JCOM

THIRD INTERNATIONAL ECSA CONFERENCE, TRIESTE 2020

Agenda 2030's, "Leave no one behind", in citizen science?

Madeleine Montanari, Liesbet Jacobs, Mordechai Haklay, Felix Kwabena Donkor and Maria Rosa Mondardini

Abstract

Citizen science (CS) is promoted as a useful practice for the achievement of the Sustainable Development Goals (SDGs). In this contribution we explore how CS aligns to the SDGs overarching pledge to 'Leave no one behind'. We propose a framework to evaluate exclusionary processes in CS. We interlink three dimensions of CS inspired by existing CS typologies with five factors underpinning exclusionary processes. With this, we are able to situate existing literature on various exclusionary effects in CS within a structured framework. We hope this contribution sparks a discussion and inspires practitioners' reflections on a more inclusive practice in CS.

Keywords

Citizen science; Social inclusion

DOI

https://doi.org/10.22323/2.20060207

Submitted: 31st October 2020
Accepted: 11th March 2021
Published: 11th October 2021

Introduction

The United Nations 2030 Agenda, titled 'Transforming our world', enacted in 2015 and ratified by 193 countries, represents a roadmap to sustainable development for signatory countries and ultimately the world. The Agenda is underpinned by 17 Sustainable Development Goals (SDGs). For monitoring and reporting purposes, the goals are translated to 169 targets, which are reviewed using a set of 231 global unique indicators. Moreover, the SDG agenda is underpinned by the pledge to 'Leave no-one behind' — a pledge which addresses a shortfall of the erstwhile Millennium Development Goals (MDGs), failing to tackle global inequality [Fukuda-Parr and Hegstad, 2018; Renner et al., 2018]. Agenda 2030 recognizes that to achieve sustainable development, the SDGs should be reached for all. Therefore, this pledge seeps in all 17 goals, and is currently monitored through the dis-aggregation of data and by a multi-dimensional poverty index [Renner et al., 2018].

To understand the world's progress towards achieving the SDGs, each signatory country is asked to monitor their national progress towards the goals. This process represents a costly process to countries [Fritz et al., 2019] and the level which the SDGs are asked to be monitored requires comprehensive spatial and temporal

dimensions that are often not possible with traditional ways of data collection [Fritz et al., 2019]. In light of these challenges, Citizen Science (CS), is currently actively promoted as a scientific participatory practice which can assist in the achievement of the Sustainable Development Goals (SDGs) [e.g. West and Pateman, 2017; Fritz et al., 2019; Fraisl et al., 2020].

CS can be defined as a collaborative endeavour between professional scientists[1] and members of the general public (i.e. lay people) in scientific research to produce science- based knowledge [adapted from Shirk et al., 2012; Wiggins and Crowston, 2012]. Fritz et al. [2019] have highlighted how CS data are pertinent to the monitoring of the SDGs. CS can generate data that have a stronger temporal frequency than current data used for the SDGs, a larger spatial representation of a country and can moreover allow the monitoring process to be open to the public.

CS is promoted as a practice which can bring the required public engagement to achieve the transformative societal aim of these goals [West and Pateman, 2017], that can help define targets which are contextually relevant to a country, region, locality because of its public engagement [West and Pateman, 2017] and that can actively participate by contributing data to the monitoring framework of the SDGs that are also at a finer scale compared to data generated by current government methods [Fritz et al., 2019]. More recently a declaration was drafted and proposed at the Citizen Science SDG conference to form a social contract between citizen scientists, academics and policy makers- to help and shape CS engagement and advancement of the SDGs (https://www.cs-sdg-conference.berlin/en/declaration.html).

However, literature on the involvement of CS with the SDGs has, to date and to our knowledge, not mentioned or observed CS relationship with the 2030 Agenda overarching pledge to "leave no one behind", crucial for the achievement of the SDGs.

West and Pateman [2017] highlight that CS, as an on the ground practice that monitors a local situation, can serve to adapt targets to marginalized groups, so that these are more realistic and context specific. These populations are least likely to have data that are representative of them or their situation, which affects their ability to influence or be taken into consideration by government's resource allocation or policy formulation, as information about them is missing [Renner et al., 2018].

The opportunity to be involved in the monitoring and target defining should be accessible to all, if the SDGs are to be achieved. Recent literature demonstrates that CS as a practice is not equally accessible to all [Haklay, 2015; Pandya, 2012; Walajahi, 2019]. In other words, while CS is recognized and promoted as a practice that can help achieve the SDGs, the practice itself appears to be potentially subdued to very same exclusionary processes described to leave individuals behind. Till now, an analysis of how CS as a practice might be affected by exclusionary processes is lacking.

