CITIZEN SCIENCE:
THEORY AND PRACTICE

Contributions of Citizen Science to the Sustainable Development Goals: Is Transformative "Global" Citizen Science Possible?

COLLECTION:
CONTRIBUTIONS OF CITIZEN SCIENCE TO THE UN SDGS

ESSAY

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ABSTRACT

Various efforts have been undertaken to encourage citizen science contribution to the United Nations' (UN's) Sustainable Development Goals (SDGs). These attempts are connected chiefly to the measurement of specific sustainability indicators. Using perspectives from critical theories on equity and justice to review the recent literature on employing citizen science for the SDGs, we argue that those advocating that citizen science be used for monitoring and fulfilling global sustainability goals should also be attentive to questions of historically inequitable power relations in the production of knowledge, and they should embrace both decolonial perspectives on science as well as a humbler stance on global data monitoring and governance. While we have argued elsewhere that citizen science should be attentive to various forms of exclusion and epistemic injustice, such attentiveness is even more relevant in the context of attempting to globalize citizen science activities. For this, we draw on alternative forms of citizen science, namely citizen social science and tracking science, and place them within the broader discussion of open science for justice. By pointing to these alternatives, we call for greater appreciation of the varieties of citizen science; for a commitment to a more self-reflexive science that embraces not only community participation and collaboration, but also community self-determination; for the acknowledgement and utilization of multiple knowledge systems to produce life-sustaining knowledge; and an action-oriented approach to science that produces practical and desirable outcomes for human and more-than-human communities.

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INTRODUCTION: JUSTICE FOR ALL?

Organizers of the WeObserve citizen science (CS) hub believe that citizen science efforts, if made mainstream, will "empower and enable citizens to become the 'eyes' of the policy makers," especially when it comes to environmental monitoring for the United Nations' (UN's) Sustainable Development Goals (SDGs) (WeObserve 2018a,b,c). But how well are these efforts contributing to the SDGs? And more importantly, what if citizens and policymakers don't see eye to eye when it comes to their vision of how *their* world should be? Who gets to build and sustain what kind of world? Can multiple self-determined and self-governed worlds coexist peacefully on planet Earth for millennia to come? These are questions of power and justice that anyone who is serious about sustainable development must grapple with.

Let us attempt to grapple with these very questions with an example. One CS project touted on WeObserve involved a citizen observatory in Zambia called Niti Luli. The three-year project focused on community-based sustainable natural resource management and was meant to correct previous failures of government policies that did not take local stakeholders' needs properly into account (Ground Truth 2.0 2019). By the time the project ended in 2019, inequitable power dynamics and struggles between local, regional, and national stakeholders prevented Niti Luli from fully operating. Its expected SDG-aligned impacts (increased influence of communities on decisions about natural resources, reduced resource degradation, and increased socio-economic benefits from said resources) were not achieved. What the project did reveal was that despite the formalization of rights of community participation in natural resource management in Zambian law, current on-the-ground power relationships prevented meaningful participation. After holding at least 50 meetings with community members, the project's evaluators concluded that the institutional structure of natural resource management was not yet aligned with community needs, such that "communities are, and feel, de facto, powerless" (Wehn et al. 2019, pp. 70,77).[1]

The challenges in sustainable natural resource management as demonstrated by the Zambian case speak to Krauss's (2022) critical analysis of SDG 15, Life on Land, which relates to biodiversity conservation. Krauss argues that the targets and indicators of this SDG fail to "champion justice systematically" by perpetuating inequitable ideas about conservation (p. 1). Ironically, the next goal, SDG 16, Peace, Justice and Strong Institutions, is meant to provide access to justice for all. However, when policymakers fail to include equitable power redistribution in their targets and indicators, true justice remains unattainable.

Despite these current challenges, there is a push within the citizen science community to globalize its efforts, envisioning citizen science as a tool for streamlining global governance through the SDGs so as to "leave no one behind" (LNOB) (UN Sustainable Development Group 2022). LNOB is one of the UN's universal values and the central promise of the SDGs. It is meant to target discrimination and inequalities as well as eradicate their root causes. Yet what if the desire to streamline global governance is itself a root cause?

