ARTICLE CASE

Pluralizing Science for Inclusive Water Governance: An Engaged Ethnographic Approach to WaSH Data Collection in Delhi, India

HEATHER O'LEARY

Department of Anthropology, Washington University in St. Louis, St. Louis, Missouri, United States
Email: olearyh@wustl.edu

ABSTRACT This case study demonstrates how water scientists can shift standard methods for water sampling to include marginalized communities as partners in ethical research. This case argues that water inequities are magnified when participation in scientific inquiry limits the participation of certain groups of people. It used hydrogen sulfide (H_2S) testing as part of a larger project tracking water purity practice patterns, responses, and research recommendations of the hydro-socially marginalized people—the people who face not only physical, but also political barriers to water. The methodological innovation draws from engaged ethnography to enable Delhi's water-poor to sample their own water. In doing so, community members become active partners who can better direct scientific inquiry. Their participation as active partners further empowers them as water stakeholders. It reveals how everyday small-scale cooperative projects became catalysts to inclusive governance.

KEY MESSAGE

1. Recognize the important contributions and insights of regular citizens and their application for advancing water management, science, and technology.
2. Identify methodological and epistemological forms of resource marginalization. In other words, learn how the ways we measure and the ways we know the world can perpetuate inequity.
3. Evaluate other projects for community engagement opportunities and apply similar citizen-scientist collaboration components.

INTRODUCTION

Millions die of basic water- and sanitation-related diseases, such as diarrhea, every year [1]. The majority of them are marginalized people—those at risk of being subjected to discriminations due to their identity (e.g., gender, education, citizenship status, or economic position). The water, sanitation, and hygiene (WaSH) attributable burden of disease is high, particularly in countries categorized as developing nations in the Global South—India ranks the highest in morbidity in South/East Asia [2]. In response, multi-scalar interventions by water scientists[1] continue to lower the burden of disease: from studying micro-level community water contaminations, scaling up to regional programs, and leading macro-level interventions with new infrastructures and information models. The success of WaSH interventions rests on collecting accurate epidemiological data that can be corrupted when the politics of knowledge production are left out of how scientists design, implement, and interpret their sampling methods. The first step toward improving data is engaging directly with these politics by including the voices they seek to leave out.

Equitable resource provision has long haunted environmental governance—from the Malthusian specter of population crisis to the twenty-first century's mounting

1. In this study, the water scientist was the author, a scholar based at an American University with temporary affiliation to Delhi University through a Fulbright-Nehru Fellowship and informal connections with the Delhi Jal Board, Ministry of Water Resources and U.S. Embassy. The author partnered with a local NGO with a multi-year presence in the *jhuggi jhopadi* which was partially funded by USAID, national and international donors. Water scientists with affiliations (layered, in the case of the author) may find that their affiliations enhance or complicate the speed with which they are able to produce community-engaged data, largely due to community perceptions of the motives of their affiliates.

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threats: climate change shocks, large-scale urban migrations, and accelerating consumption. For centuries people have worried that without regulation, too many people would decimate limited natural resources. The populations generating the most anxiety have historically been the urban poor. By 2050, 70% of our population is predicted to live in cities, with most of the absolute growth in Asia, where many urban populations already face debilitating water inequities [3]. Water is a critical resource, as vital to urban economic development as it is to the basic functions of everyday life. To control water is to control people. Because of this centrality, we can read our myriad methods of controlling water instead as an alternative history of governance.

Far from apolitical, societies control water by allocating it to governmentally recognized stakeholders as a mechanism of political recognition—by supplying water, a city provides for the people under its jurisdiction; by denying it, a city can renounce its responsibility to care for the needs of people. Across history and continents, people have leveraged their control over flows of water to also control flows of people [4]. The discourse of water exclusion (how people talk about the have-nots) has changed in different cultural moments—from feudal patronage to colonial management or international donorship. What has held steady is the common hegemonic theme that the control of water belongs with those who already have the most power. Troublingly, even contemporary arguments largely rely on civilizational arguments that have survived from racist social evolutionary models.[2] Overall, these arguments assume that only existing leaders have a firm grasp on the best interventions. However, the view from the top can obscure quite a bit—it obscures a tiered system that discredits the valuable expertise of everyday water users. Many everyday water users have critical insights borne from living with systemic issues that would contribute to overall systemic optimization. In short, by leaving everyday water users out of the production of water data, the scientific community (along with the political leaders who implement change informed by scientific data) is instead *magnifying* social and material inequities.