In this contribution, we propose a preliminary framework to analyse and understand who and why people might be left behind in the practice of CS. We first

[1] Individuals that have acquired formal scientific training and credentials.

introduce the concept of 'leave no one behind' and the five factors which have been identified to be behind exclusionary processes [Renner et al., 2018]. Next, we introduce three dimensions of CS that encompass different aspects of this participatory practice. Our proposed framework is an overlap of these dimensions and factors. Through literature extracts, the relevance of this framework by way of raising awareness of exclusion in CS is demonstrated.

The 'Leave no one behind' pledge

The 2030 Agenda pledge to "Leave no one behind" is embodied in the foundation of the United Nations Charter and the Universal Declaration of Human rights, which uphold the principles of equality and non- discrimination [Renner et al., 2018]. It entails that all goals should be achieved for "all nations, peoples and for all parts of society, endeavouring to reach the furthest behind" [Department of Economic and Social Affairs, 2016]. When countries ratified the 2030 Agenda they made the pledge to prioritize reducing inequalities, address and redress legacies that foster discrimination and exclusion, and prioritize human development progress for those who are the furthest behind [Renner et al., 2018]. Human development focuses on 'expanding the richness of human life' and has three foundations, 'live a long, healthy and creative life, to be knowledgeable, and to have access to resources needed for a decent standard of living' [United Nations Development Programme, 2019].

Individuals may be left behind due to absolute deprivation or/and relative disadvantage [Renner et al., 2018]. Absolute deprivations regard individuals that live in multidimensional poverty, below minimally accepted standards of security, income, public services, infrastructure or wellbeing. Relative disadvantage regards individuals that face exclusion, discrimination and/or entrenched inequalities, and are less able to gain influence, receive an education, survive setbacks, acquire wealth, access job markets or technologies, or have shorter/risker lives [Renner et al., 2018].

The practical implementation of the principle of "Leave no one behind" is context dependent and subject to many different interpretations [Munro and Bond 'leave no one behind' group, 2018]. However, one of the first steps towards its implementation is to first identify who is left behind [Munro and Bond 'leave no one behind' group, 2018]. To do so, the United Nations Development Program (UNDP) developed a framework to help countries and stakeholders identify who and why individuals may be left behind [Renner et al., 2018]. This framework highlights five factors which are behind exclusionary processes. These are: discrimination, geography, governance, socio- economic status, and vulnerability to shocks [Renner et al., 2018]. We will describe below these factors in more depth and how these factors are behind exclusionary processes that leave individuals behind from accessing human development progress.

2.1 The five factors of exclusion

The first factor, **discrimination**, highlights that individuals may be left behind due to their ascribed or assumed identity [Renner et al., 2018]. Ascribed and assumed identity, in the 2030 Agenda relate to 'gender, age, income, ethnicity, caste, religion, disability, sexual orientation, nationality, indigenous, refugee, displaced or

migratory status, amongst others' [Renner et al., 2018]. Criticism exists which highlights that this is not an exhaustive list of identities for which individuals may be left behind [Munro and Bond 'leave no one behind' group, 2018]. Moreover, individuals may be left behind because of their ascribed or assumed identity as it may cause them to experience unfair disadvantage in laws, policies, access to public services and social practices [Renner et al., 2018], therefore not enabling them full and equal access to human development.

The second factor, **geography**, refers to individuals being left behind because of their place of residence [Renner et al., 2018]. An individual may be affected by its place of residence if it hinders access to economic and social opportunities, to public services and security. A place of residence may dictate one's ability to have access to these opportunities, services and security because of that place's accessibility to transportation, technology, its environmental health, its infrastructure, its climatic conditions, and its stage of development (i.e. relating to a countries development stage) and if that area is affected by war remnants for example [Renner et al., 2018].

The third factor, **governance**, is a factor which may leave individuals behind, as it affects an individual's autonomy on being able to make decisions on aspects of life which affect him/her/them. This may be due to institutions, laws, policies and budgets of a country which are unjust, inefficient, corrupt [Renner et al., 2018]. An individual's access to a say in decisions that affect him/her is also influenced by the nations position and global influence [Renner et al., 2018].

The fourth factor, **socio-economic status**, represents an exclusionary factor, when individuals are hampered to fully participate within their economy and/or society because they are hindered in their ability to accumulate wealth or earn an adequate income. Renner et al. [2018] highlight that this may be caused by laws, policies and regulations governing the national economy relating to tax and one's ability to own land, have access to safe working conditions, benefit from insurance and/or social protection systems, find and sustain a job, open a bank account, have the ability to be entrepreneurial and/ or benefit from trade and investment [Renner et al., 2018].

