CITIZEN SCIENCE:
THEORY AND PRACTICE

Citizen Science beyond Science: A Collaborative Approach for Transformative Sustainable Development

COLLECTION:
CONTRIBUTIONS OF CITIZEN SCIENCE TO THE UN SDGS

RESEARCH PAPER

MAYA PASGAARD
CHRISTINA BREED
MARIA HEINES
LINETTE KNUDSEN
PETA BROM
ASTRID SCHMIDT
KRISTINE ENGEMANN

*Author affiliations can be found in the back matter of this article

]u[ubiquity press

ABSTRACT

In this paper, we lean on experiences from South Africa as a point of departure for discussing the unrealized potentials and complications of applying collaborative, transformative citizen science (CS). We first show the value of exploring community-based ecological restoration and artistic approaches in ecological and development research. Building on these empirical insights, we outline ideas for integrating CS into such research, not only to collect additional data, but as a way to increase incentives and capacities among both CS participants and researchers, and to change mindsets across time and institutional scales. Multiple interlinked Sustainable Development Goals are within reach, exemplified by the monitoring and advancement of Clean Water, Life on Land, and Sustainable Cities and Communities—critical goals to address current and prospective demographic and climatic changes in the context of fast-expanding urban environments and beyond.

CORRESPONDING AUTHOR:
Maya Pasgaard
Aarhus University, DK
mapa@bio.au.dk

KEYWORDS:
community-based science; collaborative learning; ecological restoration; photovoice; transformative change; South Africa

TO CITE THIS ARTICLE:
Pasgaard, M, Breed, C, Heines, M, Knudsen, L, Brom, P, Schmidt, A and Engemann, K. 2023. Citizen Science beyond Science: A Collaborative Approach for Transformative Sustainable Development. *Citizen Science: Theory and Practice*, 8(1): 41, pp. 1–14. DOI: https://doi.org/10.5334/cstp.574

INTRODUCTION: TAKING CITIZEN SCIENCE BEYOND SCIENCE FOR TRANSFORMATIVE CHANGE

Citizen science (CS)[1] and other community-based approaches for monitoring environmental change are gaining momentum in research and practice, especially in Global North[2] contexts (Quinlivan et al. 2020; Danielsen et al. 2021). Meanwhile, there are gaps in the monitoring of sustainable development (Klopp and Petretta 2017; Fraisl et al. 2020), including the progress (or regress) of the environmental Sustainable Development Goals (SDGs) for improving life on land and below water (SDGs 15 and 14), climate change action (SDG 13), and water quality and management (SDG 6) (UN 2015). While partnerships to collect data have been formed among government agencies, academic institutions, local governments, private businesses and civil society organizations, a recent assessment by the United Nations (UN) shows a lack of data on and monitoring of, for example, water quality, upon which 3 billion people depend (UN 2022). These and other goals are critical to reach and thus track in all countries, especially to move the world's rapidly expanding cities towards sustainability (SDG 11). With the gap in SDG monitoring and the momentum in citizen-based science, it seems logical to connect the two (cf. Fraisl et al, 2020) and take CS beyond science to mobilize positive environmental change. This is especially—but not exclusively—prospective in many regions in the Global South where institutional frameworks and resources for monitoring are largely missing (Quinlivan et al. 2020), and where research on CS in general lags behind (Denhardt et al. 2009; Requier et al. 2020; see Pocock et al. 2019 for East Africa) or do not reach a global audience due to language biases (Chowdhury et al. 2022).

Inspired by research experiences in South Africa, this paper aims to discuss the potentials and complications of applying CS for sustainable transformative change.[3] There is a need to expand and advance CS research and practice beyond the translation of science into communities. We see equally important opportunities to integrate local, traditional, and/or indigenous knowledge and practice with conventional scientific methods and worldviews. This would unleash the potential to strengthen capacities beyond improved monitoring skills among CS participants only, towards greater environmental awareness, community empowerment, and care for nature across stakeholders.

We discuss the potential of CS through examples of community-based ecological restoration and artistic research methods. First, recent studies document the potential of CS to combine nature conservation actions with rigorous data collection and increased environmental agency (Ballard et al. 2017). These studies outline requirements in terms of monitoring methods and data sharing (Sullivan and Molles 2016), and discuss the role of communities as active role players and decision-makers in all process stages of nature protection or restoration initiatives (Ortega-Álvarez et al. 2021). Studies also underline challenges concerning data quality and validation (Kosmala et al. 2016; Wiggins and He 2016). Second, community art and nature relations have been successfully combined with research to increase our understanding of human-nature perceptions and actions. For instance, studies show how nature-focused photography, painting, and other artwork can lead to stronger nature engagement and a sense of care (Farnsworth 2011; Kay et al. 2019). Art-based research can also reveal some of the intangible inner workings of fundamental human-nature relations (Masterson et al. 2018), such as place-based nature relationships (Cocks et al. 2016), prioritization of environmental issues (Cock 2006), and emotional responses of empathy and awareness (Whitley et al. 2021). However, there is a void in testing and combining different creative tools, since most studies focus on single specific methods, in particular photography (Farnsworth 2011). Moreover, CS potentials are rarely more widely explored (Rogers 2011), at least beyond photography in Northern contexts like the USA (e.g., Zha et al. 2022) and Austria (Guinand et al. 2021).

The above studies indicate an opportunity to tie CS closer to nature conservation actions and nature-focused, art-based research, especially considering the eminent need to monitor sustainable development in the Global South. However, various contextual challenges must be borne in mind when engaging in CS as part of sustainable development research. The most relevant to this paper are:

1) Conceptual and practical challenges exist regarding the legal status of CS participants and local knowledge systems. The "citizen" label does not always apply, (e.g., for illegal migration and informal settlements) nor does the "science" label necessarily resonate with traditional, indigenous knowledge and practices (Cocks et al. 2016). The recognition and inclusion of participants can thus be a sensitive matter for institutions in charge of CS activities, such as state authorities, nongovernmental organizations (NGOs), and researchers (see also Denhardt et al. 2009).

2) Local participants—formal citizenship or not—are often marginalized, and at times traumatized, by historical injustices, like in the post-apartheid South African context (McDonald 2002). In marginalized communities, there may also be ethical considerations of "occupying" people's time for research, but with no prospects for change or a direct (positive) impact on their immediate needs. Contextually relevant processes

and incentives for participation are needed (Requier et al. 2020) due to acute needs, safety, and fragile bonds of trust (cf. Denhardt et al. 2009).

3) A low baseline or starting point of participatory approaches across institutional levels might exist (see Pasgaard et al. 2017), along with a lack of institutional infrastructure and capacity for engaging citizens/communities and handling CS activities and outcomes (Pocock et al. 2019). A collaborative and transformative change of mindsets—among both CS facilitators and participants—will be required to co-develop long-lasting, mutual capacities.

With the above gaps and Global South perspectives in mind, we pose the following research questions: Where do the potentials and challenges for CS lie for sustainable development (and its monitoring)? In cases in which CS initiatives are feasible, how should one spread and embed the data, positive impacts, and opportunities beyond the participants and researchers involved during the "intervention period" towards broader transformative change? We unpack and discuss these questions through two empirical cases from South Africa, and offer concrete suggestions for advancing CS research in a creative and collaborative direction. From the perspective of sustainable development, and for tracking its progress, we illustrate prospects for simultaneously improving and monitoring water quality (SDG 6) and related goals, while educating and empowering both CS participants and facilitators. Our paper thereby offers methodological contributions to SDG monitoring with specific suggestions to address the lack of CS research in the Global South and beyond towards facilitating transformative change.

STUDY CONTEXT AND METHODS

This paper builds on two recent studies in South Africa. The first study aimed to assess livelihood benefits from community-based ecological restoration. The second study applied an artistic approach to explore community ownership and access to urban green space. While neither of the two studies directly employed CS to collect data on water quality or biodiversity, for instance, they hold strong CS potentials, as our subsequent analysis will show.