Water science, management, and technology sectors have made substantive, laudable progress in ensuring increased access to adequate water among populations around the world. In part, this is due to developing universal models and pathways to human water security. However, these methods are not without danger. Increasingly, water scientists acknowledge some of the practices by which these models are developed as contributors to the marginalization of the very communities they seek to champion. In other words, what has grown around the pursuit of increasingly institutionalized ways of knowing water is a system that streamlines the category of "water scientist," ultimately excluding the vast majority of stakeholders who have untapped, everyday expertise in their own local water systems [5–7].

CASE EXAMINATION

This case study argues that water scientists and water social scientists can work together with everyday stakeholders to pluralize [8, 9] water information practices. Pluralizing involves openly acknowledging and grappling with academic legacies of privileging certain voices as authorities and dismissing others. To pluralize scientific research is to refuse to perpetuate representations of people living in research sites as inherently less capable or devaluing their position as experts in critical everyday life and experiences. In fact, people living with water insecurity are not simply objects ripe for data extraction, but should be recognized as capable and productive partners in designing even better research. Pluralization enables the scientific community to (i) acknowledge vital information for WaSH interventions that would otherwise be suppressed and (ii) reduce their complicity in the objectification of stakeholders. By recognizing the local expertise and agency of marginalized communities, community members can become active partners who can better direct scientific inquiry and are empowered as water stakeholders with the ability to document water inequities and lobby their governments for reform.

WATER, SANITATION, AND HYGIENE (WaSH) INTERVENTIONS

Many micro-level water safety plans measure drinking water for its low infectious disease risk through its microbiological quality, specifically measuring the fecal contamination of

2. These arguments subtly stratify human access to adequate resources worldwide—becoming particularly palpable in informal, "slum" communities in the Global South, typified in the *Jhuggi Jhopadi* communities of rapidly growing megacities like Delhi, India which hold significant symbolic value that resonates with common themes of historical resource disenfranchisement, including perceived characteristics such as: poverty, overpopulation, informality/illegality, "backwardness" and pollution/disease/dirtiness.

drinking water and its sources. Often, this means that measurements are taken on-site by scientists or contracted scientific sampling teams who visit communities for the first time, entering homes to use water microbiology field analysis kits. However, access to the community groups who are most deeply impacted by waterborne disease is often mediated by complex issues of identity politics. This means that even when attempting to be inclusive by measuring so-called problem areas like "slums," many homes are left out of sampling because of internal cultural politics. That is, without knowing community norms like a community-member, the qualms that make people evade data collection result in suppressions that dramatically affect representation within communities.

GOVERNANCE IN INFORMAL SETTLEMENTS

Informal settlements, often referred to as slums, are considered to be a severe threat to urban progress because of their failure to conform to global standards of development [10]. Slums have long, cross-cultural, and cross-historical associations with characteristics associated with disease: population density, poverty, informality (as non-compliance to standards), and pollution [11–14]. As a result, informal settlements have been depicted as a scourge, or disease-ridden physical materialization of urban and moral decay, on otherwise thriving cities and on global development at large. These are also common correlates used to champion outsider-driven WaSH intervention. Societies have long used these characterizations as an argument to further disenfranchise these areas from vital resources. Often, this takes the form of claiming the need for greater management, which in turn shapes the top–down WaSH approaches implemented. This requires complicity by the state, whose power rests on retaining authority over scientific data creation.