The fifth factor, **shocks and fragility**, refers to individuals being left behind because of their accentuated vulnerability to risks that range from environmental, social, political and economic risks. Some examples given are risks associated with violence, natural hazards, conflict, health shocks, displacement, and migration.

These factors are intertwined, and individuals may be left behind due to a combination of these factors. However, individually assessing these factors allows for a better first understanding of what processes cause individuals to be left behind.

CS and the SDGs

In a recently published study, Fraisl et al. [2020] found that CS as a practice is currently already contributing to 5 indicators and has the potential to supplement or directly contribute to an additional 76 indicators, which represents 33% of all SDGs indicators [Fraisl et al., 2020]. West and Pateman [2017] and Fritz et al. [2019] mention that different forms of CS can contribute to the SDGs. For example, contributory CS projects can engage with the SDGs by increasing the geographical

scope that can be monitored and moreover generate a large amount of data [West and Pateman, 2017]. Collaborative and co-created CS projects are highlighted to be able to engage with the SDGs by contextualizing the SDGs at a local scale and give agency to lay individuals to act on issues and disseminate them thanks to their social network [West and Pateman, 2017]. Fritz et al. [2019] highlight that different kind of public participation in CS projects can be used for the SDGs, such as active or passive engagement. In addition, some CS projects were designed to contribute to the SDGs (e.g. Litter Intelligence), however even those that do not have this explicit intention, may provide valuable data [Fritz et al., 2019]. As West and Pateman [2017] underline, these projects may not contribute by providing data to the SDGs but by featuring issues, and therefore creating the potential for these to be addressed. These mentions of how different forms of CS can contribute to the SDGs brings us to the next section of our essay, of how we propose to look at the practice of CS.

The three dimensions to citizen science

Many different definitions and typologies, which classify CS practices based on the degree of engagement of participants in the scientific research process or on one or more of its practical components exist [Schrögel and Kolleck, 2019]. Each of these different typologies scrutinizes important components of CS. We therefore argue that in order to comprehensively investigate exclusionary processes, and therefore who has access to the practice of CS, we need to consider them comprehensively. We propose a framework wherein CS is examined in three different dimensions: within creation, within practice and within purpose.

Within creation. One of the dimensions which characterizes the practice of CS is the degree to which a non-scientist participates/collaborates with a scientist in the scientific research process. It has been referred to in literature as the degree of participation of a project [Shirk et al., 2012], or the level of engagement of participants in a project [Haklay, 2015]. Shirk et al. [2012] have highlighted five different degrees of collaboration that can be observed in participatory scientific practices. These are contractual, contributory, collaborative, co-created, and collegial [Shirk et al., 2012]. Contractual and collegial are at the opposite extremes of the spectrum. Contractual collaboration entails that a member of the public will ask a scientist to conduct a research, whereby the role of the public is limited to raising the question. Collegial participation lies at the other end of the spectrum: primarily non-scientists conduct the research and are helped only on some aspects by a scientist. CS projects most commonly fall in the three other categories; contributory, where participants will most likely be asked to collect data; collaborative, in which participants take part in, defining the question of study, collecting the data and analysing the data; and co-created, where more or less all the steps of the scientific research process are performed collaboratively by non-scientists and scientists. We call this dimension "within creation" of CS, as it refers to the primary principles behind the creation of the participatory practice: the collaboration between non-scientists and scientists in the scientific research process [Shirk et al., 2012].

Within practice. The second dimension includes the typologies that are defined based on the characteristics of the tasks that members of the public undertake in a CS project. In the literature it has been referred to as modes of knowledge

production [Strasser et al., 2019], form of engagement [Haklay, 2015] and participation design [Wiggins and Crowston, 2012]. This includes the type of tasks that a member of the public is asked to do, participants skills to carry out the task and/or the tools needed to perform the tasks. This dimension can be further elucidated by the typology of Strasser et al. [2019] that names five different modes of knowledge production: sensing, analysing, computing, self-reporting and making. For example, sensing refers to participants recording observations on a paper or digital format or collecting information about their direct environment, through sensors in their gardens, embedded in their smartphone or as part of an app [Haklay, 2015; Strasser et al., 2019]. Computing refers to individuals giving their unused computing resources to scientists who use large amount of computing power to conduct research [Haklay, 2015; Strasser et al., 2019]. We call this dimension 'within practice' as it addresses some of the way knowledge is produced in a citizen science project.

