How could citizen science support the Sustainable Development Goals?

Tracking progress towards the Sustainable Development Goals (SDGs) requires high-quality, timely and accessible data, often in areas where very little data exists today. At the same time, the SDGs demand public engagement, not only to keep up pressure on governments and businesses to take action, but also to generate the broad societal transformations required to bring the goals within reach. Citizen science could make important contributions to addressing both of these needs.[1]

This brief introduces the concept of citizen science and discusses how it could support SDG implementation and monitoring, along with some of the challenges of this approach. It also includes some concrete examples of how citizen science could be applied to the SDGs. The brief draws upon a decade of experience at SEI of working with citizen science approaches (see Box 1).

What is citizen science?

Citizen science is any process where scientists and (usually unpaid) volunteers from the general public work together to answer real-world scientific questions.[2] The rise of the internet and the ubiquity of information and communication technology (ICT), along with an increasingly globally connected world, create ever more opportunities for public participation in science projects at a range of scales, from local to global.

Environmental citizen science projects have the longest history but there is increasing interest in projects focused on social issues. Probably the most familiar type of citizen science project are those classed as *contributory*. In these, volunteers provide or process data requested by scientists*; for example, sightings of a species or reports of gender-based violence . The scientists then use this data to look at spatial and temporal patterns and the factors driving them. Some of these projects require specialist knowledge or equipment on the part of the citizen scientists, while others can be open to anyone. These projects can be at any scale, even national or international.

Other citizen science projects involve citizens in more stages of the research process[2], as shown in Figure 1. Like contributory projects, *collaborative* citizen science projects are led by scientists, but citizen scientists may also help in project design, data analysis or dissemination. *Co-created* projects are those where scientists and citizens work together to set research questions and design methods, and at least some of the citizen scientists are involved in most or all steps of the scientific process. Because of the resources required, these projects are more likely to be at a local scale and aimed at understanding a local issue in depth rather than generating a broad scale picture.

* Here we use scientist as shorthand for *project initiator*. Citizen science projects may be initiated and led by a range of actors, including activists, practitioners, social scientists and natural scientists. For a more detailed discussion of terms involved in citizen science, see Eitzel et al.[3]

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Residents of Nonthaburi, Thailand, quantify the monetary and non-monetary value of their home gardens, in a 2017 SEI-Kasetsart University project

The distinction between citizen science and other participatory approaches is not straightforward, particularly for collaborative or co-created projects. We use *citizen science* here for processes where the primary focus is on volunteers collecting and/or processing scientific data or observations. It is distinguished from, for example, exercises in information extraction such as responding to surveys where participants are the subjects of study. In citizen science, participants are independently gathering data about their environment and/or social setting and experiences.

Benefits of citizen science

While citizen science is not appropriate for all types of scientific inquiry, a well-designed citizen science approach can have many benefits, for data gathering and beyond. In contributory projects, citizen science can increase the geographic reach, sample size or volume of data collected far beyond what scientists working alone could cover.

At the same time, citizen science projects can help raise participants' awareness of particular issues, enhance ownership of those issues, and encourage individuals to change their own unsustainable behaviours. Through participation, some citizens gain the knowledge and confidence they need to mobilize action, build networks and/or campaign on particular issues. More broadly, partnerships between scientists and citizens can help to demystify science and build understanding of and faith in the scientific process.

For collaborative and co-created projects, involving volunteers in project design and analysis can bring in valuable new perspectives, framing issues in novel ways. And citizens can disseminate findings through their own networks and in their own terms, potentially reaching many more people.