South Africa is suffering from multiple interacting crises, including climatic changes causing flooding and drought (Otto et al. 2018; Musyoki et al. 2016), environmental degradation leading to the loss of biodiversity and ecosystem services (Lannas and Turpie 2009), low inclusion of evidence-based knowledge and monitoring of landscape restoration (Angelstam et al. 2017), and inequitable access to economic opportunities, as illustrated by high levels of poverty and unemployment (Anderson et al. 2013). These crises all occur in a historical context of racial injustices that left deep scars on people and places (Moodley 2019). Despite these challenges, South Africa is still undergoing positive changes as the lead nation in Africa in terms of scientific knowledge creation (Pasgaard et al. 2015), transnational green partnerships (Altinget 2022), and international peace-keeping (BusinessTech 2016; Good Country Index 2022), for instance, while maintaining a progressive outlook and relative economic stability.

The first study included a livelihood survey of restoration workers, who were part of public programs (the so-called "Working for Water" and "Working on Fire" programs) for the eradication of invasive alien plant species along river streams. The government established these programs to restore water catchments, and the programs jointly address poverty alleviation and ecological restoration by employing restoration workers from poor local communities (McConnachie et al. 2013). The livelihood survey was conducted in the KwaZulu-Natal province of South Africa in November 2019 and February 2020. The survey questionnaire covered the workers' socioeconomic backgrounds, their motivations, and the benefits they receive from the restoration project. Drawing on the Sustainable Livelihood Framework (Scoones 2009; DFID 1999), the survey focused on capturing changes in the workers' financial assets (e.g., income and employment), physical assets (e.g., electricity and heating facilities), human assets (e.g., health and education), natural assets (e.g., access to soil and wood), social assets (e.g., friends and networks), and political assets (e.g., decision-making and benefits distribution). Besides the survey—conducted by two local enumerators—semi-structured interviews were conducted with other project members, 12 contractors (responsible for organizing the transport, alien plant clearing, and salary payment), two supervisors, two managers, and one project coordinator.

The second study took place in the City of Tshwane, South Africa, in 2021 and 2022. The overall aim of the study was to gain knowledge on local people's use, perceived benefits and risks, challenges, and dreams relating to their nearby urban nature. A survey and semi-structured interviews were conducted in two study sites (Atteridgeville and Mabopane) among local community members living in the proximity of publicly accessible unmanaged urban green spaces hosting remnants of natural vegetation mixed with illegal (migrant) settlements, dumping sites, and informal activities like waste sorting, gardening, and livestock keeping. More specifically, the community survey was structured around nature perceptions and environmental justice dimensions (distributive, procedural,

and as recognition). A handful of targeted sub-studies aided deeper investigations into human-nature relations, sense of place, gender perspectives, environmental activism, and informal settlements. One of these parallel targeted studies applied photovoice research[4] conducted by two international university students and two local photographers. Participants from local schools in Mabopane were taught the basic principles of photography before being tasked to venture into their local unmanaged green spaces to take photographs. The photographs were later displayed in a public outdoor exhibition. Preparation for the photovoice project included conversations and logistical planning with local artists and teachers to ensure participant engagement and benefits. During the photovoice project, six focus group discussions, guided by reflections from participants about their photographs, were conducted to deliberate perceptions, values, and agency felt about nature and the green space.

For both studies, ethical clearance was granted by the respective research institutions and local authorities (City Strategy and Organisational Performance, the City of Tshwane, 17 and 28 June 2021), and consent forms were collected for all research participants. The survey and interview respondents, as well as the photovoice participants and focus groups, were offered cold drinks and a small snack as a token of appreciation for their time, but no monetary exchange was made.

RESULTS AND ANALYSIS: LEARNING FROM EXPERIENCE TO PUSH CITIZEN SCIENCE BEYOND SCIENCE

The livelihood survey among the restoration teams in KwaZulu-Natal revealed improved livelihood benefits (Figure 1) for the workers, especially in terms of financial, human, and social assets (as also reported by Olesen et al. 2021).

The educational component of the human asset responses, in particular, is thought-provoking from a CS perspective. Many workers specified what they had learned from the restoration training and activities, such as knowing about different plant species (e.g., their water requirements and whether they are alien or indigenous), and how to handle snakes and insects. While most workers had taken the restoration job to earn a living or because it was assigned to them through the public works programs, many also stated their motivation as driven by a desire to help the community and to protect nature and water sources. Extensive material, including an illustrated book for species identification and various pieces of equipment, was available to the restoration teams, who received training and supervision before and during the work. After the training, the knowledge and skills of the workers were well advanced and visible. As noted by a manager of eight restoration teams, who explains how he enjoys the link between conservation and people:

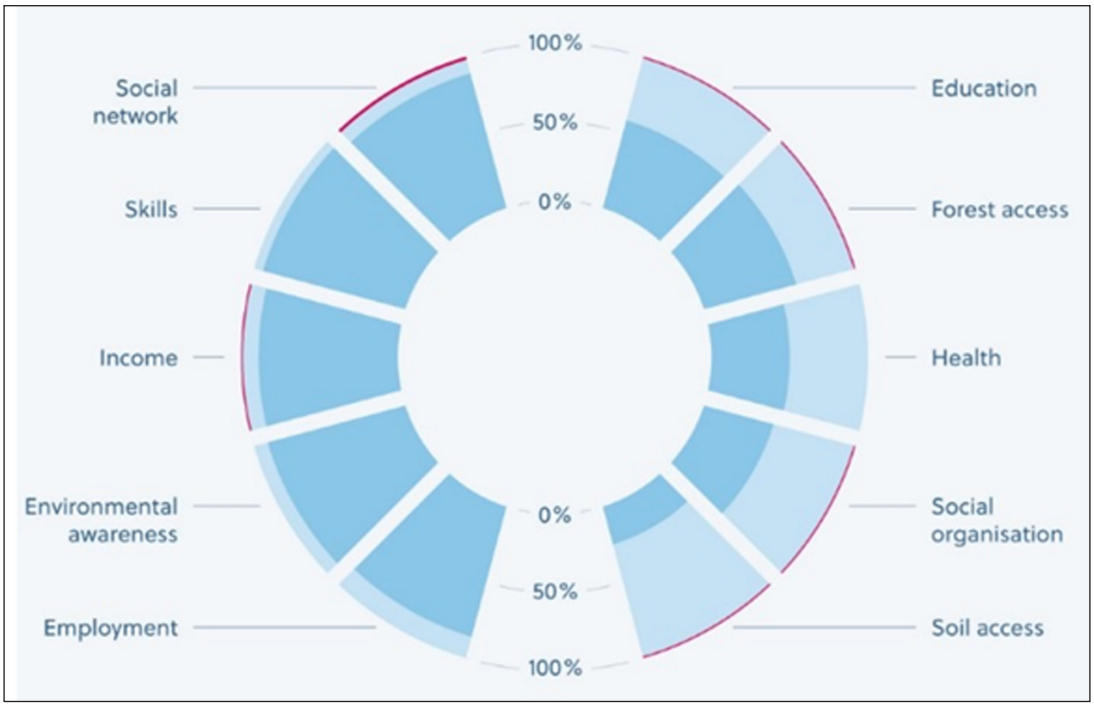

Figure 1 Changes in livelihood benefits due to involvement in restoration projects as perceived by the restoration workers. The diagram shows the percentage of workers perceiving benefits as increased (*blue*), as having no effect (*light blue*), or as decreased (*red*). N = 181. Source: Pasgaard et al. 2021.

> People are growing from this work, some start studying, and many raise their environmental awareness. We try to upscale people with training, first aid, etc. From being poor, they progress in life. You see immediate results (interview, uMngeni catchment, 2019-11-26).