Within purpose. The third dimension that we present is inspired from typologies that classify participatory endeavours based on their primary objective. In the literature it has been referred to as a projects' underlying goal [Wiggins and Crowston, 2012], outcome [Shirk et al., 2012] and topic [Haklay, 2015]. Wiggins and Crowston [2012] typology considers that participatory projects have five main focuses: action, conservation, investigation, virtual and education. For example, action projects are projects which intentionally seek to encourage participants' intervention in local concerns. Virtual projects on the other hand, are projects which are completely ICT mediated and whom, similarly to investigation projects, seek to advance scientific research. Wiggins and Crowston [2012] classification is further elaborated by describing organizational, scientific and technological issues shared by these project types. For example, conservation projects were seen to have a strong academic affiliation, to be generally funded by federal or state funds and either use very basic technology or more advanced. These additional dimensions allow to look at the practice of CS at a project scale, by considering its scientific objective, organizational structure and technological use. We call this dimension 'within purpose' as it regards the intention of a citizen science project.

The Framework: how do exclusionary factors affect the practice of CS?

CS can be related to the exclusionary factors in two ways. First, as a practice in itself that is rendered inaccessible because of the exclusionary factors. For example, discrimination as an exclusionary factor is defined as follows by Renner et al. [2018], "People are left behind when they experience exclusion, bias or mistreatment in laws, policies, access to public services and social practices due to their identity". In this definition, CS can be considered as a social practice rendered inaccessible to individuals left behind in consequence to their identity. In a second way, the exclusionary factors are pertinent to CS as it highlights components, such as geography, which can be the reason for exclusion within CS. Crosslinking the three dimensions of CS with the five identified factors in one matrix (Table 1) allows to investigate the different exclusionary processes with regard to the varying typologies of CS through one comprehensive overview. In this paper, we thus explicitly look within CS as a practice that risks being subdued to the five exclusionary factors.

By including observed exclusionary effects reported in CS literature in this framework, we want to refrain from a strictly theoretical approach and demonstrate its potential usefulness (Table 1).

Pertinence of the framework. Literature extracts included in the 'within creation' dimension of CS pinpoint exclusionary aspects that relate to four following factors: discrimination, governance, socio-economic status and vulnerability to shocks. Extracts pertained to access to the scientific discipline, science education, the culture of institutions in which CS takes place, to the recognized forms of knowledge, and familiarity of the scientific process. The passages included in discrimination connect with the opportunity that individuals face or have, regarding access to science. This same issue is observed with a found literature extract that demonstrates that some individuals may be left behind because of the culture of centres in which CS takes place. This was moreover brought forward by Anita Shervington, founder of the BLAST fest initiative (https://www.blastfest.org.uk/) during a member meeting of the Empowerment, Equity & Inclusivity working group of the European Citizen Science Association. BLAST was initiated as she saw that her community was not included in mainstream British Science Festivals and wanted to create a culturally affirming alternative that centred community leadership and belonging. Science festivals may represent a first point of access to CS. We can notice that these literature extracts are about participation — who has access to the scientific collaboration. Other found literature extracts included in governance highlight barriers that individuals with different forms of knowing face in order to participate. Walajahi [2019] challenges the idea that underrepresented communities in CS such as indigenous peoples, participate less, not because of material barriers but because their way of knowing is not recognized. Sense of belonging to a place, and having a stable living situation is highlighted to affects one's ability to partake in CS. This dimension demonstrates who is left behind in the first point of access to CS. This is not only relevant to members of the public but also to scientist that take part in this participatory endeavour. Burke and Heynen [2014] highlight that citizen science is not considered 'BIG science', science recognized as cutting edge. Scientist interested in participatory form of science may not take part or may be side-lined by their peers [Burke and Heynen, 2014]. This may cause scientist interested in participatory form of science to be left behind.

Literature extracts in the 'within practice' dimension highlight barriers to CS participation that pertain to geography, socio economic status and vulnerability to shocks. The extracts highlight access to technology, to different settings, the balance of responsibilities compared to leisure time, access to private settings, access to preparatory experiences, language type used, motivation to participate, and the allowability of a person's situation to participate as barriers for individuals to get involved in CS project's activities. Individuals may not have the possibility to partake in CS projects as they do not have the required technology. Haklay [2015] mentions that individuals may have smartphones, but web connectivity is a problem, even in urban areas. The most recent human development report underscores that the digital divide as a concept should now take into consideration the inequalities created between people that have access to entry level technology (e.g. smartphones, internet) and to present day technologies (e.g. artificial intelligence) [Conceição, 2019]. In terms of geography, urban dwellers may be at a

disadvantage to participate in some CS project that are in nature, due to lack of access to natural settings or private gardens. This may be due to a socio- economic disadvantage or lack of available public transportation. Moreover, individuals may be hindered to partake in CS if these activities are not directly relevant to their practical livelihood. Leisure time for some CS projects is required in order for an individual to partake [Haklay, 2015]. Levine, González and Martínez-Sussmann [2009] underscores that underrepresented groups in geoscience have had less exposure to natural settings, considered preparatory experiences. CS projects participants may not include those that did not have such preparatory experiences. Individuals that do not feel as though their situations is stable enough to participate or engage with CS projects, in order to build on their interest may be left behind. These individuals may be homeless people, or individuals in other precarious situations. This dimension cross-linked with the five factors can elucidate on who has the ability to partake in CS projects.