Without careful attention to power, equity, and justice at every level of human and beyond-human politicking, even well-meaning goals like LNOB and the SDGs can prove deleterious if they support a hegemonic vision of One World that continues to operate through colonial and imperialist logics (Gabay and Ilcan 2017).[2] Whether intentional or internalized, oppressive enactments of modern Western technoscience, including some forms of citizen science, help to perpetuate the One World myth.

In our review of the current literature, we draw from various critical social theories to make explicit the internalized assumptions about there being One World: a single objective reality that is only truly knowable through modern technoscience. We then point to alternative approaches to living and working together that may lead to more just futures where many worlds can thrive on one shared planet. To what extent can citizen science, the SDGs, and the UN's actions themselves heed this call for just and sustainable lifeways for all human and more-than-human Earth dwellers?

From a decolonial/justice perspective, we call for a self-reflexive (citizen) science that embraces not only community participation and collaboration, but also community self-determination; that acknowledges and utilizes multiple ecosocial worlds and knowledge systems; and is action-oriented to produce practical and desirable outcomes for communities as determined by those communities. We utilize Mamo and Fishman's (2013) definition of justice as a public matter focused on common human interests, equitable distribution of societal goods, resources, and opportunities, and a commitment to fostering empowered political participation. In short, justice is systemic, sustainable, and equitable distribution and participation for all in the creation of healthy worlds where all beings can thrive. Commitment to justice means thinking through power with the goal of dismantling oppression at all scales. We urge those in power who stand to make policy interventions on a global scale to humble themselves and distribute their power amongst the communities they seek to impact.

RECENT APPROACHES IN CITIZEN SCIENCE LITERATURE ON THE SDGS

With ever-increasing numbers of CS projects for environmental monitoring emerging, CS practitioners and their collaborators should be careful not to reinforce unjust systems of power distribution around Earth's many worlds. Yet recent scholarly work focusing on the use of citizen science for SDG achievement has, like the SDGs themselves, failed to make just practices central to their discussion. Researchers have instead focused on how to best monitor SDG indicators via citizen science projects. A narrow, overly technocratic focus on effective monitoring strategies undermines the transformative potential of the SDGs for creating just worlds on planet Earth.

Fritz et al. (2019) and Fraisl et al. (2020, 2022), for instance, have offered highly concrete and targeted attempts to contribute to the measurement of specific sustainability indicators, mostly through innovative partnerships between transnational teams of researchers together with representatives from (inter)national statistical agencies. Fraisl et al. (2020) reviewed hundreds of past and present CS projects and determined that they could contribute to about a third of the 244 SDG indicators. Parkinson et al. (2022) followed up on the work of Fritz et al. and Fraisl et al. by refining the tools practitioners can use for aligning CS projects to the SDGs, providing yet another set of indicator questions and answers that would help projects contribute to official monitoring data or directly achieve the SDGs.

These papers demonstrate how increasingly complex indicator and monitoring systems are key to measuring progress against the SDGs. Underlying these monitoring systems, however, is a mode of global governance that is dependent on Western-centric logics of quantification. In the sociology of quantification and critical policy studies, such phenomena are being gradually understood and critiqued (Ilcan and Phillips 2010; Kapoor 2008; Merry 2011; Tichenor et al. 2022) This calculative logic is however insufficiently reflected upon by CS practitioners.

Scholars have argued that citizen science could accelerate SDG progress further by strengthening partnerships between governments, national statistical offices, and CS practitioners (Fritz 2019; Fraisl 2020). However, as key stakeholders and collaborators, local communities and publics are largely missing. To wit: Fritz et al. noted that best practices should happen from the top down, developing at the national level and then "feed[ing] down" to the local level (p. 929). Meanwhile Fraisl et al. (2020) claim that citizen science can do more than simply deliver data to current governing bodies; however, they admit that such would require "changes to existing decision making procedures and practices across governance structures, economic sectors and society at large," which could "trigger shifts in governance structures and accountability" (p. 1748). These authors envision communities vis-a-vis publics informing policy and governance. But what about publics *transforming* governance?