Besides gaining knowledge and skills about nature and nature rehabilitation themselves, several workers and contractors brought these skills and knowledge into their community to teach their children and neighbors—some even removed alien plant species at their own settlements (Pasgaard and Fold, unpublished). The livelihood survey also showed that two-thirds of the workers felt that their team practiced joint decision-making Pasgaard and Fold, unpublished), indicating a collaborative culture in some of the teams. While the economic and hydro-ecological benefits and trade-offs from the restoration program have been evaluated, most assessments are conducted at catchment scales, and the monitoring of benefits, such as fire prevention and biodiversity preservation, are lacking (Hosking and du Preez 2004), including monitoring by the restoration teams themselves.

The community survey, interviews, and photovoice project conducted in the city of Tshwane gave a contrasting picture of the human-nature relationships and activities among urban residents. The survey revealed that many residents feel that the local community—instead of the government—should be the owners of the urban green spaces (Figure 2), suggesting a secret or indirect sense of ownership and a potential to upgrade local engagement and co-management. This potential seems partly hindered by a lack of influence in decisions about the green space. Specifically, more than three out of four (85%) respondents perceived their local community's influence as absent or low, indicating a feeling of alienation from management and perhaps then low responsibility; a responsibility they might be interested in having, given the values they tie to their urban green space (Figure 3). This suggests that the community feels attached to the area, despite the low actual use of the urban green spaces and a strong sense of insecurity, which is accredited to negative aspects, mainly pollution, crime, and lack of management (Engemann et al., unpublished).

When asked directly, an overwhelming number of residents expressed a willingness to participate in community-driven activities exemplified by the maintenance of facilities, safety measures like community guards, provisional services like gardening, or educational activities like teaching youth. What holds people back from engaging in such activities, according to the respondents themselves, is primarily time and resource constraints, safety concerns, and a lack of (knowledge about) the

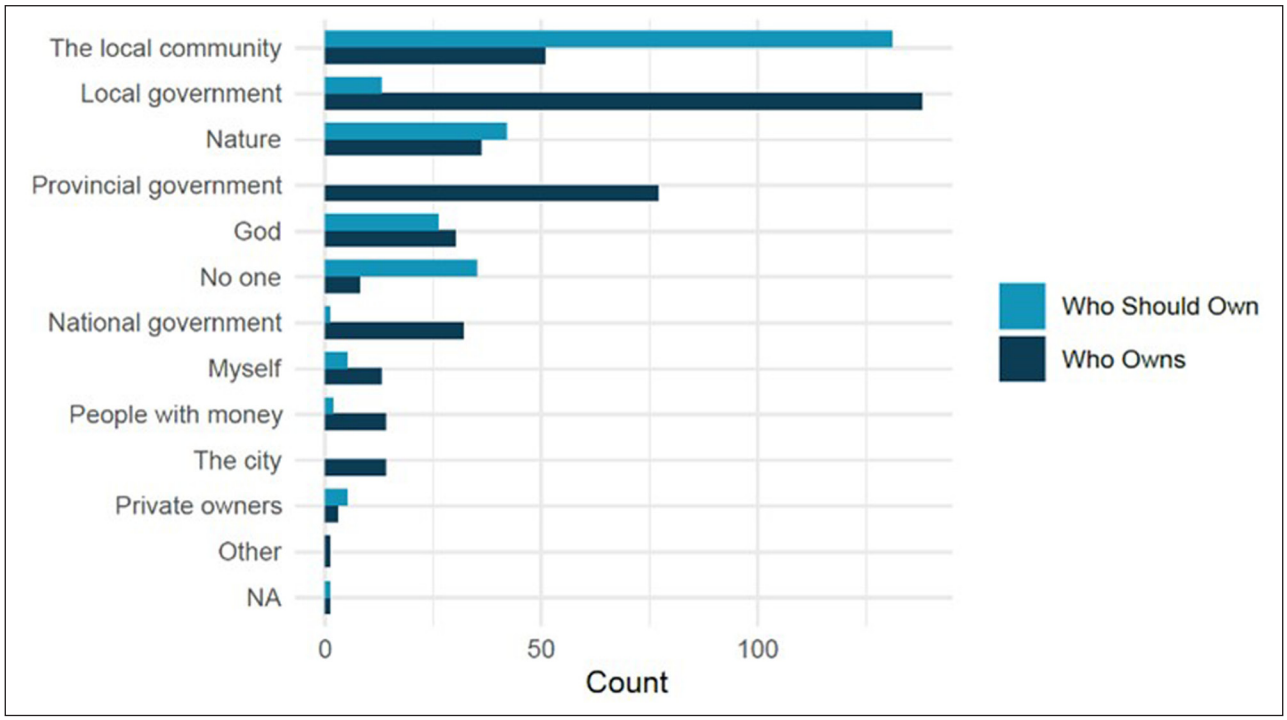

Figure 2 Responses to questions about who owns and who should own the green space. Many residents believe that the urban green space belongs to the local, provincial or national government. Yet, when asked who should own the area, "local community" is the most popular response, while "no one" and "nature" also increase in popularity. Multiple answers were allowed to each question. N (respondents) = 200.

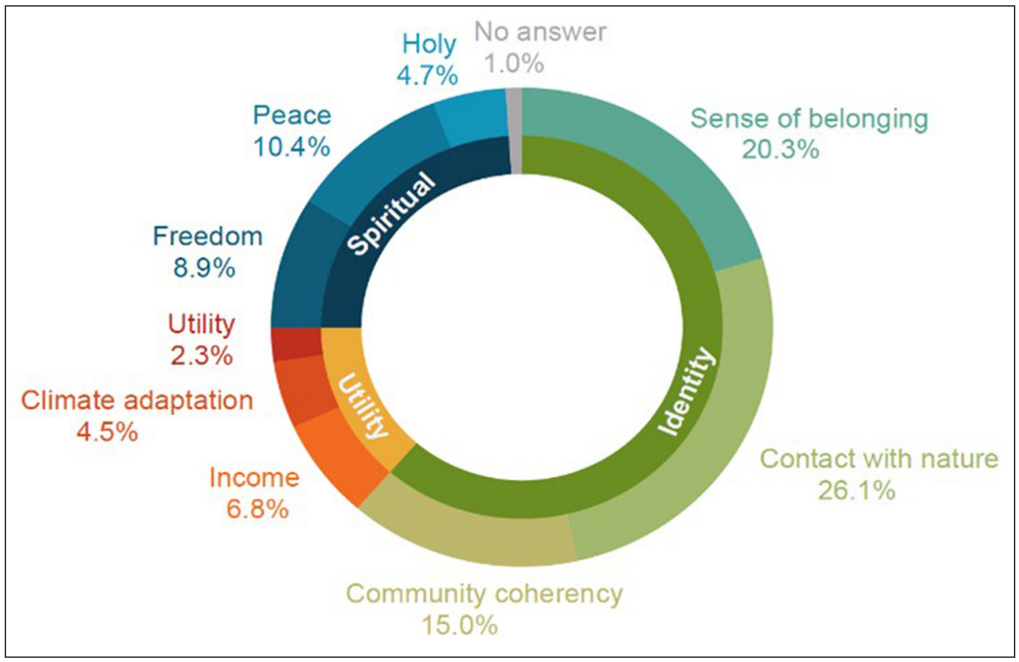

Figure 3 Frequency of values selected from a card with icons naming and illustrating each value. Local residents hold strong identity-related values about their urban green space, followed by values like peace, freedom and holiness. Use values, including climate adaptation and income, are less frequently selected. All respondents selected up to three values each. N (respondents) = 200.

organization of such activities and opportunities to get involved. This was expressed by a young woman (aged 24, Mabopane), who said she is willing to engage in the maintenance of community facilities, but she is held back by a lack of support, while feeling a need to "join forces [...] to change the site." An older man (aged 71, Atteridgeville) explained how the community has drastically changed, since the area used to be much cleaner, safer, and better maintained, but "there are no organizations that drive the community to push such agendas forward." Interestingly, while this frustration was echoed by several residents, such organizations do exist at both sites, leaving questions about the visibility, recruitment, and awareness of such activities.

