hosted some of those. .. so people can get their soil tested. .. Super important, especially in cities, older cities; there's a lot of land contamination that. .. [people] won't understand what that means,. .. ‘How much contamination is level for concern? What kind of crops you can still grow if you have contaminated soil? And what precautions you need to take?’ Those types of experts,. .. we've had [them] here in order to support our community in figuring out how they go through their own fight.

Regarding the desire for mentoring, another respondent, the Program Director of a small, Midwest non-profit said, “Well, what I would say is, if we got this grant or something like it, if we could link up college students as mentors with scientists, wouldn't that be fabulous?” Still, another interviewee, a Staff Attorney at a small, Pacific non-profit, described their challenges to “find people,” but also the benefits of an “expert witness.” They explained, “There hasn't been a way that I'm able to find people, but having expert witnesses who can testify at trial is really important for what we're trying to do in a variety of fields.” What can be seen in a few short quotes—and there were others—is the way an engineer, scientist, or particular expert can provide invaluable information, resources, and even opportunities for an EJO.

Social networking. Related to the *sharing information* category is the value of social networks and networking. For example, finding the right people and/or partnering with others is helpful for gaining more information, resources, mentors, or an expert witness. There are two ways that social networks were utilized by EJOs: (i) connecting with a new E&S through an existing network and (ii) expanding one’s networks through an E&S contact. In this excerpt, after asking an HR and Finance Specialist at an large, Northeast non-profit how they found a particular expert, they mentioned their own networks:

Through networks. .. we reach out to them because. .. that was a need. Last summer,. .. there was a news article about the neighborhood that our main site is located in; it was talking about lead contamination and it was sort of clear that. .. we didn't have a lot of information. The article just like promoted fear.

[Laughs] So for us, that was like, okay, we need to have these experts come in here and be our resource for the community so they know more.

This excerpt also emphasizes the importance of obtaining needed information and especially regarding lead contamination so community members can "know more."

As mentioned, E&Ss are not only helpful in themselves, but may also have connections to other connections and possibly helpful people. As something of a network of networks, this point is emphasized in a quote from a Director of a mid-sized, Northeast non-profit:

we're plugged in with the association, American Society of Adaptation Professionals.. .. They run the National Adaptation Forum, which is a bi-annual conference, and other networks that were involved with the Army Corps of Engineers run something called Silver Jacket Network, which tries to bridge multiple federal agencies, state agencies and local stakeholders.

We note that social networking is often related to the limited human resources of an EJO and their consequent desires for assistance. Networks can also reflect desires to create partners from the more local to the national level. Finally, some EJOs shared that they do not know how to find or work with E&Ss and this lack of access is related to cultural bias, a category that we discuss below.

Engineers and scientists strengthen the validity of data. Respondents mentioned that E&Ss have a capacity to strengthen the validity of data just by their vetting or their being present in representing it. This can be framed as a type of symbolic or cultural capital. (Expert witnesses, as already mentioned above, can also be framed as symbolic capital). For instance, in what might be called habitat biology, an Executive Director of a large, Northeast non-profit asserted that:

telling a story that building a green roof is going to create habitat for bats and pollinators and birds is a good story, but having a biologist out measuring it and quantifying it pushes that work to a whole new level.

Here, then, it is seen how a biologist can take "a story" to a place that a non-biologist cannot. There is, however, something of a double-edged sword to this validating capacity. For instance, some respondents mentioned how experts can represent the companies they are fighting against and how this representation can help to validate certain environmental injustices, which is seen in the following quote by a volunteer at a mid-sized, Midwest non-profit:

there's a professor at [the local university] who is heading up the committee to push the petrochemical crap [here] and [the community is] not very fond [of the professor as they] actually got $100,000 grant to study the economic development issues, how wonderful this is going to be. .. . [And there's another nearby college with] an oil and gas program and engineering program. One of the few in the country. So, they're definitely pro oil and gas. It's hard to get people that work in environmental departments that are willing to come out and be quoted or even go on the record as being anti-oil and gas—when you work for a university, it could mean your job.

The issue of professional risk is also subtly mentioned by this respondent and this is related to another category below: the challenges related to politically charged language and issues.