To what extent can the approach to global governance for which these authors advocate sufficiently challenge the current unjust systems of power circulating around the Earth? If citizens are still treated as "the eyes of policy makers" in such an approach, then the answer is dubious. CS projects can fall along a continuum based on the level of public participation (see Cooper and Lewenstein 2016 and Haklay 2013). The aforementioned proponents of citizen science for SDG achievement focus largely on contributory citizen science, in which publics are treated as human sensors, data collectors, and research assistants, but not full collaborators. For both citizen science and the SDGs to be truly transformative, the voices of all stakeholders—especially local communities and diverse publics—need to be fairly integrated into every step of the research and decision-making processes: from question and method development, to data collection and analysis, to application and dissemination of results for on-the-ground impacts.

DECOLONIAL PERSPECTIVES ON CITIZEN SCIENCE FOR SUSTAINABLE DEVELOPMENT

While we have argued elsewhere that citizen science should be attentive to various forms of exclusion and epistemic injustice (see Herzog and Lepenies 2022 and Lorenz 2020), such attentiveness is even more relevant in the context of attempting to globalize citizen science activities. There have been important developments across critically-oriented disciplines that call for centering justice in their approaches to theory and practice. For example, while calls for decolonizing the social and environmental sciences have long been made (see Baker, Eichhorn, and Griffiths 2019; Domínguez and Luoma 2020; Forsyth 2003; Grosfoguel 2009; Todd 2016; Tuck, McKenzie, and McCoy 2014), citizen science literature needs to catch up. Decolonial perspectives call for the acknowledgment of colonial histories of destruction; the dismantling of continued oppression based on those histories; and the promotion of healing, self-determination, and self-governance for all communities, starting with Indigenous, racialized, and minoritized communities and their more-than-human kin (Bhawra 2022; Haraway 2016; Tuck and Yang 2021).

Bhawra's (2022) framework for decolonizing digital citizen science is an excellent start. Bhawra highlights "two-

eyed seeing," a concept developed by Indigenous M'ikmaw Elder Albert Marshall. Instead of forcing publics to see like policymakers, two-eyed seeing is a decolonial perspective in which one sees with the strengths of Indigenous knowledges in one eye and the strengths of Western knowledges in the other (pp. 45–47). We would include Eastern knowledges to this perspective to stress how imperialist and scientific world-building projects have strong roots there as well; both strongly influenced modern technoscience and governance. (As per the belief of some Eastern spiritual traditions, perhaps we would see Eastern knowledges through our third eye.) Unlike the policymaker, two- (or three-) eyed seeing does not privilege one set of knowledge over the other. Nor does it attempt to adopt one as universal; there is no objective view from nowhere (Anzaldúa 1987; Collins 1990; Haraway 1988; Mignolo 2000).

The politics imbricated in international development, international relations, and the UN have been strongly shaped by colonial and imperialist world-building projects. These fields, institutions, and resulting policies are supported by the myth of the universality of aperspectival knowledge. Many knowledge systems supporting modern technoscience, with their allegedly "objective" standards of measurement, are in fact situated within the hegemonic perspectives of human exceptionalism, colonialism, imperialism, and white heteropatriarchal supremacy (Lyons et al. 2017). UN global development needs to be analyzed through a similar lens. Indicator monitoring is not objective, but is rather tied to these hegemonic perspectives. Those involved in international politicking need to acknowledge that to carry out a set of "global goals" through the SDGs—attempting to make them applicable to the denizens of an entire planet—means propagating as universal a very particular hegemonic set of subjectivities. This further internalizes the One World myth while simultaneously denying the sovereignty of the many worlds that already populate Earth (Ilcan and Phillips 2010; UN Sustainable Development Group 2022). Globalizing citizen science, then, would mean trying to govern that One World by establishing "the globe" as a seemingly universal unit of measurement.

In other words, globalizing citizen science reinforces the myth of the One World in need of management by technocratic experts at the service of political elites. However, as sociologist and critical race theorist Ruha Benjamin (2016, 2022) has documented, many local communities have challenged the notion that modern technoscience is "the best arbiter of communities" (Ruha, quoted in Pollock and Subramaniam 2016). Multi-eyed seeing serves as a decolonial tactic; the kind of tactic Indigenous Métis scholar Michelle Murphy posits can generate alternative concepts of care, responsibility, and collaboration amongst the many worlds while dismantling the One World (Murphy 2017).