Strong community interest in the research was also apparent, particularly in Mabopane. This was illustrated by some people waiting in line to be interviewed for the survey, and the vast majority of people voluntarily providing their names and phone numbers for the local enumerators in case the researchers wished to contact them again—some even asking to be part of research activities in the future. Similarly, the photovoice research indicated an eagerness to be involved in research-based community activities in and around urban nature, despite its unmanaged character and strong perceptions of insecurity. The artistic approach involved the community in a reciprocal way rather than being solely extractive. This strengthened the trust between the community and the researchers (see Knudsen et al. 2022), and perhaps this was made even stronger as the young international photovoice research team represented different genders and backgrounds.

From an educational perspective, the unique interactions and co-development of the research between the academics (scholars and researchers), local artists (photographers), and schoolteachers illustrated an untraditional setup, in which the activities were adapted to the local context and needs of the community. Especially with the youngest participants, the learning opportunity, the after-school activity, and the photography certificate they earned incentivized their participation (personal observations). The missing link in this co-creation and transformation of human-nature relations was the involvement of local authorities like city officials. These political stakeholders were asked for initial formal permission to engage with the community and were invited to the outdoor exhibition, but they did not become an integrated part of the whole collaborative process (see the Discussion section).

OPPORTUNITIES AND CHALLENGES FOR CITIZEN SCIENCE BEYOND SCIENCE

Results from the two studies reveal both opportunities and challenges for adding and co-developing CS components—not only for sustainable development progress and monitoring, but to simultaneously facilitate transformative change.

The restoration workers from our first study gained knowledge about nature and how to protect it. This presented an obvious opportunity to integrate, for instance, species registration and water-quality assessment into

their standing activities. An added and co-developed CS component could further increase their skills and sense of pride, as already documented for such restoration programs (Olesen et al. 2021; DEA 2019). Prospective CS activities could also add to the social and political livelihood assets through an increased sense of belonging and ownership (see also Golding 2021), as well as extending networks that bring in academic partners or environmental education. The latter components could be facilitated through free, easy-to-use monitoring software and platforms, such as EpiCollect (Aanensen et al. 2009), iNaturalist (iNaturalist 2022), or the River and Ocean Cleanup Survey (OceanCleanUp 2022). Through these tools, the workers can (co-)develop surveys and identify species themselves, and thereby build digital know-how. Inviting local schoolchildren to visit the restoration teams and take part in some of the easy and safe activities, such as the identification of recognizable species and the removal of non-toxic invasives, could increase environmental awareness and the broader uptake of skills across generations. Some, but not all restoration teams already practiced joint decision-making, leaving space for the co-development of CS methods that allow for the inclusion of local knowledge systems integrated back into the CS theory and tools. Other teams were more hierarchical and top-down, calling attention to various baselines of collaboration, which should be considered in prospective participatory processes (cf. Pasgaard et al. 2017). In addition, the stop-and-go nature of restoration programs, which is rooted in unpredictable and changing budget allocations (see also McConnachie et al. 2013), hinders a continuous exchange of knowledge, skills, and awareness between the workers and the broader community in time and space. This lack of continuity could also negatively affect a potential CS monitoring process, requiring flexible protocols for data collection.

In the urban context of our second study, the local community appears enthusiastic to get involved in both community and research activities, but is held back by a lack of resources, opportunities, and concerns about their safety when entering densely vegetated areas. Similar to the ecological restoration, the photovoice activities could have integrated a CS component of species recordkeeping for ecological monitoring, applying similar digital tools and simple methods as described above, showing the potential of CS in art-based research. While the research-driven photography activities and exhibition were successful in mutually benefitting the research project, university students, artists, local teachers, and participants, the engagement of city officials could have been strengthened through more formal process-oriented and task-driven approaches, if these were aligned with the city's institutional goals and strategies.

Leaning on experiences from both studies, CS potentials in future projects are clear, but questions remain regarding who should initiate and lead the activities (including beyond the research project period), and how to close the divide between stakeholder hierarchies. While the inclusion of the local community and local authorities in all CS processes could be the answer to both questions, both groups of stakeholders are juggling multiple tasks and pressing priorities, while their joint presence would bring up deeper issues of (dis)trust, informality, and illegality (e.g., settlements and crime), and contested ownership. Moreover, the suggested collaborative approaches to CS integration could clash with cultural hierarchies including compulsory entry points through ward councilors and public programs, and communications that maintain a cultural worldview of order and legitimacy through hierarchy. Acknowledging that these processes, despite their limitations, aim to maintain equal access to benefits (Cobbinah et al. 2020), the responsibilities of stakeholders, processes, and outcomes of CS can be different for different projects, as suggested in the following.

For ecological restoration projects, the organization and setting of targets are already in the hands of professional coordinators and managers who would be able to integrate the CS monitoring of vegetation and water with local knowledge, if this becomes a stated priority. It will require changes in work protocols, training, and data handling, but the infrastructure and expertise exist. Examples are found in which local people with nature-based livelihoods do natural resource monitoring for sustainable management and provide policy recommendations (Johnson et al. 2016).

For art-based CS activities, the local anchoring of future projects through a collaboration between community groups, youth clubs, and public schools seems feasible given that the willingness and capacity are present. To realize this potential, higher education institutions, such as universities, and municipal or governmental departments in charge of sustainable development, could facilitate the process following the photovoice example above, but with a stronger inclusion of community members to design and conduct the activities. In countries of historical, political, cultural, and socio-economic divides, CS can also serve the purpose of bringing researchers, students, and practitioners closer to the worldview, beliefs, and nature understandings of the people they work with.

By following these examples and approaches, the CS activities become much more than scientific data collection and one-way capacity building of "scientific" skills. In a reciprocal, collaborative process, the outcomes will more purposefully fit and appropriately respond to the intangible local realities, while community practices and knowledge systems receive well-deserved attention and recognition.

DISCUSSION: RETHINKING CITIZEN SCIENCE TOWARDS MORE INCLUSIVE AND TRANSFORMATIVE CHANGE

Based on the two empirical examples, the analysis above paints a relatively optimistic picture of the opportunities for integrating CS in development research and practice in South Africa. Here, we rethink the conceptualization, incentives, and baselines for CS before we exemplify the use of CS in achieving and tracking the SDGs, and point a way forward.

RETHINKING BOTH THE "CITIZEN" AND THE "SCIENCE" IN A GLOBAL SOUTH CONTEXT

In the context of South Africa and elsewhere in Africa (see Pocock et al. 2019), as well as in, for instance, Inuit, Native American, or aboriginal communities in the so-called Global North, disputes about citizenships, territories, and knowledge systems are ongoing (Ernstson and Sverker 2019). Our research highlights issues of trust, illegality, ownership, and traditional practices, which clash with the formally institutionalized perceptions of being recognized "citizens" (Ansoms and Cioffo 2016), and with ideas about producing reliable, repeatable, generalizable scientific data for CS (Johnson et al. 2021). This, in turn, calls for a rethinking or reconceptualization of CS, both in terms of terminology (see Eitzel et al. 2017) and practice.

We, the science community, (should) have an improved understanding of how local communities connect to nature and socioecological systems (Cocks et al. 2016), and how this can contribute to stewardship initiatives (Toomey et al. 2020). As our research shows, CS provides an opportunity to advance this link between local (Indigenous) understanding and the need to protect, restore, and monitor nature; not only to collect hard data, which is a tendency in many CS projects (Golding 2021), but by deepening the understanding and respect for different types of knowledge, and by advancing conventional scientific methods with locally adapted ways of doing and knowing (Cocks et al. 2016). We need to look beyond only strengthening local capacities in conducting science as we researchers understand it. We should also extend the benefits of CS beyond those individuals who engage in the activities at a certain point in time. Lessons from our research indicate how community-based restoration and art-based research approaches can potentially lead to greater environmental awareness and care for nature across various stakeholders if they are all included throughout the process. This opens an avenue for integrating CS to strengthen mutual capacities through dual incentives and collaborative processes. While these aspects are explored further below, the starting point should be a renegotiation of who stands to benefit and how (besides the researcher and the "citizen"), and what knowledge and understanding we are seeking together and for what purpose (besides science).