Literature extracts in the 'within purpose' dimension highlight barriers to CS participation that pertain to governance. The literature extracts highlight access to financial and organizational capacity, scientific research establishment-funding schemes, establishing credibility, knowledge sharing as barriers faced by CS projects. These extracts included in governance underline the complexity that some CS projects demand to take ground. Projects that are generally bottom-up initiatives, called action projects by Wiggins and Crowston [2012] whose main purpose is to respond to local concerns, are more susceptible to be left behind. The literature extracts identify lack of available resources for either community engagement, or organizational structure as barriers. CS projects may be left behind, because they are outside scientific institutions and are not able to get the credibility that comes with recognition from a scientific institution. This may hinder the impact these CS projects can and may have especially in terms of contributing to the SDGs, as contributing to the SDGs is linked to scientific rigour. Moreover, the intention of a CS project may cause these participatory forms to push individual out. For example, Ellis and Waterton [2005] highlight that some amateurs from the Bryologist society preferred to not contribute to a participatory project for policy biodiversity action as the gift economy their practice was based on was violated. Policy makers that benefited from the data of amateurs did not reciprocate with a mutual benefit under the format of environmental policies for example that protect the subject of observation of these amateurs. In this case, individuals are not left behind, but however choose to not participate. This said, it is important to specify that this essay doesn't call for the idea that everyone should be pushed to participate in CS, but it is about understanding who has or has not access to this opportunity. By looking at CS at a project scale, this dimension can moreover illuminate at a topic and geographical scale, who is left behind. For example, Cigliano et al. [2015] shows that marine ecosystems in CS projects are underrepresented. This may mean that individuals that live and depend on marine ecosystems for their livelihood may have less of an opportunity to get their voices heard within the SDGs framework as they do not have access to CS projects that could enable this.

These above examples advance that the factors behind exclusionary processes are observed in CS and that CS as a practice exclude individuals' participation at different levels.

Table 1: The proposed framework with literature extracts to demonstrate how this framework can be relevant and used. Quotes are directly taken from literature with minor in- text modifications.

Within Creation	Within Practice	Within Purpose	
Access to scientific discipline. Underrepresented groups in science participate less in CS, such as African Americans, Latinos and American Indians. [Trumbull et al., 2000; Evans et al., 2005]. From Pandya [2012]. **Access to science education.** Men overrepresent participants in citizen science. From Haklay [2015].			**Discrimination;** on the basis of assumed or ascribed identity or status.
	Differentiated access to technology. Even for those who have access to a smartphone, many of the software applications (apps) that support citizen science assume continuous web connectivity, even though 3G and 4G coverage is partial in highly urbanized environments such as London or New York City, let alone in remote nature reserves. From Haklay [2015]. **Access to different settings.** Lack of access to a natural setting [Evans et al., 2005] may prohibit individuals the opportunity to take part in a CS project that are geared in these settings. From Pandya [2012].		**Geography;** isolation, risk or exclusion due to location; includes environmental degradation, transport, technology.

Continued on the next page.

Table 1: *Continued from the previous page.*

Within Creation	Within Practice	Within Purpose	
Culture of place of practice. The culture and norms of centres in which citizen science projects take place may be exclusive to individuals of certain communities [Jolly, 2002; Levine, González and Martínez-Sussmann, 2009] From Pandya [2012]. **Recognized form of knowledge.** What gets restored is strongly influenced by the social groups and therefore the kind of knowledge that is recognized. From Burke and Heynen [2014].		**Access to financial and organizational capacity.** Projects that are bottom up initiatives may have a harder time to take ground due the lack of organizational and financial support. From Haklay [2015] and Wiggins and Crowston [2012] characteristics of action projects. **Scientific research establishment- funding timelines.** The demands of projects that include high community engagement does not fit with the current scientific funding scheme and its timeline. From Walajahi [2019]. **Establishment of credibility.** Citizen science communities which are outside recognized academic institutions have to go out of their way to gain credibility. From Cigliano et al. [2015]. **Knowledge sharing.** The lack of felt reciprocity of giving and taking knowledge between amateurs and policy makers to inform conservation policy has removed the willingness and appreciation that participants had to gather and share their knowledge. From Ellis and Waterton [2005].	**Governance;** laws, policies, institutions, voice & participation (includes informal and traditional governing systems.