Informal settlements, by definition, exist without the authorization of the state. Some are occupied with the government's acknowledgment and may be sanctioned for basic urban services, such as water and sanitation, even without the legal recognition of the residents. However, informal settlements are more often characterized by a lack of adequate access to critical infrastructures and vital natural resource provision (Figures 1 and 2). At best, this is simply an issue of burgeoning urbanization that outpaces development capacities, and at worst, it is the deliberate discouragement of non-middle-class lifeways in cities that are increasingly pushing out the poor. In India, surging urban economies have amplified speculative urbanism which increases slum clearance schemes [15]. By removing the "scourge" of the slum, politicians argue that they can remove the WaSH issues that allegedly damper overall urban development. Tactics range from supervised WaSH interventions on the one hand to complete slum removal on the other. Informal communities are thus considerably vulnerable to politicians, whose relationship to the community can result in a broad range: from eviction and sanctioning to legal protection, patronage, and resource provision—often correlating with reciprocation by votes [16–20].

THE POLITICS OF DOCUMENTATION

In urban climates where people seek to eradicate "slum" life, informal settlement communities face legitimate fears about data collection. Documenting even mundane aspects of everyday routines establishes a scientific record of the activities and resources that make life possible in oppressive urban environments [4, 21]. Every data point has the potential to be usurped by advocates of slum clearing policies. Moreover, there is caution within communities, where illegal access to natural resource provision[3] is guarded from neighbors. Resource knowledge is kept from not only official state documentarians and scientists, but also from neighbors who may spoil access by over-extraction or through gossip which could reach authorities. For these reasons, documentation of informal community resource flows can be grossly inaccurate without the trust and cooperation of the community.

The politics of documentation can also hurt scientific inquiry through another kind of omission: the homogenization of communities in scientific design. Combined studies fusing qualitative and quantitative insights increasingly call for interventions that attend to inter-community variation [22]. A lack of inclusive community engagement in scientific data collection can lead to precarious silences in modeling WaSH issues [23–25]. In particular, when critical gaps in data overlook the intersections of gender, poverty, and illiteracy, they can lead to the systematic exclusion of the communities that need WaSH solutions the most. In essence, this means that through non-inclusive research design, water scientists reproduce

3. Natural resources can be depleted quickly if information is shared too widely. Some examples of guarded resources in this fieldsite are firewood, medicinal plants, cow dung (used as fuel), and, of course, water sources.

FIGURE 1. Community members haul water home from a water tanker delivery on the open road. These vessels will soon be stored both inside and outside of their homes for use until the next tanker delivery.

FIGURE 2. Women share a hose at a community standpipe. Like at the tanker, there are many opportunities for the water to be contaminated. For example, the hose could touch the ground near an open defecation site or the shallow uncovered gutter that lines this lane, or bacteria could be transferred from hands jockeying for the hose or in screwing on the vessel lids.

hydro-social inequities. Another result can be carefully designed interventions that only work for the least marginalized in a population. In the case of most informal settlements around the world, this excludes the very populations who are tasked with managing water and family health: poor, illiterate women.

IN-MIGRANT HOUSEHOLD DYNAMICS

In contemporary urban India, cultural customs can prevent women from interacting with strangers, impacting their ability to unrestrictedly move about their communities and to freely host people inside their homes [20]. Arriving from rural areas with traditionally staunch gender roles, newer urban in-migrants are often more compliant to the politics of ritual pollution and moral purity, shying away from participation in water sampling. This can skew water management documentation by omitting the data of households that are transitioning from rural WaSH habits to the new perils of urban waterscapes.

The number of households transitioning to urban WaSH is high—rural to urban in-migration rates continue to increase throughout India, in part to cities such as Delhi [26]. Many move to informal communities as a way to leverage their limited savings toward their top priority: securing an economic future for themselves and their families [27]. Women (and if need be, their daughters) often devote their lives to this end—spending significant time procuring resources like water and, when possible, finding domestic employment in informal jobs that require no paperwork nor literacy. A popular narrative for economic development is that the educational opportunities the city provides will enable the next generation to pursue productive technical careers and eventually take care of their

parents. For this reason, science is seen as a particularly favorable pathway to a career in the lucrative medical field.