RETHINKING INCENTIVES IN CITIZEN SCIENCE—FROM BOTH PARTICIPANT AND RESEARCHER PERSPECTIVES

In a context in which many participants have few resources, short or no formal education, and other disadvantages rooted in historical injustices, incentives are needed to develop CS projects that explicitly voice community needs and interests. Such "community-based science" or "extreme citizen science" projects are designed by bottom-up collaborations, and most likely differ from the "traditional" CS ones that gather volunteers to large-scale projects designed by scientists (Bonney 2021). Since many participants might be economically constrained or unemployed, incentives become an ethical consideration, and not just a known bias (Pretty 2003). If incentives are used in terms of paid work or financial compensation, this could corrupt the motives of engaging in pro-environmental behavior (Pretty 2003) or spur conflict within the community in terms of who gains access to these incentives. In this context, even a small monetary payment means an extra nutritious meal or paying school fees (cf. Pasgaard et al. 2021). Even so, our research shows how the restoration workers were not only driven by the income opportunity, but by desires to help people and the planet. In the urban study, participants did not receive any financial paybacks; rather, they expressed their willingness and were engaged because of the opportunities for learning and socializing. Perhaps participation was encouraged by genuine interest and recognition from the (student) researchers (also reported by Roux et al. 2017), or by relations of trust, exchange, and feelings of connectedness (as advocated by Pretty 2003).

While several studies discuss how to raise incentives for CS participants (e.g., Wehn and Almomani 2019), few scholars discuss the need for CS projects to explicitly incentivize researchers (or other CS facilitators), not overlooking other stakeholders like local authorities and funding agencies to include, acknowledge, and promote CS (Skarlatidou et al. 2019). Our research findings lay out several prospective benefits for CS facilitators and other stakeholders, including the acquisition of locally adapted data, the advancement of conventional scientific knowledge and practices, and the co-development of need-based solutions. For researchers to include CS in their project portfolio, organizational incentives also need to be in place. Such incentives could materialize as more and targeted courses in CS, interdisciplinary networking platforms (see AU 2022; TBA 2022), and funding opportunities.

RETHINKING COLLABORATION IN CITIZEN SCIENCE TOWARD TRANSFORMATIVE CHANGE

Hierarchical cultural departure points and conventional scientific worldviews can sidetrack inclusive and collaborative CS. On both sides of the collaboration, the citizen and the scientist need to transform their mindsets. Collaborative management partnerships can influence community perceptions and change ideas about nature disservices (Graham 2015), fears, and taboos, and can change the researchers' and students' perceptions of nature values and benefits (Breed and Mehrtens 2022). Collaborative approaches need to rest on several interlinked criteria, such as an institutional culture that is receptive and committed to learning from outcomes (Roux et al. 2017), champions who are embedded in the relevant institutions and communities (Roux et al. 2017), and partners who are all conscious of social rules and managing expectations (Pretty 2003), especially those coming from different countries and/or cultures. To be worth the effort and time for all involved, incentives also need to be in place, as argued above. The CS outcomes and engagement should ideally stretch beyond the project activities in time and place, and across stakeholders to be truly transformative through fundamental structural change and adaptive approaches (cf. IPBES 2019). To ignite and incentivize such a process, all stakeholders should join forces for a common purpose. That purpose could be reaching and tracking sustainable development.

CITIZEN SCIENCE AND (THE ASSESSMENT OF) SUSTAINABLE DEVELOPMENT

Transdisciplinary, community-based, interactive, or participatory research approaches—like the approaches we propose in this paper—have the potential to address real-world problems in a sustainable and transformative manner (Lang et al. 2012). For instance, community collaboration and CS can aid in the maintenance of natural open-space systems (Sullivan and Molles 2016), which falls under Target 15.1 of SDG 15 (Life on Land), the conservation of ecosystems. There is more to gain, however, especially in light of the current lack of monitoring and data collection in the Global South (Fraisl et al. 2020; UN 2022). In other words, CS can be part of both reaching and monitoring the attainment of the SDGs. While our proposed collaborative CS activities pursue multifunctionality by simultaneously addressing several SDGs, we can illustrate the specific potentials by looking at SDG 6 for Water and Sanitation (Figure 4), for instance. Our study on ecological restoration indicates an unrealized potential of community-led initiatives to reduce and monitor water pollution (Target 6.3) and thereby track, protect, and restore water-related ecosystems (Target 6.6) through a strengthening of "the participation of local communities in water and sanitation management" (Target 6b). These targets link directly to SDG 16, Strong Institutions and Education; SDG 4, Quality Education (through community participation); SDG 12, Responsible Consumption and Production (by reducing

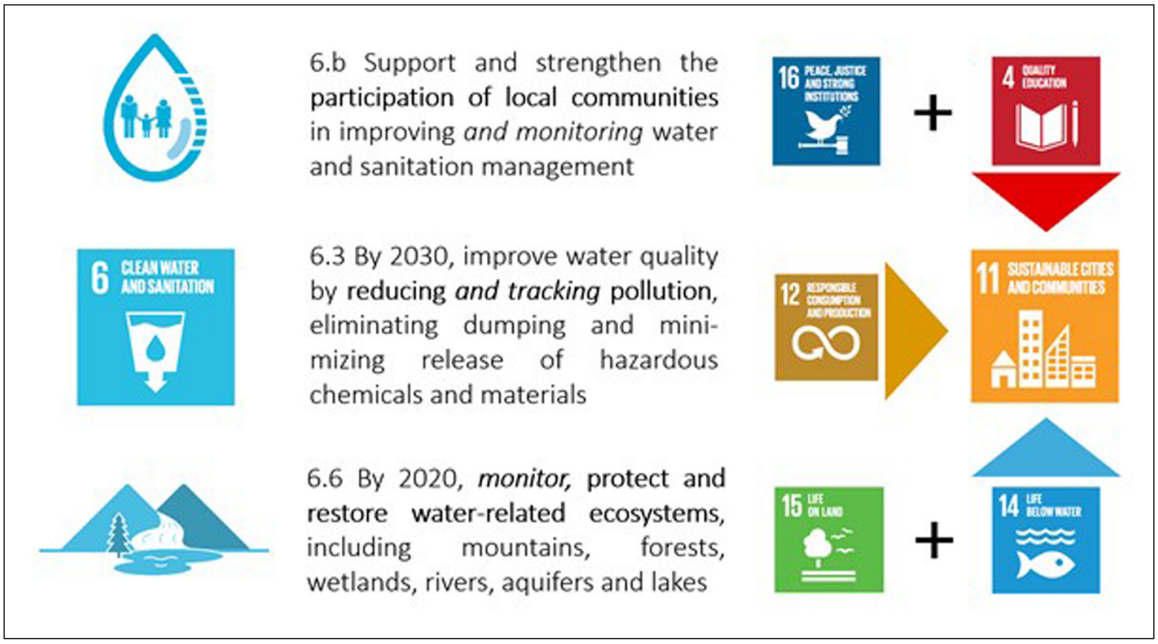

Figure 4 The potential of citizen science to improve specific targets for Sustainable Development Goal 6—Clean Water and Sanitation—and how improvements relate to several other goals. Icons and text adapted from https://sdgs.un.org/goals (text in italics added by authors).

pollution); SDG 15, Life on Land; and SDG 14, Life below Water (by restoring ecosystems) for moving towards SDG 11, Sustainable Cities and Communities.