Continued on the next page.

Table 1: *Continued from the previous page.*

Within Creation	Within Practice	Within Purpose	
Familiarity with scientific processes. Participation will depend on the opportunities individuals have to familiarize themselves with science and scientific processes. From Pandya [2012].	**Balance of responsibilities and access to leisure time.** Citizen science is generally an extra- curricular activity which may be less accessible to low- income families, due to the fact they may not be able to allow themselves this 'leisure time' [Evans et al., 2005]. From Pandya [2012] and Haklay [2015]. **Access to a private natural setting.** Lack of access to a private property where CS projects are asked to take place [Evans et al., 2005]. **Access to preparatory experiences.** Citizen science projects that require individuals to have had preparatory experience (e.g. outdoor exposure) in order to take part may leave those who do not have access to them behind. [Levine, González and Martínez-Sussmann, 2009]. From Pandya [2012]. **Language type used.** The language used by certain project may be inaccessible to some individuals whom are not family to scientific specific jargon. From Haklay [2015]. **Motivation to participate.** The motivation to take part in a citizen science project can be influenced by an individual's level of education and the presence of a reward [Beza et al., 2017]. From Pocock et al. [2018].		**Socio- economic status;** multidimensional poverty, inequalities.

Continued on the next page.

Table 1: *Continued from the previous page.*

Within Creation	Within Practice	Within Purpose	
Sense of belonging. Individual whom do not feel in a safe and or stable living conditions are less likely to commit to participatory practices [Lawless, 2007]. From Ferilli, Sacco and Tavano Blessi [2016].	**Ease to participation.** The success of a project depends on a participant's perception of its accessibility to build on interests, easily try something new and its link with place and community [Lawrence, 2006; Bell et al., 2008]. From Chandler et al. [2017].		**Vulnerability to shocks;** includes conflict, climate, environmental.

Conclusion

With this framework we would encourage a conversation that looks at who the practice of CS is leaving behind. We do not think that all projects should reach everyone and are aware of the complexities and the costs that are associated with wider reach. Indeed, practitioners in CS often need to make balanced methodological choices with regard to — among others — technology, ethics, data quality and research objectives, often in time-or resource limited context. Yet, for CS as a whole, we should pay attention for the mechanisms that operate within it, to avoid it from becoming institutionally exclusionary. The intention of the authors is therefore not to shame or praise different practices of CS, but to look at it as a whole, participatory practice. The three dimensions enable different types of CS projects to be included and its intersection with different causes of exclusion facilitates the questioning required to understand who is left behind from being able to partake in this practice.

Understanding who is left behind in citizen science can make it a more powerful contributory practice to the SDGs. The same aforementioned UNDP discussion paper highlights that community level SDG planning, monitoring and reporting can be powerful in improving the results of SDG initiatives [Renner et al., 2018]. The involvement of communities for data collection was part of the U.K.'s Department for International Development (DFID) approach to 'leave no one behind' in its aid programmes [Munro and Bond 'leave no one behind' group, 2018]. Along with the findings of Fraisl et al. [2020], this governmental initiative reveals that citizen science is relevant in including the public in the achievement of the SDGs. Understanding and being transparent about who citizen science is accessible to is a first step for the practice to integrally take part in achieving the SDGs, assisting with the monitoring of the SDGs whilst achieving the pledge of 'Leave no one behind'.

With a greater level of literature research and perhaps a call out to citizen science practitioners and analysts, this framework could be more comprehensively filled. We hope that this framework can serve as a preliminary endeavour to understand who is left behind.

References

Bell, S., Marzano, M., Cent, J., Kobierska, H., Podjed, D., Vandzinskaite, D., Reinert, H., Armaitiene, A., Grodzińska-Jurczak, M. and Muršič, R. (2008). 'What counts? Volunteers and their organisations in the recording and monitoring of biodiversity'. *Biodiversity and Conservation* 17 (14), pp. 3443–3454. https://doi.org/10.1007/s10531-008-9357-9.

Beza, E., Steinke, J., van Etten, J., Reidsma, P., Fadda, C., Mittra, S., Mathur, P. and Kooistra, L. (2017). 'What are the prospects for citizen science in agriculture? Evidence from three continents on motivation and mobile telephone use of resource-poor farmers'. *PLOS ONE* 12 (5), e0175700. https://doi.org/10.1371/journal.pone.0175700.

Burke, B. J. and Heynen, N. (2014). 'Transforming participatory science into socioecological praxis: valuing marginalized environmental knowledges in the face of the neoliberalization of nature and science'. *Environment and Society* 5 (1). https://doi.org/10.3167/ares.2014.050102.