The close working relationship between researcher and participant that is often required for these projects increases

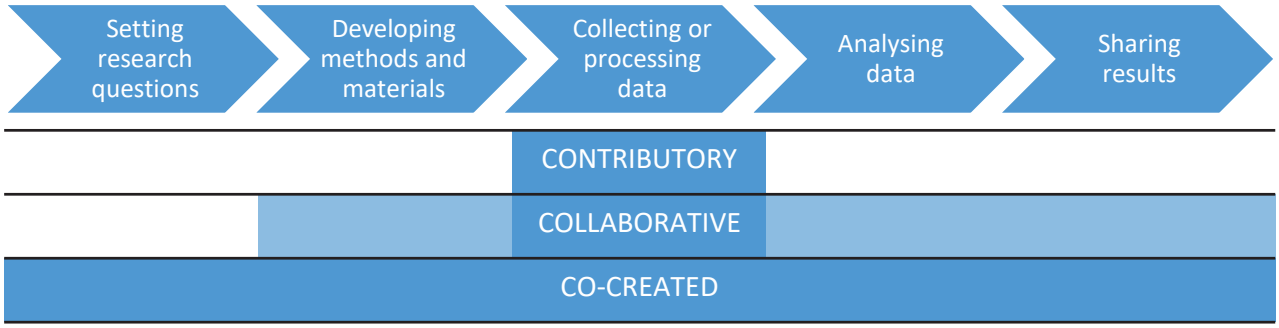

Figure 1: Stages of the scientific process that involve citizens in different types of citizen science project

the chances of there being educational outcomes, and if the project topic has been decided at the local level, the results are more likely to be locally relevant and thus used by local people. Furthermore, from the perspective of public engagement, it has been found that the more stages of the scientific process citizens are involved in, the greater the chances are that a project will encourage changes in knowledge, attitude, skills and behaviour.[4]

Challenges in citizen science

Two common concerns raised about citizen science are that data gathered will be of poor quality, and that the resulting data set will not be statistically valid or reliable, and thus not a good basis for hypothesis-testing, monitoring change of policy-making, particularly when it comes to prioritizing between a range of options.

However, a large body of literature suggests that when a study is well designed and implemented, the quality of citizen-collected data is in fact comparable to that collected by professional scientists.[5,6]

To increase the quality of the data, instructions should be clear and materials piloted with the volunteers who will be using them. Where appropriate and feasible, volunteers should receive training. Data can also be screened at the point of submission, and quizzes can be used to test the data submitters' knowledge, with data from low-scoring participants removed or given a lower weighting in subsequent analyses. Regular contact between scientists and participants (either face-to-face, by email or social media) can also help to deal with any data quality issues early.

The question of statistical validity and reliability is more complex. Participants in citizen science are often self-selecting which introduces risks of bias. This risk becomes higher when, as is often the case, the participants have a stake in the outcomes – for example, if the study could help bring budget support to a particular community or group. Being clear about who collected the data and when, and including this as part of metadata associated with the data, can help at the interpretation stage.

There have been rapid developments in analytical techniques, which can be used to control for uneven sampling and coverage. Furthermore, specific groups (e.g. people in certain geographic areas or with particular livelihoods) can be targeted to improve the representativeness of data being collected. This may require additional resourcing or sometimes alternative methods of data collection (for all the talk of the data revolution, there are still many millions of people around the world who do not have access to mobile phones[1]) which may limit how far the data can be safely compared or combined with other data sets.

However, being able to collect information from underrepresented groups is often worth the extra investment, as they are frequently precisely the marginalized people that need to be reached in order to achieve the universal SDG targets. Even if citizen science data from these groups is not always comparable with national data sets, it does provide rich and detailed information about their experiences and needs.

Citizen science and the Sustainable Development Goals

Citizen science could make contributions in three types of process linked to the SDGs: **defining national and subnational targets and metrics**, **monitoring progress** and **implementing action**. Table 1 suggests some potential roles for citizen science in relation to specific SDG targets. This section gives a general overview and discusses some challenges.

1) **Defining**. Although international targets and indicators for the SDGs have already been established, there is scope for involving citizens in defining targets at scales more relevant to people's lived experience. Many of the SDG targets include wording that needs further definition according to context, for example target 7.1, "By 2030, ensure universal access to affordable, reliable and modern energy services". In this case, citizen science could play a role in defining criteria for (as well as monitoring) affordability and reliability.