4.3.2 Challenges of working with engineers and scientists.

Need to pay for services/funding issues. There were a number of challenges that our respondents cited in working with E&Ss with the greatest being related to funding and the need to pay for an E&S's services. This was an extremely salient code—in nearly all the interviews—and was often scripted as critical to daily operations. Related to this, an Executive Director at a mid-sized, Southeast non-profit emphasized payments and the quality of an expert's services rendered. They said,

most experts need to make a living and so the projects that they naturally turn to are the ones that can pay them at least a minimal amount. So, the problem is, free experts, you tend to get what you pay for.

In other words, if an EJO is unable to pay an adequate amount, they may not get the quality of work or expertise they want. There is the implication that certain experts cannot be afforded. Adding to this, some respondents said there was unequal treatment in the way larger payments from a particular grant, for instance, were given to academics rather than to an EJO.

Time challenges and scheduling issues. Challenges with time were very salient issues for our respondents. Challenges with time were framed in three different ways: (1) the understanding that community-oriented E&Ss were in high demand and, thus, access to them was a challenge and, even then, they might only be available for short-term visits/projects (e.g., one academic semester). (2) EJOs themselves were challenged with time and their own issues of limited access and availability. EJO members also had jobs and families, and limited human resources. (3) Respondents also mentioned that working with E&Ss was itself time consuming. Each of these time issues can be discerned in the two quotes below from two different respondents: an Organizer from a mid-sized, Northeast non-profit said,

it's tough because the academic world and technical partners are working the nine-to-five, Monday through Friday, and residents and the people that we want to be included and seated at the table have their day job.

Another respondent—the Founder of a Southeast, community group—detailed some group and personal challenges saying, "The problem for me is that I don't have [time]; I'm only one person. So being one person and trying to do all that, it's just a bit messy".

Cultural bias. The category of cultural bias is complex and has great breadth. For instance, it includes the way E&Ss might speak or behave inappropriately for a collaboration, how their narrow views can cause frustration for others, and how they might excessively rely on a particular skill while being ignorant of other issues, e.g., policy implications, gender and race dynamics, and how to be a team-member. E&Ss can also lack awareness of issues in the local context and how communities and community members are experts in their own experience. E&Ss have also been known to disrespectfully extract data and information from communities without reporting back on their findings. For some of our respondents, such behaviors could terminate relations with an engineer or scientist. In short, the lack of broader cultural understandings and behaviors on behalf of some E&Ss is problematic for EJOs. Many of these issues are highlighted in a longer quote by the Executive Director of a Midwest, mid-sized non-profit:

we've got a couple of engineers on our team to help us select our [solar] installer and all they care about is the engineering. They're. .. not very adept at understanding the equity implications and, can I say, been ignoring the implications.. .. They just seem to have a one-track mind in a way that's super frustrating.. .. [Moreover,] what we need them to do is literally be trained on how not to be a mansplainer. I'm dead serious.. .. They need hours. .. of training about how to sit with young people and share their knowledge without dominating.. .. then you need to have unconscious bias training. .. Engineers are good at following instructions, right? So, if they can have a set of guidelines about how to behave, it would be just fantastic.. .. I don't know. Teaching white male engineers, I'm thinking about my father. .. an environmental lawyer, I can only spend so many hours, so many minutes with him before he has just lodged into his ‘go on telling me how the world works’ and I'm just like,. .. allergic to it.

Science communication. Related to cultural bias is the issue of science communication. These are the challenges that an E&Ss may have in communicating what might be highly-technical ideas in a language that is accessible to mixed audiences, or as an Executive Director of a mid-sized, Southeast non-profit said, “getting experts who are able to explain things to regular people.” This challenge is alluded to in this quote about community solar from a Government Affairs Coordinator at a large, Northeast non-profit:

You're not gonna find a lot of people who don't like community solar. But there's a lot of people who don't know how it's possible. I feel like an engineer would make a big difference in this. Like an engineer who knew how to communicate.

Another respondent (an Organizer at a small, Northeast non-profit) suggested that simply sharing information is not enough. In other words, giving information in forms of articles produced by an E&S can be inaccessible to a lay audience and better means of interpretation/communication are needed.