Lastly, there is a need to consider the scientific quality of CS data and whether it will be accepted in the SDG assessment machinery, for instance, in terms of standardization and quality assurance (Fraisl et al. 2020). Here, a main challenge is the diverse cultural backgrounds—including language and worldview (spiritual/religious) —that might make the interpretation of recorded phenomena harder to reconcile between different communities and worlds of thought. Roux et al. (2017) warn that all transdisciplinary research must guard against the perceived superiority of scientific knowledge, and Engels and Waltz (2018) point out that successful collaboration relies on working constructively with our differences instead of forcing unified perspectives. In line with this thinking and our collaborative and reciprocal approach, we argue in favour of integrating CS into the methodologies of SDG indicators based on an inclusive discussion of data quality criteria and processes. For such integration, early dialogues and collaboration with data end-users (e.g., national statistical authorities) are of paramount importance (Kosmala et al. 2016).

WAY FORWARD AND AFTERWORD

For transformative change to happen through CS, we need to extend our perception of the outcomes and capacities of CS across time and social/institutional scales. Based on our research, we outline how long-lasting structural changes in science and society can potentially be aided by several concrete CS initiatives, including:

- the involvement of stakeholders (including local authorities and statistical departments) throughout the process, while being mindful of informalities and trust;
- mutual capacity building among participants and facilitators/researchers through the integration of different knowledge systems and practices;
- the co-development of easy-to-use monitoring tools and guidelines adapted to the local context and applicable to (existing) activities;
- on-site engagement beyond the project period and immediate participants (e.g., by the inclusion of educational institutions); and
- the integration of CS lessons and practices across perceived North-South divides, such as the inclusion of reciprocity and incentive exchange that is (perhaps non-monetary, yet) economically beneficial for disadvantaged communities.

As an untraditional afterword, we wish to mention that to practice what we preach in this paper, we are initiating several projects with elements of CS that follow the collaborative approach proposed. We encourage interested readers to contact the corresponding author for more information and the exploration of potential for collaboration.

NOTES

1 We use the term citizen science in line with this special collection, but encourage discussions on the terminology (see Eitzel et al. 2017).

2 We use the terms Global South and Global North in the absence of better terms (e.g., developed versus developing).

3 Our definition of transformative change leans on that given in the report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019, p. 14) as a "fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values," while our broad take on sustainability rests on inter- and intra-generational equity, cf. the Brundtland (1987) report.

4 Details on methods and data from the Tshwane study can be found in the student dissertations (Heines 2022; Knudsen 2023) available online.

ACKNOWLEDGEMENTS

The authors would like to thank all the restoration workers, managers, and residents who took part in the surveys and interviews, and all the participants, along with local schoolteachers and photographers Lwandiso Colo and Sibusiso Mdluli, who engaged in the photovoice research. Special thanks to Zama, Jadir, Sinobelo, Sifiso, Lwandiso, Rose, and Elvis who contributed with (cultural) translation and data collection.

FUNDING INFORMATION

The research is funded by the Danish Ministry of Foreign Affairs through the Danida Fellowship Centre grants for "Socio-Economic Benefits of Ecological Infrastructure" (SEBEI) (Grant No.17-M07-KU) and "Integrative Green Infrastructure Planning" (GRIP) (Grant No. 20-M09AU).

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Overall conception by Maya Pasgaard, with contributions to the initial idea and outline from Christine Breed, Kristine Engemann, and Maria Elizabeth Heines. Data was collected

by Maya Pasgaard, Maria Elizabeth Heines, and Linette Knudsen with the help from local translators. The initial data analysis and writing of the first draft were done by Maya Pasgaard, and all authors contributed to the subsequent analyses and article versions.

AUTHOR AFFILIATIONS

Maya Pasgaard orcid.org/0000-0003-4536-9621
Aarhus University, DK

Christina Breed orcid.org/0000-0003-2185-8367
University of Pretoria, ZA

Maria Heines
University of Copenhagen, DK

Linette Knudsen
University of Copenhagen, DK

Peta Brom orcid.org/0000-0002-9183-438X
University of Pretoria, ZA

Astrid Schmidt
Nordic Foundation for Development and Ecology (NORDECO), Copenhagen, DK

Kristine Engemann orcid.org/0000-0003-1431-1726
Aarhus University, DK

REFERENCES

Aanensen, DM, Huntley, DM, Feil, EJ, Al-Own, FA and **Spratt, BG.** 2009. EpiCollect: Linking smartphones to web applications for epidemiology, ecology and community data collection. *PLOS ONE*, 4: e6968. DOI: https://doi.org/10.1371/journal.pone.0006968

Altinget. 2022. Danmark og Sydafrika skal være partnere i den grønne omstilling, 18 February 2022. Available as https://www.altinget.dk/artikel/danmark-og-sydafrika-skal-vaere-partnere-i-den-groenne-omstilling. DOI: https://doi.org/10.7146/samfundsokonomen.v2022i2.132839

Anderson, PL, Okereke, C, Rudd, A and **Parnell, S.** 2013. Regional assessment of Africa. In: Elmqvist, T, Fragkias, M, Goodness, J, Güneralp, B, Marcotullio, PJ, Mcdonald, RI, Parnell, S, Schewenius, M, Sendstad, M, Seto, KC and Wilkinson, C (eds.), *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*. Netherlands: Springer.

Angelstam, P, Barnes, G, Elbakidze, M, Marais, C, Marsh, A, Polonsky, S, Richardson, DM, Rivers, N, Shackleton, RT and **Stafford, W.** 2017. Collaborative learning to unlock investments for functional ecological infrastructure: Bridging barriers in social-ecological systems in South Africa. *Ecosystem Services*, 27: 291–304. DOI: https://doi.org/10.1016/j.ecoser.2017.04.012

Ansoms, A and **Cioffo, GD.** 2016. The exemplary citizen on the exemplary hill: The production of political subjects in contemporary rural Rwanda. *Development and Change*, 47: 1247–1268. DOI: https://doi.org/10.1111/dech.12271

AU. 2022. AU citizen science. Aarhus University (AU). Available at https://projects.au.dk/citsci.

Ballard, HL, Dixon, CGH and **Harris, EM.** 2017. Youth-focused citizen science: Examining the role of environmental science learning and agency for conservation. *Biological Conservation*, 208: 65–75. DOI: https://doi.org/10.1016/j.biocon.2016.05.024

Bonney, R. 2021. Expanding the impact of citizen science. *BioScience*, 71: 448–451. DOI: https://doi.org/10.1093/biosci/biab041

Breed, C and **Mehrtens, H.** 2022. Using "live" public sector projects in design teaching to transform urban green infrastructure in South Africa. *Land*, 11: 45. DOI: https://doi.org/10.3390/land11010045

Brundtland, GH. 1987. Our Common Future: Report of the World Commission on Environment and Development. Geneva: UN-Dokument A/42/427.

BusinessTech. 2016. The "goodest" countries in the world – where does South Africa rank? Available at https://businesstech.co.za/news/trending/125997/the-goodest-countries-in-the-world-where-does-south-africa-rank/.

Chowdhury, S, Gonzalez, K, Aytekin, MÇK, Baek, S-Y, Bełcik, M, Bertolino, S, Duijns, S, Han, Y, Jantke, K, Katayose, R, Lin, M-M, Nourani, E, Ramos, DL, Rouyer, M-M, Sidemo-Holm, W, Vozykova, S, Zamora-Gutierrez, V and **Amano, T.** 2022. Growth of non-English-language literature on biodiversity conservation. *Conservation Biology*, 36(4): e13883. DOI: https://doi.org/10.1111/cobi.13883

Cobbinah, PB, Gaisie, E, Oppong-Yeboah, NY and **Anim, DO.** 2020. Kumasi: Towards a sustainable and resilient cityscape. *Cities*, 97: 102567. DOI: https://doi.org/10.1016/j.cities.2019.102567

Cock, J. 2006. Connecting the red, brown and green: The environmental justice movement in South Africa. In: *Voices of Protest: Social Movements in Post-Apartheid South Africa*, pp. 179–201.