There are many worlds, as reflected by the diversity of knowledge systems that create them, shape them, and maintain them. Decolonial science is a practice that allows for multiple worlds—with their multiple knowledge systems and logics—not only to exist, but to peaceably thrive alongside each other. Embracing biocultural diversity leads to a multi-eyed, multi-world perspective of life on a shared planet, rather than a singular globe in need of managing by the hegemonic powers that be. We therefore argue that those who advocate for the use of citizen science for fulfilling global sustainability goals need to attend to questions of historically inequitable power relations in the production of knowledge, embrace decolonial perspectives on science, and adopt a humbler stance on global data monitoring and governance. This requires the exploration of alternative forms of citizen science.

TOOLS FOR JUSTICE: CITIZEN SOCIAL SCIENCE, TRACKING SCIENCE, AND OPEN SCIENCE

Rather than advocate for the instrumentalization of citizen science for global governance, which remains silent on matters of politics and democratic self-determination, we propose the adoption of egalitarian scientific practices that explicitly center justice for all as determined by all. There are two strands of citizen science that are aligned with this vision of decolonial and justice-centered science: citizen social science and tracking science.

Citizen social science is a form of citizen science that explicitly tackles issues of diversity, inclusion, access, self-determination, and collective action for the well-being of all communities of human and more-than-human kin (Lorenz 2020). It utilizes a community-based research framework to bring together researchers and publics in order to solve complex ecological and social problems (see, for example, Purdam 2014). Researchers and publics become partners and collaborators in each step of the process, from question development to dissemination of findings to enactment of specific socioecological interventions to the evaluation of results—all while recognizing that this process is iterative and always justice-centered, never formulaic or didactic.

Citizen social science recognizes that the investigation and transformation of socioecological issues are inseparable from the scientific endeavor. It recognizes that there are multiple knowledge- and material worlds, and thus prescribes no one way to do science. The approaches of any given citizen social science project are molded by all stakeholders/actors/collaborators/community

members involved in order to meet the group's collective needs throughout the entirety of the research process. Its practices and knowledge systems are thus as diverse as there are communities of life on Earth. Everyone is invited to own the project and its outcomes; to share power and resources equitably; to be responsible for each other's well-being; and to commit to resolving conflicts peacefully. Citizen social science tenets include being for, by, and with more-than-human communities; activating multiple knowledge systems parsimoniously; recognizing the expertise of the lived experience, or living knowledge; being self-reflexive in theory and practice; being action oriented to produce practical positive outcomes for communities; and being democratic and liberating to end all forms of exploitation and oppression.

Yet citizen social science has its limits. Liebenberg et al. (2021) have proposed the term "tracking science" instead of "citizen science," since tracking science challenges the use of the term "citizen" altogether. Like citizen social science, anyone can participate in the scientific process regardless of socio-cultural background. By replacing "citizen" with "tracking," however, this kind of science explicitly includes Indigenous peoples, immigrants, and other displaced peoples, their knowledge systems, lifeways, and their worlds. The authors (who include Indigenous trackers) propose the term tracking science to engage the citizen science community in discussion about what it means to actually *do* science. Thus, the authors hope that these discussions will transform science and governance to become more just. This shift in understanding about how science is done, who gets to participate, and who is excluded helps put the SDGs in the context of a planetary-scale decolonial moment in which marginalized groups continue to work for justice and space for peaceful cohabitation.

As opposed to the term "citizen," "tracking" refers to

> "a process that involves empirical observation, experimentation, and causal inference through scientific hypothetico-deductive reasoning, including the creation and testing of hypotheses and theories and making novel predictions, as well as comprising critical discussion and peer review, with the purpose of producing scientific knowledge about the world, regardless of who participates" (Liebenberg et al. 2021, p. 9).