SCIENCE IN YOUR HOME

Ethnographic knowledge of the socio-cultural background of Indian urban informal communities gave significant insight to the barriers to collecting accurate data on the WaSH for the most marginalized members—yet most important managers—of the community's water. The project to reframe a standard hydrogen sulfide (H_2S) test to measure the fecal contamination in drinking water responded to both the community's constraints in reporting data and also its self-articulated priorities.

Standard Scientific Testing Models

The standard method for fecal contamination monitoring was developed for use without access to a microbiology laboratory nor a full field laboratory test kit. It was created to be used in places like Delhi's informal communities by people with limited training [28]. The H_2S method measures bacteria through their production of hydrogen sulfide, which visibly reacts with iron to form an insoluble, black precipitate of iron sulfide (Figure 3). Typically, the sample would be taken by a local village public health worker, going door-to-door requesting entry. However, for the reasons mentioned above, adherence to this standard method would likely cause sample selection bias and could drastically misrepresent the water quality of the community at large.

Citizen-Science

Implementing large-scale research projects through the participation of citizen-scientists has increased in recent decades. Scientists from highly developed countries rely on numerous privileges of their local volunteers: education, literacy, free time, legal status, access to technology, and so forth [29, 30]. Whereas, for citizen-science research located in the Global South, school partnerships are a common approach to including a population with similar privileges [31]. But if only privileged people are included in citizen-science, it perpetuates inequalities. While the informal settlement had a high number of children enrolled in both municipal and private schools, recruiting this population would continue to alienate the primary managers of domestic water from the research: illiterate women. Because of this identity, these women's lives were uniquely structured around the pulse of domestic water management and waterborne illness—giving them unparalleled expertise in community WaSH issues.

FIGURE 3. H_2S testing vials. Ready for distribution to citizen-scientists who will self-manage sampling.

Learning to Measure

The experiment in ethnographically engaged H_2S testing began with the objective of local adaptation. The most vulnerable stakeholders in the community were never incorporated in the standard research design because it was too intrusive. Specifically, the women divulged that there were cultural taboos against having strangers visit a woman's home—particularly during the scientist's prime window for sampling: during a standard workday. This made women vulnerable to gossip because they permitted strange men into their homes seemingly clandestinely when husbands and neighbors were not at home. Many women did not dare to face social ostracization (nor, in some homes, the threat of physical violence from suspicious husbands). Women had a repertoire of tactics that would remove them from the sample pool (denying access, pretending to be a neighbor, pretending to not be at home, feigning only regional language comprehension) or to minimize time spent inside a home (methods for denying or hiding multiple water stashes). This directly impacted scientific sampling: only certain homes were sampled and of those, only certain types of water storage. This information, provided by citizen-scientist partners severely limited previous studies' claims to representative sampling.

Scientists gained more representative sampling at the household level through the partnership with citizen-scientists. At the same community-training session, the group helped determine sectors of the community. A few community volunteers marked the proposed divisions into colorful clusters on a poster-sized pictorial map during debate. After the meeting, homes were randomly selected from among each cluster. Each sector's eligible households were cross-referenced with Indian census reports as well as NGO rosters and community-generated maps provided by women's

groups. To empower women to participate, additional community-training sessions were led in the women's groups to which they belonged. In the cases women were not able to attend women's groups, trainings were led by neighbors with whom they regularly socialized.

Scientists, through this partnership, also learned tactics to obtain samples from sensitive interior household water stashes. The parameters of the hydrogen sulfide test made the method ideal for women to administer themselves. The stark visual change in the color of the sample in each vial—from clear to rust or a thick, inky black—enabled easy, confident test result interpretation for people without literacy training nor a background in science. Together, the team incorporated extensive ethnographic insight and co-design to design sampling training sessions that conformed to local cultural values. The team held very brief women-only community-training sessions in open-air common spaces to respect privacy taboos. A community volunteer was given oral instructions spoken loudly by a local woman who had been trained the day before. The volunteer then demonstrated the art of keeping their hand out of the water when submerging the vial and, with the audience, brainstormed suggestions for a safe place to keep it. This diffused the perception of ownership over scientific expertise.