Cocks, M, Alexander, J, Mogano, L and **Vetter, S.** 2016. Ways of belonging: Meanings of "nature" among Xhosa-speaking township residents in South Africa. *Journal of Ethnobiology*, 36: 820–841. DOI: https://doi.org/10.2993/0278-0771-36.4.820

Danielsen, F, Johnson, N, Lee, O, Fidel, M, Iversen, L, Poulsen, MK, Eicken, H, Albin, A, Hansen, SG, Pulsifer, PL, Thorne, P and **Enghoff, M.** 2021. *Community-Based Monitoring in the Arctic*. University of Alaska Press.

DEA. 2019. A socio-economic, environmental and economic impact evaluation of selected EPWP programmes within the Environmental Programmes branch for the period 2012–2016. Draft 1c. Department of Environemntal Affairs (DEA).

Denhardt, J, Terry, L, Delacruz, ER and **Andonoska, L.** 2009. Barriers to citizen engagement in developing countries. *International Journal of Public Administration*, 32: 1268–1288. DOI: https://doi.org/10.1080/01900690903344726

DFID. 1999. Sustainable livelihoods guidance sheet. London, UK: Department for International Development.

Eitzel, MV, Santos-Lang, C, Duerr, RE, Virapongse, A, West, SE, Kyba, C, Bowser, A, Cooper, CB, Sforzi, A, Metcalfe, AN, Harris, ES, Thiel, M, Haklay, M, Ponciano, L, Roche, J, Ceccaroni, L, Shilling, FM, Dörler, D, Heigl, F, Kiessling, T, Davis, BY and **Jiang, Q.** 2017. Citizen science terminology matters: Exploring key terms. *Citizen Science: Theory and Practice*, 2: 1–20. DOI: https://doi.org/10.5334/cstp.96

Engels, A and **Walz, K.** 2018. Dealing with multi-perspectivity in real-world laboratories: Experiences from the transdisciplinary research project urban transformation laboratories. *GAIA – Ecological Perspectives for Science and Society*, 27: 39–45. DOI: https://doi.org/10.14512/gaia.27.S1.10

Engemann, K, Breed, C, Brom, P and **Pasgaard, M.** unpublished. Multifunctional and unmanaged: Unexpected synergies between health and biodiversity benefits from urban green spaces in the City of Tshwane, South Africa. In *preperation for journal submission*.

Ernstson, H and **Sverker, S.** 2019. *Grounding Urban Natures: Histories and Futures of Urban Ecologies*. Cambridge, MA: MIT. DOI: https://doi.org/10.7551/mitpress/11600.001.0001

Farnsworth, BE. 2011. Conservation photography as environmental education: Focus on the pedagogues. *Environmental Education Research*, 17: 769–787. DOI: https://doi.org/10.1080/13504622.2011.618627

Fraisl, D, Campbell, J, See, L, Wehn, U, Wardlaw, J, Gold, M, Moorthy, I, Arias, R, Piera, J, Oliver, JL, Masó, J, Penker, M and **Fritz, S.** 2020. Mapping citizen science contributions to the UN sustainable development goals. *Sustainability Science*, 15: 1735–1751. DOI: https://doi.org/10.1007/s11625-020-00833-7

Golding, J. 2021. South African groundwater project shows the power of citizen science. *The Conversation*. Available at https://theconversation.com/south-african-groundwater-project-shows-the-power-of-citizen-science-172309.

Good Country Index. 2022. The Good Country Index. Available at https://index.goodcountry.org/.

Graham, M. 2015. Everyday human (in)securities in protected urban nature – collaborative conservation at Macassar/Wolfgat dunes nature reserves, Cape Town, South Africa. *Geoforum*, 64: 25–36. DOI: https://doi.org/10.1016/j.geoforum.2015.05.016

Guinand, S, Rojo, AM and **Scherner, M.** 2021. Exploring lived space of new build urban environment through photovoice interview. *Cidades*, 43. DOI: https://doi.org/10.15847/cct.23864

Heines, M. 2022. Political opportunities and threats impacting the emergence of environmental justice movements in urban green spaces. University of Copenhagen. Available at https://bio.au.dk/en/research/research-centres/biochange/research/grip.

Hosking, SG and **Du Preez, M.** 2004. A cost-benefit analysis of the *Working for Water Programme* on selected sites in South Africa. *Water SA*, 30(2): 143–152. DOI: https://doi.org/10.4314/wsa.v30i2.5059

iNaturalist. 2022. How it works. Available at https://www.inaturalist.org/.

IPBES. 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Johnson, N, Behe, C, Danielsen, F, Krümmel, EM, Nickels, S and **Pulsifer, PL.** 2016. Community-based monitoring and indigenous knowledge in a changing arctic: A review for the sustaining arctic observing networks. *Sustain Arctic Observing Network Task*, 9: 74.

Johnson, N, Druckenmiller, ML, Danielsen, F and **Pulsifer, PL.** 2021. The use of digital platforms for community-based monitoring. *BioScience*, 71: 452–466. DOI: https://doi.org/10.1093/biosci/biaa162

Kay, AD, Scherber, E, Gaitan, H and **Lovelee, A.** 2019. Transitional ecology: Embedding ecological experiments into temporary urban public art. *Journal of Urban Ecology*, 5. DOI: https://doi.org/10.1093/jue/juz020

Klopp, JM and **Petretta, DL.** 2017. The urban sustainable development goal: Indicators, complexity and the politics of measuring cities. *Cities*, 63: 92–97. DOI: https://doi.org/10.1016/j.cities.2016.12.019

Knudsen, L. 2023. Abandonment or opportunity? A situated study of sense of place and place-making in the Mabopane River Corridor. University of Copenhagen. Available at https://bio.au.dk/en/research/research-centres/biochange/research/grip.

Knudsen, L, Heines, M, Pasgaard, M, Colo, L and **Ngcobo, S.** 2022. My Mabopane: Opportunities of photo-voice to support inclusive urban green space engagement and plannings. The City is [Not] a Tree: The Urban Ecologies of Divided Cities, South Africa.

Kosmala, M, Wiggins, A, Swanson, A and **Simmons, B.** 2016. Assessing data quality in citizen science. *Frontiers in Ecology and the Environment*, 14: 551–560. DOI: https://doi.org/10.1002/fee.1436

Lang, DJ, Wiek, A, Bergmann, M, Stauffacher, M, Martens, P, Moll, P, Swilling, M and **Thomas, CJ.** 2012. Transdisciplinary

research in sustainability science: Practice, principles, and challenges. *Sustainability Science*, 7: 25–43. DOI: https://doi.org/10.1007/s11625-011-0149-x

Lannas, KSM and **Turpie, JK.** 2009. Valuing the provisioning services of wetlands contrasting a rural wetland in Lesotho with a peri-urban wetland in South Africa. *Ecology and Society*, 14. DOI: https://doi.org/10.5751/ES-02919-140218

Masterson, VA, Mahajan, SL and **Tengö, M.** 2018. Photovoice for mobilizing insights on human well-being in complex social-ecological systems case studies from Kenya and South Africa. *Ecology and Society*, 23. DOI: https://doi.org/10.5751/ES-10259-230313

McConnachie, MM, Cowling, RM, Shackleton, CM and **Knight, AT.** 2013. The challenges of alleviating poverty through ecological restoration: Insights from South Africa's "Working for Water" program. *Restoration Ecology*, 21: 544–550. DOI: https://doi.org/10.1111/rec.12038

McDonald, DA. 2002. *Environmental Justice in South Africa*. Ohio: Ohio University Press.

