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Authors
Hobbs, Shakira R
Ivey, Cesunica
Patterson, Regan
et al.

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Innovation in Environmental Engineering for Community-Engaged Research

Shakira R. Hobbs [1], Cesunica Ivey [2], Regan Patterson [3], Jessica R. Ray [4], Jacelyn Rice-Boayue [5]

[1] Assistant Professor, Civil & Environmental Engineering, University of California, Irvine
[2] Associate Professor, Civil & Environmental Engineering, University of California, Berkeley
[3] Assistant Professor, Civil & Environmental Engineering, University of California, Los Angeles
[4] Assistant Professor, Civil & Environmental Engineering, University of Washington
[5] Assistant Professor, Civil & Environmental Engineering, North Carolina State University

Introduction

In this editorial, we synthesize and elevate key findings from our special issue, "Focus on Innovations in Environmental Engineering for Community-Engaged Research." This collection of articles is particularly timely, given the crises that demand local knowledge and community participation; persistent environmental inequities and mistrust; the limitations of conventional research approaches in environmental engineering; and the increasing calls for justice, accountability and economic opportunity for all. In many articles, there is a recurring theme of the distribution of power, knowledge, and resources among community members and environmental spaces. Taken together, these studies offer techniques for enhancing traditional environmental engineering, while pointing toward an emerging blueprint for change and protective policies. These authors argue that we are in a critical moment when the world must be willing to listen to communities who live in environments with tainted air, water, and land quality and invest billions of dollars to collaboratively eliminate poverty, replace substandard housing with healthy communities, and support sustainability goals to ensure the well-being of people across the world and future generations. Furthermore, these authors empirically demonstrate that communities need to be a part of the decision-making process, not merely affected by decisions made for them. When communities most affected by environmental health disparities help shape engineered solutions, policies, and investments, the result is a healthier, and safer, and more just environment for all.

Structure of Submitted Articles

Together, these articles provide a multi-scale view on how environmental burdens and benefits are distributed and governed across multiple regions and sectors globally. These case studies range from rural and urban communities in the US, rural and decentralized contexts in Belize, and disadvantaged communities across Alabama. Thematically, they address, air quality and industrial exposure [1-7]; water security and contamination [8-10]; flooding and stormwater management [11]; solid waste management [12]; STEM and water, sanitation and health (WASH) education [13-15]; and infrastructure finance and policy [10, 16]. These articles employ tools such as low-cost sensors [1] and episode detection algorithms [2], high-resolution environmental modeling and mapping, participatory geographic information system (GIS) [17], life cycle [12], policy and funding analyses in addition to community-engaged research [18]. Across these different articles and utilized methods, a consistent data-driven pattern emerges. Communities with fewer economic and political resources experience higher environmental and infrastructural risks and face greater barriers to accessing the benefits of proposed solutions.

Community, Scholars, and Co-Creators

A defining feature of many articles in this collection is the central role of communities as partners in knowledge production and problem-solving. Commonly, leaders within community-based organizations (CBOs) partner with researchers, and the leadership structure and relationships within those organizations inform and support research engagement. CBOs featured in this Focus Issue include the Newark Water Coalition [19], the Puerto Rican Agenda [3], Center for Community Action and Environmental Justice [1], American Indian Mothers, Inc. [10], Bayou City Waterkeeper [11], the National Coalition of 100 Black Women [7], and the Belize Solid Waste Management Authority [8]. In other cases, researchers worked directly with impacted community members, such as the Piney Grove Neighborhood in Winston-Salem North Carolina (U.S.) [20]. These partnerships center mutual respect and co-learning, recognizing the expertise and lived experience of community members alongside academic knowledge.

Rather than being treated solely as data sources or intervention targets, residents and CBOs often serve as co-designers, co-interpreters, and co-implementers throughout the research process. This aspect of community-engaged research is critical to ensure that findings are interpreted within their sociopolitical contexts. Sustained communication with partners across throughout all stages of a research project reduces the risk of inadvertently injecting personal biases and knowledge gaps into analyses of community-derived data. Majluf et al. (2025) suggest that the specific roles that technical and community partners play over the lifetime of the work may be adjusted depending on capacity, skillset, and goals. Ramaswami (2025) notes that community engagement benefits can be up-scaled by aggregating insights and adoption at the metropolitan government level. Collectively, these articles illustrate that when communities, scholars, and practitioners operate as co-creators, the resulting outcomes are more contextually grounded, the proposed interventions better match local priorities and constraints, and the likelihood of sustained adoption increases.