Typically, we link to a lot of articles. .. [to] our website. So, I don't know. .. how much people read that sort of thing, because actually,. .. At this point now,. .. there's almost too much information.. .. I gotta be honest,. .. I don't always get to read everything.. .. I'm reading like a blurb in the first paragraph or two and then moving on.

Restrictions on politically charged language and acquiescence to more technical interpretations. This category relates to the use of terms like “climate change” that may be politically sensitive or charged depending on the context (like states in the US that ban climate change considerations for planning purposes). In such instances, an engineer or scientist (or EJO member) may acquiesce toward a less charged interpretation of an issue. In two quotes, respondents allude to these dynamics: first a Policy and Advocacy Manager at a Northeast, small Non-profit said,

Experts at the state level know the issue and know that action needs to be taken, but they cannot talk about it publicly and they cannot use ‘climate change.’ So how do you as a local health department leader, someone who probably understands more and is more in touch with the inequities in the county, the more local level, and understands access to resources, how do you provide what your constituents need when you have no support from the state?

Relatedly, an Executive Director at a Southeast, mid-sized non-profit mentioned how they would like to see more experts “who are independent and who are willing to sort of just challenge the predominant paradigm.”

4.3.3 Better practices for collaborations with environmental justice organizations

Mindful of local contexts; start where people are. Respondents sometimes alluded to ideas, either explicitly or implicitly, for improving the ways an E&S might collaborate with an organization. The most prominent of these was to be more mindful of local contexts and cultures—as a Manager at a Northeast, small Non-profit asserted, “just meet people where they are.” Respondents, then, emphasized the importance of E&Ss first understanding local efforts, what had been done, and supporting those efforts. This requires spending more time with a community. E&Ss should also realize that there are many resources, networks, and assets already present in a community. One respondent—an Executive Director at a small, Midwest, non-profit—simply mentioned that, “the most effective way for Indiana communities to be inspired is to find out what other Indiana communities are doing” and, at a deeper level of community-mindedness, a Program Director at a mid-sized, Northeast non-profit said,

We sometimes make explicit decisions not to work with certain experts,. .. they really do want to be helpful, but it's always, their perspective is, ‘Hey, let's go work with locals and show them all the great things that we can help to do and all the tools that we can bring,’ and they don't take the time to listen to what it is needed. .. or how tools can function better.

This next respondent, the Executive Director of a Northeast, mid-sized non-profit, mentions how communities historically marginalized by “power entities” are not used to thinking for themselves.

So, the beginning part of that work is just having the conversations with the community and asking them what they want. That's actually a very taboo thing in the communities that we work in like culturally and historically, the operator or outside power entities have always had the control and no one has actually ever really asked the communities what they want. .. And so, that process in itself can be kind of hard for people to even like vision or think that they have the ability to get something other than what the coal industry wants or the gas industry wants.

A built relationship, community rapport, trust, commitment, dialogue and feedback. Notably, EJOs are particularly mindful about their relationships: they need to be reciprocal, maintained, trusting and therefore functioning. Said relationships may also be important for support around politically charged issues. An

Executive Director of a Southeast, small non-profit simply said,

we have cultivated really good working relationships with our regulatory agents. .. it's not just about doing one little project and then leaving, it's about maintaining that relationship and educating, I guess, in some way, right?

This process also requires commitment, dialogue and community feedback. Another Executive Director at a small Southeast non-profit decided to give us advice when we explained what this research was about:

I think building the trust is really going to be number one for you all, because there are networks that are already formed, and there are technical experts that are already helping communities. And. .. that was. .. building trust over many years.

Relationships and partnering are also helpful to EJO operations and possibly efficiency, as this respondent, a Project Director of a community group in the Pacific explains,

Our work is really centered around partnerships with other organizations. We depend a lot on other organizations to help us do outreach, help us facilitate training, help us continue to build relationships, that is how we became a cooperative.