Box 1: Citizen science experience at SEI

SEI has a wealth of experience of using citizen science and other participatory approaches in many parts of the world, from sub-Saharan Africa to the polar regions. Different projects have involved participants in all stages of the scientific process.

Staff at SEI's York centre have been involved in citizen science for nearly a decade. Initially this involved designing and running citizen science projects in the UK, but it has now broadened out to include researching citizen science as a method, and using citizen science approaches with collaborators overseas. Some of our flagship citizen science projects are OPAL (local to national biodiversity surveys in the UK), Moors for the Future (climate change and biodiversity at the regional level), Parenting Science Gang (supporting parents to conduct their own science experiments around parenting issues), and AQD Nairobi (monitoring air pollution in an informal settlement in Nairobi).

Table 1: Suggestions from SEI staff of how citizen science approaches could help with definition, monitoring or implementation of specific SDG targets

Target	Defining	Monitoring	Implementing
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round		Generate fine-scale data and data from under-represented groups.	
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers . . .			Co-learning between farmers and researchers to understand yield under different management scenarios, which could be co-designed between scientists and farmers.
2.4. By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production . . .			Community knowledge generation and sharing to understand success of agricultural practices under different scenarios, for example using crop trials.
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species		Collect data on local genetic diversity.	
2.a. Increase investment . . . in rural infrastructure, agricultural research and extension services . . :		Report and monitor where services such as agricultural extension services are available.	
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.		Fill gaps in information on neglected tropical disease prevalence or changing trends.	
3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.		Monitor progress towards promotion of mental health and well-being, for example by documenting promotion campaigns.	
3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.			Include a strong educational focus to help prevent substance abuse.
3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.		Monitor access to sexual health care for different groups of society	Include a strong educational focus to help ensure better reproductive health.
3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.			Recognition of emerging health risks, through crowdsourcing, data mining of social media etc.
5.1. End all forms of discrimination against all women and girls everywhere.		Report when and where discrimination in happening, by those experiencing it.	
5.2. Eliminate all forms of violence against all women and girls . . . including trafficking and sexual and other types of exploitation.		Record violence against women through peer interviews.	

Target	Defining	Monitoring	Implementing
5.3. Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation.		Record harmful practices against women through peer interviews.	
5.4. Recognize and value unpaid care and domestic work . . .		Record hours of unpaid work to monitor gender division of labour.	
5.5. Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.		Ask women to assess their level of participation in selected decision-making processes.	
5.6. Ensure universal access to sexual and reproductive health and reproductive rights . . .		Report on violation of sexual and reproductive rights, and map sources of sexual and reproductive health advice and clinic locations.	
5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws.			Assess rights vis-a-vis formal laws and use the results to improve services and equal rights.
5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.			Provide women with capacity in using information and technologies as part of citizen science projects.
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.		Collect data on where water is not accessible, quality of water within households and the location and accessibility of communal water sources.	
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.		Map sanitation facilities to assess access at local levels.	
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater . . .		Report dumping and monitor release of untreated waste into the environment.	
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater . . .		Report leaks and reliability of supply, monitor extraction of water at the household or community level.	Monitor soil moisture to help manage supply and demand of water, and through such monitoring encourage behaviour change to more efficient water use.
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.		Monitor data from stream gauges, groundwater wells etc.	
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes		Collect data on endangered freshwater species and their habitats.	