Chandler, M., See, L., Copas, K., Bonde, A. M. Z., López, B. C., Danielsen, F., Legind, J. K., Masinde, S., Miller-Rushing, A. J., Newman, G., Rosemartin, A. and Turak, E. (2017). 'Contribution of citizen science towards international biodiversity monitoring'. *Biological Conservation* 213, pp. 280–294. https://doi.org/10.1016/j.biocon.2016.09.004.

Cigliano, J. A., Meyer, R., Ballard, H. L., Freitag, A., Phillips, T. B. and Wasser, A. (2015). 'Making marine and coastal citizen science matter'. *Ocean & Coastal Management* 115, pp. 77–87. https://doi.org/10.1016/j.ocecoaman.2015.06.012.

Conceição, P. (2019). Beyond income, beyond averages, beyond today: inequalities in human development in the 21st century. Human development report. New York, NY, U.S.A.: United Nations Development Programme. URL: http://hdr.undp.org/sites/default/files/hdr2019.pdf.

Department of Economic and Social Affairs (2016). Leaving no one behind: the imperative of inclusive development. Report on the world social situation 2016. New York, NY, U.S.A.: United Nations. URL: https://www.un.org/development/desa/publications/report-of-the-world-social-situation-2016.html.

Ellis, R. and Waterton, C. (2005). 'Caught between the cartographic and the ethnographic imagination: the whereabouts of amateurs, professionals, and nature in knowing biodiversity'. *Environment and Planning D: Society and Space* 23 (5), pp. 673–693. https://doi.org/10.1068/d353t.

Evans, C., Abrams, E., Reitsma, R., Roux, K., Salmonsen, L. and Marra, P. P. (2005). 'The Neighborhood Nestwatch Program: Participant Outcomes of a Citizen-Science Ecological Research Project'. *Conservation Biology* 19 (3), pp. 589–594. https://doi.org/10.1111/j.1523-1739.2005.00s01.x.

Ferilli, G., Sacco, P. L. and Tavano Blessi, G. (2016). 'Beyond the rhetoric of participation: new challenges and prospects for inclusive urban regeneration'. *City, Culture and Society* 7 (2), pp. 95–100. https://doi.org/10.1016/j.ccs.2015.09.001.

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., Moorthy, I., Arias, R., Piera, J., Oliver, J. L., Masó, J., Penker, M. and Fritz, S. (2020). 'Mapping citizen science contributions to the UN sustainable development goals'. *Sustainability Science* 15 (6), pp. 1735–1751. https://doi.org/10.1007/s11625-020-00833-7.

Fritz, S., See, L., Carlson, T., Haklay, M., Oliver, J. L., Fraisl, D., Mondardini, R., Brocklehurst, M., Shanley, L. A., Schade, S., Wehn, U., Abrate, T., Anstee, J., Arnold, S., Billot, M., Campbell, J., Espey, J., Gold, M., Hager, G., He, S., Hepburn, L., Hsu, A., Long, D., Masó, J., McCallum, I., Muniafu, M., Moorthy, I., Obersteiner, M., Parker, A. J., Weisspflug, M. and West, S. (2019). 'Citizen science and the United Nations Sustainable Development Goals'. *Nature Sustainability* 2 (10), pp. 922–930. https://doi.org/10.1038/s41893-019-0390-3.

Fukuda-Parr, S. and Hegstad, T. S. (2018). '"Leaving no one behind" as a site of contestation and reinterpretation'. *Journal of Globalization and Development* 9 (2). https://doi.org/10.1515/jgd-2018-0037.

Haklay, M. (2015). Citizen science and policy: a European perspective. Washington, DC, U.S.A.: Common Lab, Wilson Center. URL: https://www.wilsoncenter.org/publication/citizen-science-and-policy-european-perspective.

Jolly, E. J. (2002). 'Confronting demographic denial'. *Journal of Museum Education* 27 (2-3), pp. 3–6. https://doi.org/10.1080/10598650.2002.11510461.

Lawless, P. (2007). 'Continuing dilemmas for area based urban regeneration: evidence from the New Deal for Communities Programme in England'. *People, Place and Policy Online*, pp. 14–21. https://doi.org/10.3351/ppp.0001.0001.0003.

Lawrence, A. (2006). 'No Personal Motive? Volunteers, Biodiversity, and the False Dichotomies of Participation'. *Ethics, Place & Environment: A Journal of Philosophy & Geography* 9 (3), pp. 279–298. https://doi.org/10.1080/13668790600893319.