Moving beyond technical solutions. This category encompasses the ways it would be helpful if an E&S knew more than just the technical dimensions of an issue. For example, like how a problem may also relate to socioeconomic issues or other inequities. In turn, here is an opportunity to learn about a diverse set of topics that marginalized communities mind find helpful in tackling any environmental issues. Thus, greater understandings of community dynamics are required, including cultural humility and the realities of marginalized communities. It is preferable, then, that experts seeking to collaborate with communities should have training in community capacity building, i.e., local-empowerment, while also seeking to find ways to compensate community members who give their time and energy for collaboration. One respondent—the Executive Director at a mid-sized, Midwest non-profit—mentioned that, "our general approach [is to] lead with the equity, community-oriented goals rather than engineering and science" and another said,

I feel like when scientists or the technologists or engineers work on a problem, what they sometimes fail to see is that it's not just a technical problem, it's actually a socioeconomic problem. . .

Still, another Executive Director at a mid-sized, Northeast non-profit spoke about building political power in the community. . .

Our laws aren't strong enough to begin with, and so just having the right test results or hiring the right expert, or giving the testimony that they need, that's not what's going to solve the problem for them; it's really going to be about building that political power and running an effective grassroots campaign.

Some respondents emphasized the need for greater personal care and understanding of the needs of individual community members: proper care and even social niceties as a means of reciprocity and compensation. For example, an Executive Director at a mid-sized, Southeast non-profit articulated, ". .. we have to buy everyone dinner and we have to provide childcare and we have to provide transportation, otherwise, we haven't done our jobs scoping out the project." Another respondent—the Director of Capacity Building of a Northeast, mid-sized Non-profit—emphasized that such an approach could foster inclusivity and get more "folks to participate in a co-design process."

Finally, regarding successful community engagement, an Executive Director of a small, Pacific, non-profit emphasized capacity building:

a lot of times you can do a really great job of connecting communities with needs to their technical service providers, but if we don't simultaneously build the capacity of the communities to actually engage with the technical specialists, the process will fall flat.

Identifying low-cost and accessible solutions. Respondents mentioned their desires for more community appropriate solutions with reference to both cost and applicability. In short, how beneficial it would be to have an inexpensive and readily available solution. Like an inexpensive smartphone application for data collection. Relatedly, offering an expensive option that is not affordable might frustrate a community's incentives. E&Ss could also spend more time exploring and creating options with communities. It is also important for E&S to remain accessible for possible consultations with communities. Notably, there may be a tension between scalability, cost, and simplicity of solutions. One respondent, the Executive Director of a mid-sized, Midwest non-profit recounted a particularly negative experience with consultants. . .

They got data trained engineering type people nationally and. .. would fly the experts in to have a workshop on this building or something like that. They would come in for like two days, they would like demonize every aspect of a building in conjunction with the local people and then they would wing off. It was just super not successful because I don't. .. have the money to fix it.. .. if I can say anything in this entire interview, it's setting people up with technological solutions that they can't pay for is like harmful, it's not helpful

Another respondent—the Deputy Director of a Rocky Mountain, mid-sized non-profit— mentioned practicality and emphasized "lighter, quicker, cheaper":

at a certain point you get these like really grandiose visions that 'yeah, that would be terrific,' but like, it's not gonna happen if it's this or nothing. So, trying to get that more practical sense of lighter, quicker, cheaper, but still safe and still at least have some environmental benefits that can help mitigate some of the environmental issues that we have in the city. . .

This respondent, the Executive Director of a Southeast, small non-profit mentions former developments and also desires for more with regards to air monitoring:

we use low-cost air monitors, and we, with the help of a previous grant, we were able to develop an online mapping tool. .. With that, we store all our research data on that platform. We need to add more functionality to that tool. We would like to develop a mobile app that links to that tool to be push-alert systems for the community.

Unconscious bias training. Respondents also mentioned that trainings to counteract skewed power dynamics or inoculate the cultural biases of E&Ss are appropriate and could be helpful. Like trainings in gender, racial, and social justice, structural and systemic dynamics, and an overall cultural humility. The Executive Director of Midwest, mid-sized non-profit spoke of becoming more culturally successful through an unconscious bias training:

I'm excited about this unconscious bias training because in this case, it's like, you know what, racist or not, all of us are racists, the world sucks, you've got a bad task, yup, we agree about that. Now, here's some actual tools that you can employ in the workplace that are just gonna make you more culturally confident and successful.

Discussion

In reviewing our results, we primarily draw attention to two broad findings: (i) the myriad ways E&Ss can engage with EJOs in addressing environmental, climate, and energy justice challenges and (ii) the cultural challenge of learning to interact with EJOs and their members. We discuss the first and then the latter.