The term emphasizes the process involved in generating scientific knowledge rather than the kind of person engaged in that process. The goal of using the term is to encourage everyone involved in citizen science to "develop an inclusive understanding of what it means to do science" and to recognize how the process of scientific thinking and knowledge creation can "empower people with or without academic credentials to make novel contributions to how we understand the world" (Liebenberg et al. 2021, p. 11).

Science is a way of thinking and engaging with the world that has ancient roots. The authors claim that scientific thinking can be traced to hunter-gatherers who tracked animals in Africa over 100,000 years ago, and that it has been practiced by people long before the concept of a "citizen" or "states" existed (Liebenberg et al. 2021, p. 9). Tracking science, which is based on these prehistoric methods for tracking animals, honors all Indigenous peoples and their tracker ancestors whose practices may have been the origins of science (see Carruthers 2002 and Tomaselli and Grant 2020 in Liebenberg et al. 2021).

Yet the creation of states by colonial powers, states that unjustly bestow certain rights to its citizens while denying rights to non-citizens, led to the dispossession of Indigenous people, denied them access to the lands they called home, and destroyed their livelihoods. Today, nation-states continue to exclude and oppress groups of people (not to mention non-human beings), creating millions of refugees and "stateless" people and communities that are left without support. The affordances of global citizenship are not justly distributed to all beings. Thus, current attempts to globalize citizen science reflect the unjust ways that global citizenship, as well as global governance of those citizens, are being enacted. Moreover, Indigenous, racialized, and minoritized groups have been excluded from the process of creating and sustaining knowledge systems and the lifeways they uphold, meaning their knowledge and lifeways are neither valued nor even allowed to exist peaceably alongside other knowledge systems and lifeways. The state-and-citizen system itself is unjust and likely incapable of dealing with the planetary-scale upheavals that climate change is already unleashing.

With tracking science emphasizing the process of scientific endeavors for all, and citizen social science emphasizing that the process *and* results of that process be for the benefit of all, we are thus arguing for a stronger justice lens not just for citizen science but also for the larger trend of open science. Current discussions about open science need to be more attentive to power distribution and enactment. Fraisl et al. (2022) have noticed a global transition towards open science, which stands on the pillars of public engagement (of which citizen science is a part), along with open access to data and education. The goal is to make science more participatory, inclusive, and accessible to all members of society, and encourages collaborations that benefit both science and society. Grahe et al. (2020) argue how transparency and fair access to science can promote diverse, just, and sustainable

outcomes. Echoing Grahe et al., we believe open science should be a just science, one in which its assets are fairly distributed to all (including future generations), and all have a voice in and shared control over the process.

Unfortunately, Grahe et al. limit their discussion of open science to academic settings. The authors focus on making academic communities more just, focusing on collaborations between researchers, students, and future scholars. Students, they argue, "can carry diversity, justice, and sustainability into the world around them" (p. 15). They focus narrowly on research projects in classroom or professional situations. Moreover, researchers and participants are still considered to be separate categories. We need to push open science outside of formal research spaces and classrooms. We need to go beyond interactions between researchers and participants in which the formal "experts" still lead, providing space only for crowdfunding, crowdsourcing, and scientific volunteering as avenues for public participation. In a truly just science, everyone is a collaborator, everyone shares power and ownership. Everyone decides together how scientific knowledge is created, applied, evaluated, and disseminated.

At the heart of science, according to our understanding, is curiosity. Someone has a question about the world around them. It may come from a need to live a better life for themselves and their more-than-human communities. So they design an intervention, an experiment, to try to answer that question, create knowledge, and activate that knowledge to affect change in their lives and the lives of their multispecies kin. Everyone should have access to this endeavor and should receive the support they need for this endeavor. Alternative forms of citizen science can steer us in that direction. These are the kinds of science in which the myth of objectivity is discarded. Community-oriented scientific endeavors, with the understanding that everyone is welcome into the community, has as its goal the well-being of everyone in the community. Conflicts will arise in the scientific process, naturally; yet a just practice of science (be it "social citizen-," "tracking-," or otherwise) means that conflicts are handled peaceably, without resorting to violence of any kind, including the suppression or oppression of viewpoints, perspectives, understandings, lived experiences, and knowledges.