Levine, R., González, R. and Martínez-Sussmann, C. (2009). 'Learner diversity in earth system science'.

Munro, K. and Bond 'leave no one behind' group (2018). *Leave no one behind: how the development community is realising the pledge*. URL: https://www.bond.org.uk/resources/leave-no-one-behind.

Pandya, R. E. (2012). 'A framework for engaging diverse communities in citizen science in the US'. *Frontiers in Ecology and the Environment* 10 (6), pp. 314–317. https://doi.org/10.1890/120007.

Pocock, M. J. O., Chandler, M., Bonney, R., Thornhill, I., Albin, A., August, T., Bachman, S., Brown, P. M. J., Cunha, D. G. F., Grez, A., Jackson, C., Peters, M., Rabarijaon, N. R., Roy, H. E., Zaviezo, T. and Danielsen, F. (2018). 'A vision for global biodiversity monitoring with citizen science'. In: Advances in Ecological Research. The Netherlands: Elsevier, pp. 169–223. https://doi.org/10.1016/bs.aecr.2018.06.003.

Renner, S., Bok, L., Igloi, N. and Linou, N. (2018). *What does it mean to leave no one behind? A UNDP discussion paper and framework for implementation*. [Discussion paper]. URL: https://www.undp.org/content/undp/en/home/librarypage/poverty-reduction/what-does-it-mean-to-leave-no-one-behind-.html.

Schrögel, P. and Kolleck, A. (2019). 'The many faces of participation in science: literature review and proposal for a three-dimensional framework'. *Science & Technology Studies* 32 (2), pp. 77–99. https://doi.org/10.23987/sts.59519.

Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B. V., Krasny, M. E. and Bonney, R. (2012). 'Public Participation in Scientific Research: a Framework for Deliberate Design'. *Ecology and Society* 17 (2), p. 29. https://doi.org/10.5751/ES-04705-170229.

Strasser, B. J., Baudry, J., Mahr, D., Sanchez, G. and Tancoigne, E. (2019). '"Citizen science"? Rethinking science and public participation'. *Science & Technology Studies* 32 (2), pp. 52–76. https://doi.org/10.23987/sts.60425.

Trumbull, D. J., Bonney, R., Bascom, D. and Cabral, A. (2000). 'Thinking scientifically during participation in a citizen-science project'. *Science Education* 84 (2), pp. 265–275. https://doi.org/10.1002/(SICI)1098-237X(200003)84%3A2%3C265%3A%3AAID-SCE7%3E3.0.CO%3B2-5.

United Nations Development Programme (2019). *About human development*. Human development reports. URL: http://hdr.undp.org/en/humandev.

Walajahi, H. (2019). 'Engaging the "citizen" in citizen science: who's actually included?' *The American Journal of Bioethics* 19 (8), pp. 31–33. https://doi.org/10.1080/15265161.2019.1619868.

West, S. and Pateman, R. (2017). *How could citizen science support the Sustainable Development Goals?* URL: https://www.sei.org/publications/citizen-science-sustainable-development-goals/.

Wiggins, A. and Crowston, K. (2012). 'Goals and Tasks: Two Typologies of Citizen Science Projects'. In: *Proceedings of the 45th Hawaii International Conference on System Science (HICSS-45)*, pp. 3426–3435. https://doi.org/10.1109/HICSS.2012.295.

Authors

Madeleine (Cléa) Montanari is a master student at Wageningen University in Environmental Policy. E-mail: madeleine.montanari@wur.nl.

Liesbet Jacobs is a post-doctoral researcher KU Leuven and citizen science practitioner. E-mail: liesbet.jacobs@kuleuven.be.

Mordechai (Muki) Haklay is a senior lecturer in geographical information science in the Department of Civil, Environmental and Geomatic Engineering at University College London and co-director of the UCL Extreme Citizen Science group. E-mail: m.haklay@ucl.ac.uk.

Felix Kwabena Donkor is a research associate at the College of Agriculture & Environmental Sciences of the University of South Africa. E-mail: felixdonkor2002@yahoo.co.uk.

Maria Rosa (Rosy) Mondardini is the managing director of the Citizen Science Zurich Center. E-mail: maria.mondardini@uzh.ch.

How to cite

Montanari, M., Jacobs, L., Haklay, M., Donkor, F. K. and Mondardini, M. R. (2021). 'Agenda 2030's, "Leave no one behind", in citizen science?'. *JCOM* 20 (06), A07. https://doi.org/10.22323/2.20060207.

© The Author(s). This article is licensed under the terms of the Creative Commons Attribution — NonCommercial — NoDerivativeWorks 4.0 License.
ISSN 1824-2049. Published by SISSA Medialab. jcom.sissa.it