When considering the breadth of our sample's goals—e.g., justice, community building, and organizational goals (Table 2)—and engineering and scientific challenges from topical to methodological (Table 3 and Table 4), we find that our results both *affirm* and *expand* the existing literature. Mostly, we *affirm* the literature through the *content* of our findings and *expand* it through the *form* of our findings. For example, we affirm the literature in the way we also find that EJOs in the USA work on issues related to: energy, climate, water, and land uses (Njue et al. 2019; EWB-USA 2020a; Scheidel et al. 2020); environmental impacts and monitoring (Conrad and Hilchey 2011); conservation and GIS mapping (Kullenberg and Kasperowski 2016); data management (Sharpe and Conrad 2006; Newman et al. 2011); while they are challenged in the areas of funding, communications (Sharpe and Conrad 2006; Buckland-Nicks et al. 2016) and educating their communities (Bonney et al. 2009). Furthermore, we affirm the literature with the findings that E&Ss are busy and difficult to access (Pivik and Goelman 2011; Boucher et al. 2020); that trusting/communicative relations with them are important (Pivik and Goelman 2011; Lesen et al. 2019); that E&Ss could do a better job at meeting communities where they are, while also being careful of power dynamics (Lesen et al. 2019); additionally, an E&Ss commitment to a community and regularity in relations is also important (Pivik and Goelman 2011).

Regarding our *expansion* of the literature in the *form* of our findings, we see this in the order and different categorizations of the particular issues mentioned by EJO representatives: their organizational goals and engineering and scientific challenges. We also expand the literature by outlining particular EJO experiences with engineers and scientists, in particular the advantages and challenges of working with E&Ss, and better practices for collaboration. In short, there appears to be an overwhelming assemblage of opportunities or areas of undone science where E&Ss can interact, engage, and hopefully create relationships with EJOs. Such relations may further illuminate the engineering and scientific bases for EJ challenges, and how E&Ss might help address said challenges and participate in building a more just community future.

There is something of a tension in our findings, though, in the way EJOs can receive much information and insights—and even symbolic capital—from working with E&Ss while also express frustration with an E&S's multidimensional cultural biases and their challenges with seeing beyond technical solutions. We have identified better practices for engineering, scientific, and EJO collaborations, but this cultural issue does seem to be a particularly tenacious. For instance, there might be something of a subtractive learning process (Valenzuela 1999) that needs to be addressed—in the way acquiring one skill might detract from another. There is some evidence that a STEM degree itself—through the educational process—can diminish one's community concerns (Cech 2014; Canney and Bielefeldt 2015; Boucher et al. 2020). This is perhaps an area for further research: in-depth interviews with those E&Ss who are "multiculturally-skilled," both in their engineering and scientific disciplines and EJO collaborations.

A cultural lens (and a field of collaboration?). It appears, then, that a cultural framework may be illustrative regarding our findings, particularly a recent Bourdieusian conceptualization of a "field of collaboration" between engineers, scientists, and community groups (Boucher et al. 2020). We do affirm that there is some grounding for this in the ways EJOs are calling for trainings of E&Ss in what might be termed a collaboration culture, which also draws attention to a suspected cultural mismatch (Bourdieu 2007) between E&Ss and EJOs. (Mismatch is the way one's strengths in one field are less applicable to another field.) However, considering the salience of social networking for our respondents—something that is not present in Boucher et al.'s (2020) study—and its seeming connection to a lack of time and funds, it seems that EJOs are embedded in a more collaborative culture than engineers and scientists. Consequently, we suggest that the "field of collaboration" comprises the whole field of EJOs and that all those comprising this field may be practicing a culture of collaboration—but this needs further research. Mandell (1999, p. 43) reviews and expresses this succinctly by identifying community "network structures" and asserting that many communities "must organize in a unique way that allows them to try to solve . . . [complex] problems on equal terms with the public, non-profit and private sectors." Thus, these network structures are the outcomes of management styles that are different from "more typical bureaucratic efforts" (Mandell 1999, p. 43). Seemingly fitting to our study, Mandell (1999) adds further complexity to a cultural mismatch between E&Ss and EJOs while aligning with theory on the exchange of capitals: where declines in one form of capital like funding can prompt a dependence on others like social networks (Bourdieu 1986). We also note that for Boucher et al. (2020), social networks—or social capital—are not salient in their study, but, somewhat inversely, they do identify a "collaboration burden" expressed by some E&Ss who cited the demands of collaboration as a barrier to working with community groups.