CONCLUSION: EMBRACING BIOCULTURAL DIVERSITY IN SCIENTIFIC PRACTICES FOR JUST WORLD-BUILDING

Citizen science should be as diverse as there are participants to engage in the practice. Everyone is welcome, and everyone is welcome to make citizen science their own. And that might mean changing its name. No longer "citizen" or even "science" but the process of inquiry for equitable world-building. Appreciating diversity in citizen science means appreciating that it goes by many different names, not just the ones we have highlighted here. If committed to justice, citizen science in all its different forms may be able to transform science and science-backed governance, helping to break the cycle of hegemonic oppression and violence.

Epistemic justice in science and governance means acknowledging that traditional, lay, Indigenous, feminist, decolonial, and many other forms of knowledge inquiry and creation deserve as much respect as modern technoscience. What if we Earth dwellers worked towards more egalitarian systems of governance than the ones currently dominating the planet? These systems would not rely on hierarchies of knowledge and power that were built on thousands of years of ecocide, genocide, and exploitation. Difference is embraced, not destroyed.

Difference is diversity. And diversity is not only valuable epistemologically. Planet Earth represents the totality of diverse ways of life. That totality is an emergent property; Earth is greater than all the worlds that make up the sum of its parts. To recognize one Earth with many worlds is not to flatten them all and make them the same, or to subsume the many diverse forms into a singular kind of universalizing ontology. A healthy Earth requires biocultural diversity as well as onto-epistemological diversity (see Barad 2007). Just, peaceable diversity makes for just worlds on an emergent Earth.

The question remains, then, whether any implicit or explicit world-building project taken up on a *global* scale can truly be just, can truly utilize science as a tool for dismantling oppression—through the SDGs or otherwise. Is the UN's vision for a sustainable future for all big enough for many worlds to coexist? Or does it continue to force onto all others the myth of the One True World, a Eurocentric worldview consisting of one socioecological global order backed by one kind of science? Without a commitment to justice, promoting the SDGs and citizen science as vehicles for global change may become another tool for perpetuating human exceptionalism, colonialism, imperialism, and white heteropatriarchal supremacy. If committed, perhaps a radical revisioning of the SDGs and citizen science can become the very tools *for* justice, provided that those tools and their underlying philosophies about how life should be lived are as diverse as the human and beyond-human communities that put them to use. Global powers, whether operating through the UN or not, must therefore recognize, upend, and transform current power structures and relations by relinquishing and distributing their unjustly earned power.

Black feminist poet Audre Lorde (1984) famously wrote, "The master's tools will never dismantle the master's house" (as quoted in Pollock and Subramaniam 2016). Will the master prove history wrong and dismantle his own house? Whether liberation, self-determination, and sovereignty for all socioecological communities is achievable through any centralized global developmental framework, no matter how noble, is ultimately up for debate. Our hope is that by attending to power redistribution and working for just transformations of global systems from many diverse community-based approaches, we Earthlings can "imagine worlds as otherwise" and recognize that many other worlds are already here (Mamo and Fishman 2013). Once we do, we can collectively work together to sustain them.

NOTES

1 In personal correspondence with Ellen Pfeiffer, one of the Niti Luli project organizers, the authors learned that since the publication of the 2019 impacts report the Zambian national government has agreed to support further development of the citizen observatory. The authors hope that the upscaling of the project will indeed address the institutional and jurisdiction issues that impede the effectiveness of this community-based, co-designed initiative.

2 The argument we develop in this essay about one versus many worlds on a shared planet Earth was inspired by a discussion of Indigenous perspectives on the One World myth led by Indigenous Métis Michelle Murphy that took place during their presentation entitled "Chemical Pollution and Land/Body Futures on the lower Great Lakes." The presentation and resulting discussion took place at Cornell University on April 22, 2022. The authors would like to acknowledge the painful histories of dispossession of Indigenous human and more-than-human communities entangled in these discussions and places and honor their ongoing connections to these human and beyond-human people, land, and waters.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

The authors jointly generated the idea and initial arguments for this essay. LL introduced the One World myth to the discussion, developed the analysis, and wrote the manuscript. RL edited the manuscript and contributed relevant literature.

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