Guiding Frameworks for Justice-Centered Research

These studies bridge the gap between the theoretical concepts of justice and engineering practice by employing a range of guiding frameworks and operational approaches. Justice-centered research has often focused on identifying spatial inequities; however, the contributions in this Focus Issue demonstrate diverse approaches that move beyond diagnosis and towards action. The authors apply technical rigor to their justice-centered studies in different ways, including integrating environmental justice and cumulative impact frameworks into engineering metrics and/or employing mixed-methods approaches to incorporate social perspectives and attitudes [9, 15]. For example, Do et al. (2025) implemented a cumulative scoring system that integrates multi-pollutant exposure and socioeconomic and health vulnerability indicators to prioritize interventions. Other studies use mixed methods approaches to bridge qualitative and quantitative data. Long et al. (2025) assess water security through an ongoing community-based participatory research partnership using semi-structured interviews, while Rice-Boayue et al. (2025) pair geospatial analysis with surveys and focus group discussions to collect community and individual perspectives on the use of participatory geospatial information systems in community-level environmental justice efforts. These frameworks and approaches presented in this collection integrate equity considerations, community partnerships, and rigorous technical analyses into actionable practices and collectively provide a practical foundation for justice-centered research.

Rethinking What Counts as Success

Successful environmental interventions are strengthened by community-engaged research in which impacted community members serve as active partners in study design, data interpretation, and the dissemination of finding related to environmental risks, exposures, and remediation progress alongside with the scientific collaborators [5, 20]. Beyond re-envisioning how success is evaluated in environmental engineering, community-based participatory research can influence municipal environmental regulations and enhance protections for populations facing the highest exposures [6, 7, 10]. One authors demonstrates that meaningful success includes not only technical performance, but also building trust, increasing perceived safety, and improving affordability and access to safe drinking water [10]. Collectively, these articles in this Focus Issue demonstrate that "bench-to-people" science should be evaluated not only by engineering outcomes, but also the degree to which benefits reach those at greatest risk.

Notably, this Focus Issue highlights community-engaged research led by many early-career environmental engineering faculty, many of whom share lived experiences and culturally identify with the communities they serve, while delivering societal benefits. At the same time, we affirm the continued importance of established indicators of scholarly impact, such as citation counts, h-index, and grant volume. However, in promotion and tenure evaluation, the definition of excellence should be enriched to recognize community-engaged outcomes as complementary, core indicators of translational environmental research success. Such scholarly endeavors should be evaluated alongside traditional research metrics, rather than relegated as ancillary or "service" activities. The impact of not adopting this will only exacerbate the anti-intellectual sentiment towards science and engineering and limit academic institutions from positively impacting the world.

Obstacles on the Path to Justice

One prominent set of obstacles involves eligibility, administrative, and financial barriers embedded in infrastructure funding and regulatory systems. Several articles show that funding criteria systematically favor well-resourced jurisdictions with high administrative capacity, effectively excluding communities with the greatest environmental burdens. Requirements such as "shovel-ready" project status, common in federal programs including the Bipartisan Infrastructure Law, can exclude communities that lack the resources to maintain portfolios of pre-designed projects, limiting their access to rapid-response funding cycles [16].

Several articles also highlight the risk of unintended consequences associated with "green" interventions [3, 11, 12]. Technologies and policies framed as environmentally beneficial can introduce new environmental or social burdens if implemented without attention to local context, governance capacity, and downstream impacts. In some cases, interventions risk exacerbating exposure, shifting burdens elsewhere, or contributing to displacement in already vulnerable communities.

Trust and historical context emerge as additional cross-cutting barriers. Communities with histories of neglect, environmental racism, or regulatory failure often approach new research and infrastructure initiatives with skepticism. The collection documents how past injustices continue to shape residents' willingness to engage with monitoring and intervention efforts [10, 19]. Several articles emphasize that building and maintaining trust requires time, transparency, and continuity, needs that are often at odds with short project timelines and narrow performance metrics [6, 19]. Without meaningful engagement, monitoring efforts risk becoming extractive or "helicopter" science, in which researchers collect data without delivering tangible local benefit [6].

Together, these articles underscore that advancing justice in environmental engineering requires more than improved technologies or data. It demands procedural justice, restructured governance, and institutional reforms that align innovation with the lived realities of communities facing the greatest environmental risks. By documenting these obstacles, the articles in this special issue provide a foundation for targeted reforms that can better align environmental engineering research and practice with equity.

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