Additionally, and seemingly related to the cultural and networking character of collaboration, there are issues of funding and time, and this is for both our interviewed EJOs and E&Ss (Boucher et al. 2020). This suggests that, in the present contexts, a field of collaboration would be populated by people that are all short on time and money; and such a circumstance may not bode well for an aspiring field. To their credit, though, Boucher et al. (2020) call for greater research on said field while asking what might be its valued currencies. They suggest that this field may be something of an anomaly from more customary conceptualizations of fields that identify highly operative economic, cultural, and social capitals (Bourdieu 1984). Within this context, the plea for lower cost engineering and scientific interventions by several EJOs bears understanding: engineering and scientific work is expensive, which may be exacerbated when embedded in the historical legacies of environmental injustice. Moreover, it may be the lack of appropriate investments that created environmental injustices in the first place. While a desire for low-cost interventions is reasonable, we question how legacies of injustice can be addressed in a low-cost manner.

Like Mandell (1999), we should also draw attention to the profit/non-profit dichotomy of many EJOs versus E&Ss. EJOs seem to collaborate as part of their daily struggle against environmental injustices, whereas most E&Ss are apparently captured in a for-profit marketplace (Mirowski 2011; Lave 2012) or within academic power structures, and at an extreme may be contributing to environmental injustices. Collaboration with an EJO, then, would constitute something of a not-for-profit-shift for an E&S whereas it would be—aside from the specific interaction with the E&S and possibly a fee-for-service—a continued part of a collaborative and networked style of daily interaction an EJO.

Finally, our findings suggest that though E&Ss can be extremely helpful to EJOs in the US, many EJO challenges seem to require a broad, multi-skilled team. Such a team might include experts in engineering and science related to environmental, energy, and climate justice, but also a broader array of experts like community organizers and developers, communications and educational professionals, information and data specialists, lawyers, political lobbyists, and more.

Future research and recommendations

The EJOs we examine in this study all have seemingly laudable goals, but also extensive engineering and scientific challenges that may well be in the area of undone science (Frickel et al. 2010; Hess 2010). How might tackling these undone areas be accomplished and, moreover, funded? Additionally, there appears to be a tension between an EJO's desire to build long-term relationships and the immediacy of an array of environmental injustices. Consequently, how might collaborative relationships between EJOs, engineers and scientists be built in ways that can accelerate EJO goals? Additionally, might there be new forms of augmenting community participatory efforts (Morales-Guerrero and Karwat 2020) to enhance community collaborations? Given that multiple injustices may intersect in areas deemed "scientifically undone," we feel that new levels of criticality are due by engineers, scientists, and researchers alike. How might this be achieved?

Regarding EJOs and this study, future research could explore the creation of a more precise questionnaire—taken from our findings—in order to survey a larger national or international field. With such data, a number of different statistical analyses could be conducted. For instance, a test for associations between organization size and engineering and scientific needs. Additionally, as some of our respondents were at a loss to find engineers and scientists, perhaps an internet-based matching or sharing platform could be developed.

Conclusion

After exploring the engineering and scientific challenges of (n = 47) EJOs in the US, we contribute to the literature by further identifying the character of EJO goals and engineering and scientific challenges. We also acknowledge and broadened the complexity of EJO experiences with E&Ss and their collaborations. EJOs and E&Ss have multiple barriers to collaboration, the greatest possibly being cultural differences. Such a finding calls for an amelioration of differences if any long-term collaborations can be expected. This can include a range of recommendations from directly turning the EJO field into a more financially viable space or greater cultural shifting for E&Ss. In sum, we find that better practices for E&S collaborations with EJOs in a field of collaboration include: a greater mindfulness of local contexts; building relational rapport and trust; a moving beyond narrow technical solutions; identifying low-cost accessible solutions; and, finally, unconscious bias training.