Target	Defining	Monitoring	Implementing
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services.	Help define metrics and ensure reliability, affordability and modernity of energy supply is measured in a way that is contextually relevant.	Monitor progress towards the target.	
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.		Generate data around cooking fuels, where data is less easy to gather and does not exist at a national level.	Understand what motivates people to adopt new technologies.
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.		Collaborate with existing projects monitoring issues such as air pollution, access to waste management facilities etc., to modify their methods to help monitor and address this target.	
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.			Implement a more inclusive design process.
11.b. By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards . . . mitigation and adaptation to climate change, resilience to disasters . . .			Involve citizens in decision-making at a local level through citizen science approaches, e. g. to explore impacts of climate change, document disaster responses.
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains . . .			Understand patterns and drivers of food waste and explore the efficacy of behavioural change initiatives.
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle . . . and significantly reduce their release to air, water and soil . . .			Explore the efficacy of behavioural change initiatives relating to hazardous chemicals, particularly in developing countries.
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.			Explore the efficacy of behavioural change initiatives relating to recycling, by monitoring any changes in household or business waste disposal.
12.8. By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.	Give clarity on what "relevant information" is needed to support sustainable development.		
12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.			Develop technical capacity through participation in CS, particularly if targeted at "younger" people who might move into scientific roles.

Target	Defining	Monitoring	Implementing
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.		Monitor hazards and natural disasters – existing projects already do these, for example, using remote sensing data. Better understanding of the issue may help strengthen resilience and adaptive capacity.	
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning			Include a strong educational focus as part of citizen science projects to help achieve the target.
13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.			Give a voice to marginalized groups and raise their capacity to effect change through participation in citizen science projects, which can empower people by giving them confidence, knowledge and a voice.
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services . . .		Monitor distribution of species and habitats (already used in many countries).	
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.		Monitor progress relating to deforestation rates, e.g. using remote sensing images and "ground-truthing" these.	
15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity . . .		Monitor progress, for example, by recording particular species presence/absence and density.	
15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species . . .		Map the locations of invasive alien species.	

CS = citizen science
Source: Based on responses to questionnaire survey of SEI international staff, 2016.

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Exploring the spread of invasive marine species using the Marine Biological Association's Shore Thing citizen survey, Yorkshire, UK

This could be particularly important in the context of marginalized groups, whose situation may not be well captured by targets or statistics designed for the mainstream population.

Such work could be done in collaboration with local or regional government staff, as this is the level of government best placed to link the global goals with local communities, and all SDGs have targets that relate to the daily work of local government staff.[7] Involving citizens in defining specific national SDG targets could help to ensure that national governments develop and implement strategies to meet them, as citizens would then be more likely to hold the government to account.

2) **Monitoring**. The 2030 Agenda for Sustainable Development, the plan of action that incorporates the SDGs, states, "Quality, accessible, timely and reliable disaggregated data will be needed to help with the measurement of progress and to ensure that no one is left behind"[8]. However, many gaps exist in the required data. Statistical officers could identify data gaps and work with citizen science practitioners to generate data that can help fill them, or to disaggregate national-level data in order to provide clearer pictures of geographic, gender, socio-cultural or other inequalities. Involving citizens in data gathering can also aid accountability and transparency.

3) **Implementing**. Citizen science can also help achieve the SDG targets through mechanisms other than monitoring, particularly at the local level. For example, while citizen-collected data might not always be statistically valid it can "tell a story", which can be just as persuasive for leveraging funding or inspiring new interventions or actions on the ground.

Participation in a citizen science project can educate and inspire the participants, changing their attitudes and behaviours and even turning them into advocates or activists for a particular development challenge. A citizen science project can provide a platform for citizen engagement in decision-making.

Finally, as citizen science relies on partnerships between the public and state, civil society, academic and/or private-sector actors, it can help to strengthen collaboration, share knowledge and build capacity among these sectors, all key elements of SDG 17.

Applying citizen science approaches to SDG targets

In late 2016, the authors surveyed SEI staff about how they thought citizen science approaches could be used in relation to the SDGs within their areas of expertise. Below we give some detail on a few of these to illustrate some of the ways different types of citizen science could be used. Other suggestions from the survey can be found in Table 1.

Helping define subnational targets for SDG 7

As noted above, SDG Target 7.1 is a good example of where the wording of an SDG requires interpretation in order to apply it to a particular context. Affordability depends on a range of objective and subjective factors that might vary between groups, or even households. Citizen science could be very useful in defining what affordability means in a given context, and thus identifying (and maintaining) more nuanced and revealing indicators. The reliability of a given energy source is similarly context-specific. And citizen science could help to explore users' attitudes and preferences in relation to what constitutes a "modern" energy source, to guide policy and action aimed at meeting Target 7.1.