Moodley, S. 2019. Why do planners think that planning has failed post-apartheid? The case of eThekwini Municipality, Durban, South Africa. *Urban Forum*, 30: 307–323. DOI: https://doi.org/10.1007/s12132-018-9357-0

Musyoki, A, Thifhulufhelwi, R and **Murungweni, FM.** 2016. The impact of and responses to flooding in Thulamela Municipality, Limpopo Province, South Africa. *Jamba: Journal of Disaster Risk Studies*, 8. DOI: https://doi.org/10.4102/jamba.v8i2.166

Ocean Cleanup. 2022. Become a citizen scientists. Available at https://theoceancleanup.com/research/citizen-science/.

Olesen, RS, Rasmussen, LV, Fold, N and **Shackleton, S.** 2021. Direct and indirect socio-economic benefits from ecological infrastructure interventions in the Western Cape, South Africa. *Restoration Ecology*, 29: e13423. DOI: https://doi.org/10.1111/rec.13423

Ortega-Álvarez, R, Tobón, W, Urquiza-Haas, T, Ruiz-González, SP and **Koleff, P.** 2021. Exploring local perceptions, implementation, benefits, and limitations of community-based restoration projects in Mexico. *Restoration Ecology*, e13604. DOI: https://doi.org/10.1111/rec.13604

Otto, FEL, Wolski, P, Lehner, F, Tebaldi, C, Van Oldenborgh, GJ, Hogesteeger, S, Singh, R, Holden, P, Fuckar, NS, Odoulami, RC and **New, M.** 2018. Anthropogenic influence on the drivers of the Western Cape drought 2015–2017. *Environmental Research Letters*, 13. DOI: https://doi.org/10.1088/1748-9326/aae9f9

Pasgaard, M, Coldrey, K, Cullis, J, Esler, K, Fold, N, Gokool, S, Hallowes, J, Holden, H, Methner, N, Midgley, S, New, M, Olsen, RS, Rasmussen, LV, Rebelo, A and **Shackleton, S.** 2021. Policy Brief: How can investment in ecological infrastructure increase water security and alleviate poverty?

Pasgaard, M, Dalsgaard, B, Maruyama, PK, Sandel, B and **Strange, N.** 2015. Geographical imbalances and divides in the scientific production of climate change knowledge. *Global Environmental Change-Human and Policy Dimensions*, 35: 279–288. DOI: https://doi.org/10.1016/j.gloenvcha.2015.09.018

Pasgaard, M, Dawson, N, Rasmussen, LV, Enghoff, M and **Jensen, A.** 2017. The research and practice of integrating conservation and development: Self-reflections by researchers on methodologies, objectives and influence. *Global Ecology and Conservation*, 9: 50–60. DOI: https://doi.org/10.1016/j.gecco.2016.11.006

Pasgaard, M and **Fold, N.** unpublished. How to assess livelihoods? Critical reflections on using common indicators capturing socioeconomic impacts for ecological restoration workers in South Africa. Submitted to Journal of South African Studies.

Pocock, MJO, Roy, HE, August, T, Kuria, A, Barasa, F, Bett, J, Githiru, M, Kairo, J, Kimani, J, Kinuthia, W, Kissui, B, Madindou, I, Mbogo, K, Mirembe, J, Mugo, P, Muniale, FM, Njoroge, P, Njuguna, EG, Olendo, MI, Opige, M, Otieno, TO, Ng'weno, CC, Pallangyo, E, Thenya, T, Wanjiru, A and **Trevelyan, R.** 2019. Developing the global potential of citizen science: Assessing opportunities that benefit people, society and the environment in East Africa. *Journal of Applied Ecology*, 56: 274–281. DOI: https://doi.org/10.1111/1365-2664.13279

Pretty, J. 2003. Social capital and the collective management of resources. *Science*, 302. DOI: https://doi.org/10.1126/science.1090847

Quinlivan, L, Chapman, DV and **Sullivan, T.** 2020. Applying citizen science to monitor for the Sustainable Development Goal Indicator 6.3.2: A review. *Environmental Monitoring and Assessment*, 192: 218. DOI: https://doi.org/10.1007/s10661-020-8193-6

Requier, F, Andersson, GK, Oddi, FJ and **Garibaldi, LA.** 2020. Citizen science in developing countries: How to improve volunteer participation. *Frontiers in Ecology and the Environment*, 18: 101–108. DOI: https://doi.org/10.1002/fee.2150

Rogers, H. 2011. Amateur knowledge: Public art and citizen science. *Configurations*, 19: 101–115. DOI: https://doi.org/10.1353/con.2011.0009

Roux, DJ, Nel, JL, Cundill, G, O'Farrell, P and **Fabricius, C.** 2017. Transdisciplinary research for systemic change: who to learn with, what to learn about and how to learn. *Sustainability Science*, 12(5): 711–726. DOI: https://doi.org/10.1007/s11625-017-0446-0

Scoones, I. 2009. Livelihoods perspectives and rural development. *The Journal of Peasant Studies*, 36: 171–196. DOI: https://doi.org/10.1080/03066150902820503

Skarlatidou, A, Suskevics, M, Göbel, C, Prūse, B, Tauginiené, L, Mascarenhas, A, Mazzonetto, M, Sheppard, A, Barrett, J and **Haklay, M.** 2019. The value of stakeholder mapping to enhance co-creation in citizen science initiatives. *Citizen Science: Theory and Practice*, 4. DOI: https://doi.org/10.5334/cstp.226

Sullivan, JJ and **Molles, LE.** 2016. Biodiversity monitoring by community-based restoration groups in New Zealand. *Ecological Management and Restoration*, 17: 210–217. DOI: https://doi.org/10.1111/emr.12225

TBA. 2022. Citizen science Africa. Tropical Biology Association (TBA). Available at https://tropical-biology.org/citizen-science-in-africa/.

Toomey, AH, Strehlau-Howay, L, Manzolillo, B and **Thomas, C.** 2020. The place-making potential of citizen science: Creating social-ecological connections in an urbanized world. *Landscape and Urban Planning*, 200: 103824. DOI: https://doi.org/10.1016/j.landurbplan.2020.103824

UN. 2015. Transforming Our World: The 2030 Agenda for Sustainable Development. United Nations (UN).

UN. 2022. The Sustainable Development Goals Report 2022. Department of Economic and Social Affairs (DESA), United Nations (UN).

Wehn, U and **Almomani, A.** 2019. Incentives and barriers for participation in community-based environmental monitoring and information systems: A critical analysis and integration of the literature. *Environmental Science and Policy*, 101: 341–357. DOI: https://doi.org/10.1016/j.envsci.2019.09.002

Whitley, CT, Kalof, L and **Flach, T.** 2021. Using animal portraiture to activate emotional affect. *Environment and Behavior*, 53: 837–863. DOI: https://doi.org/10.1177/0013916520928429

Wiggins, A and **He, Y.** 2016. Community-based data validation practices in citizen science. *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work and Social Computing, Association for Computing Machinery*, San Francisco, CA, USA. DOI: https://doi.org/10.1145/2818048.2820063

Zha, CC, Jansen, B, Banchoff, A, Fernes, P, Chong, J, Castro, V, Vallez-Kelly, T, Fenton, M, Rogers, J and **King, AC.** 2022. Integrating photovoice and citizen science: The our voice initiative in practice. *Health Promotion Practice*, 23: 241–249. DOI: https://doi.org/10.1177/15248399211054784

TO CITE THIS ARTICLE:
Pasgaard, M, Breed, C, Heines, M, Knudsen, L, Brom, P, Schmidt, A and Engemann, K. 2023. Citizen Science beyond Science: A Collaborative Approach for Transformative Sustainable Development. *Citizen Science: Theory and Practice*, 8(1): 41, pp. 1–14. DOI: https://doi.org/10.5334/cstp.574

Submitted: 30 September 2022 **Accepted:** 18 April 2023 **Published:** 27 June 2023