Declarations

Acknowledgements

We would like to thank all of those who participated in our interviews, and we want to especially acknowledge the legacy of two people related to this research, fighting for environmental justice, who have died due to complications with cancer. We express our appreciation and thanks to our publication reviewers for their support and guidance.

Ethical Approval.

Due to minimal risk to our participants, this study was deemed "exempt" from ethical review.

Consent to Participate

All participants freely gave their informed consent to participate in this study.

Consent to publish

All participants freely gave their consent to have any of their comments published.

Authors Contributions

1. L. Boucher - Conceptualization, Investigation, Methodology, Software, Validation, Resources, Data Curation, Formal Analysis, Writing, Visualization, Review, Editing, Supervision.
2. M. Levenda - Conceptualization, Investigation, Methodology, Validation, Data Curation, Formal Analysis, Writing, Review, Supervision.
3. Morales-Guerrero - Conceptualization, Methodology, Software, Validation, Data Curation, Formal Analysis, Resources, Writing, Visualization, Review.
4. M. Macias - Conceptualization, Methodology, Software, Validation, Resources, Data Curation, Formal Analysis, Writing, Visualization.
5. M. A. Karwat - Conceptualization, Methodology, Formal Analysis, Resources, Writing, Review, Editing, Supervision, Project administration, Funding acquisition.

Funding

Part of this research was conducted with the support of NSF Award 2016108.

Competing Interests

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Availability of data and materials

Due to the confidential nature of this study, data is only available by special request to the corresponding author.

Appendix

Semi-structured Interview Questions

1. What are the main issue areas your group focuses on? (For example: air pollution, community health, energy transitions, poverty)

2. What approaches or strategies does your group use to address the issue areas you focus on? (For example: direct action, policy advocacy, etc.)

3. If your group works with other groups, who are they?

4. What are some of your group's main goals with regard to (one of their focuses)?

5. What are some of the main barriers to achieving these goals? Have you faced barriers in getting assistance with technical challenges?

6. Does your group use technical tools in its work? if yes, can you tell me about them?

7. Does your group interact with technical experts?

   a. Who are these experts?
   b. How did you connect with [expert descriptor]?
   c. How does [expert descriptor] help your group?
   d. What challenges do you have interacting with experts?

8. Do you have any current problems/challenges that you think could be solved by having access to a scientist, engineer or other technical expert?
9. Over the next two or three years, what scientific or technical things could help you in your work?