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Using the OPAL Soil Survey to find out about earthworms and soil types on the site of a former colliery, Yorkshire, UK

Crowdsourcing data to monitor progress on SDG 6

Target 6.2 reads: " By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations". A crowdsourcing citizen science approach (using large numbers of volunteers to collect large quantities of data, via an online platform or SMS, supplemented with paper-based collection where ICT access is limited) could be used here to map locations of basic sanitation services, whether they are functioning and include soap and water. Sometimes sanitation access data is available at a coarse, country-level scale through national household surveys, but detailed data on the status of sanitation is often lacking at the local and regional scale. Data gathering could be done through free platforms such as Epicollect, OpenDataKit, CyberTracker and Sapelli.

Citizen science can also help to monitor levels of water extraction from community or household wells, for example. (Target 6.4: "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity").

As well as producing useful data, this kind of data collection could encourage citizens to adopt more water-efficient behaviours, by raising their awareness of the issues, giving them a sense of ownership and encouraging them to reflect on potential solutions .

There are many existing water monitoring citizen science initiatives around the world, including the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) and FreshWater Watch. The methods used in these initiatives could be adapted to include, for example, monitoring the location and flow of natural springs, which are often ephemeral but potentially important parts of the watershed.-

Co-creating ways to increase recycling and reuse to meet Target 12.5

SDG Target 12.5 says: "By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse". SEI has started to develop a co-created citizen science project focusing on waste in the Aida refugee camp in the Palestinian West Bank, with employees of the Lajee Centre, a community centre in the camp. Litter was identified as a key environmental concern for camp residents. Litter collections are unreliable and all waste is sent to landfill.

The citizen science project will measure the volume of different types of waste generated by households, and help residents use this data to make the business case for recycling, composting and reuse. Co-designing the project with camp residents from the beginning maximizes the chances of collecting robust data which is of direct use to the community.

A growing movement

There is increasing recognition of the potential role of citizen science in realizing the SDGs. A number of organizations focused on data requirements for sustainable development have highlighted the potential of citizen science. The Eye on Earth Alliance, for example, has called for citizen science to be used to fill gaps in data required to measure progress towards the SDGs. Academics have also called for the mobilization of citizens to track sustainability and generate data where official statistics are missing9. Similarly, organizations promoting citizen involvement in development have recognized the role that citizen science can play (see, for example, the Global Partnership for Social Accountability Knowledge Platform).

This recognition has resulted in an increasing number of projects, and initiatives designed to support them. For example, the Open Seventeen platform (http://openseventeen.org/) offers support to crowdsourced SDG monitoring projects. CIVICUS, the World Alliance for Citizen Participation leads DataShift, which aims to help civil society organizations to "produce and use citizen collected-generated data", including through direct support. The Global Partnership for Sustainable Development Data has collected examples and case studies of citizen science projects being used in relation to the SDGs.

Citizen science approaches have the potential to support the definition, monitoring and implementation of the Sustainable Development Goals. Citizen science approaches, like any other research method, do have challenges, but these can be overcome by good planning, design and delivery.

This brief was written by Sarah West and Rachel Pateman of SEI. It is the result of an SEI Seed and Innovation-funded project to investigate how citizen science could be used to monitor progress towards, or help achieve, the Sustainable Development Goals. Activities under the project included: a review of the literature; a questionnaire survey among SEI staff; seminars on citizen science and the SDGs (with SEI staff) and ethics (at an event co-hosted with the University of Reading's Participation Lab); a pilot project between SEI York, SEI Asia and Kasetsart University, Thailand to explore the use of citizen science approaches in a new context (home-gardens in Thailand); and a three-day workshop in York on water and waste issues in the Palestinian West Bank and exploring the relevance of citizen science approaches to this context.

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