Learning to measure was an iterative process for the scientist, resulting in valuable new directions of inquiry. Through the discussions that emerged once the women became active data collectors, many new questions arose that established new lines of WaSH inquiry. For example, the directive to sample "household water" yielded several questions from citizen-scientists about "which day water?" The team's discussion educated scientists about domestic water categories not only at the vessel level (e.g., bathing water storage, drinking water storage) but an entirely new category of inquiry: temporal water categories. This demonstrated a rigorous system of multi-streamed water management in households that are conventionally misrepresented as homogenous storage systems. Further, the citizen-scientists provided voluntary analysis of the ranked placement of water storage containers and their use in highly private activities such as cleansing after defecation or during menstruation. This raised additional opportunities for future study. These data would have otherwise been suppressed in traditional sampling.

This partnership resulted in a synergy of reciprocal learning for both the primary-investigator and citizen-scientists. Through the scope of the project, the primary investigator learned more about the unexamined and underreported factors of WaSH by receiving privileged knowledge about the *jhuggi jhopadi*. Reciprocally, the women who participated learned more about the standards of data production in water science, management, technology, and governance—and how to use these skills to achieve their self-determined goals.

Pluralizing Scientific Inquiry

The impetus of this case study is to reconsider scientific methods by breaking with development-centric models of scientific inquiry. These methods smack of the "colonial" era because they replicate hierarchies of power by naturalizing global north-centric epistemic privilege as an objective [32, 33]. This case challenges water science to acknowledge and overturn the politics of excluding local water management experts in its standard research methods. It contributes to emerging arguments that move beyond transforming these managers from objects of study into recognized subjects capable of conducting research. Here, the act of participating in co-designed research becomes a productive political strategy that can provoke action toward equitable forms of environmental governance [34].

EMPOWERED WATERSHED STAKEHOLDERS

By recruiting primarily illiterate women as citizen-scientists, these water-managers could learn to monitor and express their stakeholder's concerns in new ways that are recognized by the scientific and governance communities.

The women built solid evidence databases, reaching the primary objective of establishing a baseline waterborne disease risk profile for the community. The results from the 40 sampled households confirmed that the tanker water source was the cleanest, while 60% of the community pump samples were within the bacteriological limit for drinking. The water storage vessels that were sampled confirmed the community practice of designating water unfit for drinking after day 2 post-collection. The women were increasingly interested in experimenting with various storage techniques to improve the length of their water's shelf life—a valuable avenue for future research. However, the research outcomes did not end with the production of these data. Rather, it was a catalyst for broader community impacts.

The first major impact of the partnership with community women through scientific endeavor was the empowerment of traditionally marginalized stakeholders. Women learned that

they were not limited by their identities and, particularly salient to them, their inability to read. Rather, the act of recording data reinvigorated peer-to-peer literacy initiatives in women's groups. Many of the women showed greater interest in boosting their literacy through engagement with their children's school materials. This was complemented by an increase in discourse demonstrating a broader sense of personal value that pervaded the fieldsite as news of the project traveled among other households. Specifically, ethnographic evidence [35] indicated that women began to think of present opportunities for their own lives, rather than just the future-oriented hopes for life improvement through their children.

The second major impact was the women's achievement of becoming autonomous practitioners in scientific recordkeeping. Women spearheaded their own data collection independent of the biological, sociological, and ethnographic data being created in partnership with the community. The community had approached municipal authorities on several occasions about their suspicion that their neighborhood was being deliberately underserved by government workers who were receiving pay to provide them with basic services. However, they were routinely dismissed in their endeavor to prove corruption. Drawing from the training they received in the program, two of the four women's groups compiled datasets regarding the timing and completion of municipal water and sanitation services. Their objective was to provide a self-generated scientific record of (1) the sanitation worker dredging of open-gutters and (2) water tanker delivery arrivals. After collecting 1 month of data, they elected representatives to present it to the municipal corporation in order to demonstrate the lack of critical urban services and the corruption in official records of servicing. The result was that their complaints were recognized as legitimate and there was greater municipal oversight to ensure that the community received WaSH services on a regular basis and that the workers complied with expectations. Further, by the government recognizing the women as stakeholders with valuable data, the women felt empowered to aim their sights higher toward making policy and programming recommendations about their community.