10. How do your needs overlap with the needs of other groups?

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Figures

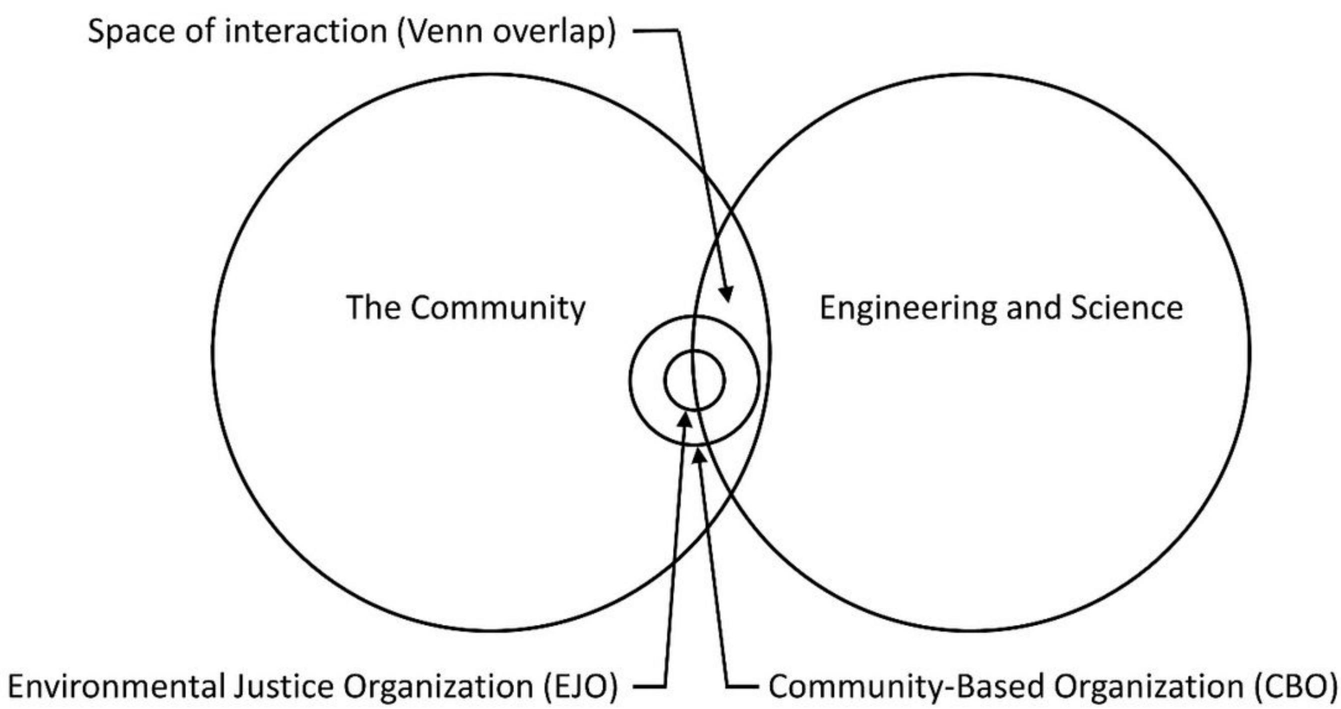

Figure 1

Defining key terms and interactions: environmental justice organizations, the community, and engineering and science.

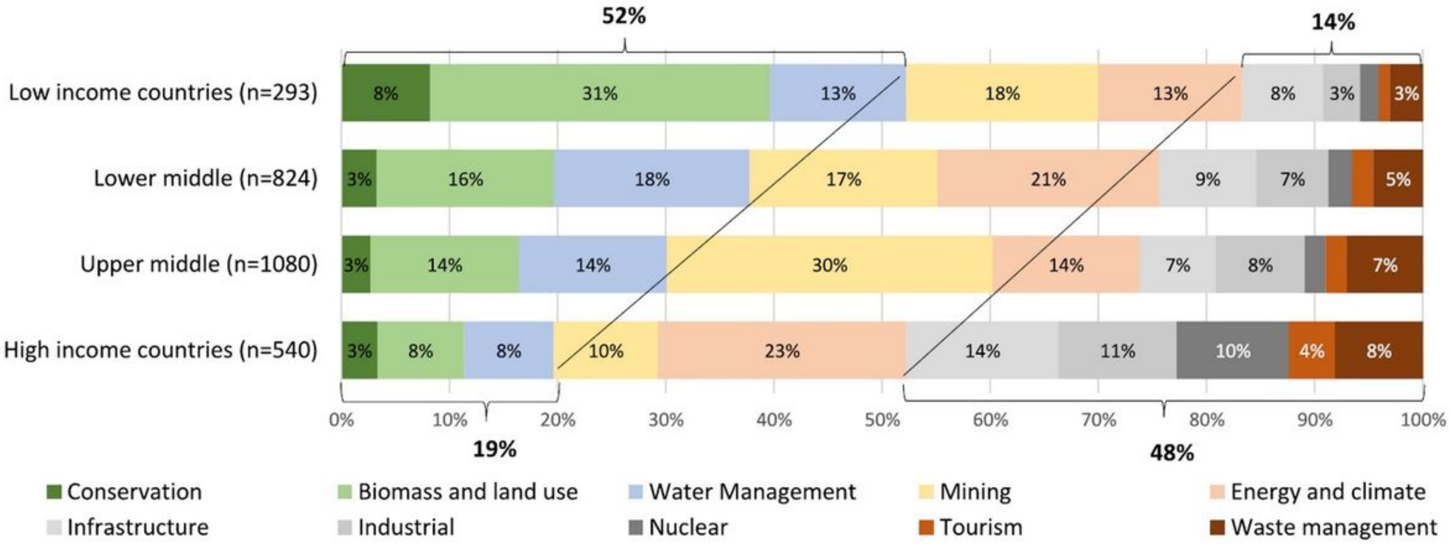

Figure 2

Occurrence of types of environmental conflicts across world income regions (n = 2737). Source: Scheidel et al. (2020, p. 7); used with permission.