CONCLUSION

While training this vulnerable population of informal community women in data collection could be viewed as creating new biopolitical subjects—citizens whose lives and bodies are under increased control through reporting and surveillance technologies—the women, ultimately, described the experience empowering: as being "more in control of their data than ever." They explained that their training allowed them to transform the previous practice of regular, invasive objectification of their lives into a consensual process where they had input on how and what was collected, by their own hands. The consent was even more impactful than before, since, ultimately, they felt that they knew much more about the afterlives of their data and the overall process of scientific data collection and its operationalization in governance. If these women were becoming biopolitical subjects, they embraced their new elevated recognition as subjects while at the same time, demonstrated that they could make gains by strategically managing data sharing and suppression at a new level.

The co-training inherent in engaged ethnography is not enacted to make vulnerable community members more governable through simply facilitating the translation of their embodied lives into legible data. While this process does make the community legible, it does not do so for the purpose of leveraging the data into a system which further controls, polices, and condemns them. Rather, by removing the intrusive step of an outsider rendering community members into objects of data extraction, training vulnerable populations in self-measurement empowers them to become agent-experts on their own behalves, on the behalf of scientists seeking better solutions, and on behalf of everyone limited by systems that are designed and implemented without adequate, representative data. In terms of WaSH, in advocating for their own community, these women in tandem provide insights to better direct the billions of dollars spent each year on investments into water infrastructures, institutions, and information systems.

This case study argues that water scientists and water social scientists can work together with everyday stakeholders to pluralize water information practices. Problematic solutions to WaSH issues often begin with misrepresentative, incomplete data. Given the complexity in improving global WaSH, it is imperative to more rigorously include marginalized local water stakeholders as early as the research design phase. By recognizing the important contributions and insights of marginalized groups, data collection is improved because it captures critical new data.

At the same time, this case study demonstrates that the broader concepts of collaboration and epistemic equity have immediate benefits to science and governance. Local

insights are a way to co-establish new directions in water-management, science, and technology. By recognizing the potential to co-train (training everyday citizens in water data management and training scientists in local water management techniques), citizens and scientists can maximize the value of their knowledge sets. Ultimately, small-scale cooperative projects like this become catalysts to inclusive governance by (i) empowering marginalized people with the language of science and (ii) challenging scientists to acknowledge their assumptions about how solutions can be scaled-up.

Standard scientific methods have made progress toward improving water around the world. However, these methods systematically exclude perspectives that could very well transform persistent failure points (such as resource pollution, scarcity, population politics and inequitable allocation) into opportunities to optimize the system. By leveraging engaged anthropological techniques, collaborative inclusion is a strong and viable approach to the most pressing water issues of the twenty-first century and to the barriers to humanity's overall resilience and sustainability: the problems haunting our shared future. Let's recognize the vast and varied knowledge that is already available.

CASE STUDY QUESTIONS

1. What are the benefits of adapting standard water science management and technology data collection to local places? What are the new challenges that come with adapting?
2. How can water scientists include marginalized groups? Which parameters experienced in Delhi may be applicable elsewhere?
3. How can policy makers be more equitable and inclusive in the people they consider water authorities when counting on reliable, actionable data?
4. Increased urbanization under climate change is a future concern. How should urban water scholars think about designing WaSH programs in light of that?
5. What other long-term problems do you foresee for those trying to create equitable, inclusive water governance mechanisms?
6. How are knowledge politics obscured in scientific data collection in your region? What are the (political, economic, environmental) outcomes for the beneficiaries and for the marginalized?

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The author has declared that no competing interests exist.

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