European Commission

Mutual Learning Exercise

Citizen Science Initiatives - Policy and Practice
Second Thematic Report: Challenge Paper on Ensuring Good Practices and Impacts

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Mutual Learning Exercise on Citizen Science Initiatives – Policy and Practice
Second Thematic Report: Challenge Paper on Ensuring Good Practices and Impacts

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Mutual Learning Exercise on Citizen Science Initiatives - Policy and Practice

Second Topic Challenge Paper:

Ensuring Good Practices and Impacts

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LIST OF ABBREVIATIONS

CS: Citizen Science

CSI-PP: Citizen Science Initiatives- Policy and Practice

DG: Directorate-General

ECSA: European Citizen Science Association

ERA: European Research Area

EU: European Union

MLE: Mutual Learning Exercise

R&I: Research & Innovation

RRI: Responsible Research and Innovation

1. INTRODUCTION: THE ROLE OF CITIZEN SCIENCE TO OPEN UP RESEARCH & INNOVATION

"Interaction between citizens, scientists and policy makers is essential to enrich research and innovation, and reinforce trust of society in science. I am proud of the hundreds of thousands involved citizens that already contributed to research and innovation and look forward to continue opening up research towards society and the world".

Mariya Gabriel, Commissioner for Innovation, Research, Culture, Education and Youth[1].

1.1 Citizen Science: A great opportunity to align Science with Societal Challenges and Needs

Citizen Science (CS) broadly refers to the (active) engagement of the general public in scientific research. It is a growing practice in which scientists and citizens collaborate to produce new meaningful knowledge aligned with societal needs and challenges, applicable to any research field, including the social sciences and humanities. It entails different strategies, methodologies and phases of research in which citizens can participate or get actively involved up to different levels[2]. The overall landscape of different practices makes it difficult to come up with a unique definition of CS[3]. Providing an exhaustive definition which encompasses the many different purposes and approaches applied to even more diversified contexts is an inherent challenge in itself[4]. The *European Citizen Science Association* (ECSA) adheres to a definition which takes into account the participation of the general public in scientific processes through an open and inclusive approach and its use for societal benefit and decision-making processes. ECSA has also developed the 10 Principles of Citizen Science[5] and the Characteristics of Citizen Science[6], which guides practitioners in the implementation of CS projects. In addition, CS is one of the eight pillars of the European's Union (EU) Open Science policy and the European Research Area (ERA), which intends to position open science as the *modus operandi* of modern science, and seeks as an ultimate goal that "The general public should be able to make significant contributions and be recognized as valid European science

[1] Horizon 2020 SwafS Citizen Science Project Cluster Event; (21 January 2021); Report.
[2] Haklay M. DITO's escalator model of engagement. P22-Motivations_Skarlatidou_Haklay_2020_ECSA_Poster.pdf (ecsa-conference.eu)
[3] Haklay M., Dörler D., Heigl F., Manzoni M., Hecker S., Vohland K. (2021). What Is Citizen Science? The Challenges of Definition. In: Vohland K. et al. (eds). The Science of Citizen Science. Springer, Cham. https://doi.org/10.1007/978-3-030-58278-4_2
[4] Haklay et al. 2021
[5] ECSA (European Citizen Science Association). 2015. Ten Principles of Citizen Science. Berlin. http://doi.org/10.17605/OSF.IO/XPR2N
[6] ECSA characteristics of Citizen Science: https://zenodo.org/record/3758668#.YhZJCt_MI2w

knowledge producers"[7]. In doing so, the active engagement of citizens in science has the potential to improve research and reinforce societal trust in science, since it boosts:

- Relevance and effectiveness of research agendas aligned with society
- Ensures the consideration of the needs, expectations and values of society, taking into account citizen's concerns
- Creativity and better quality of research, the quality and quantity of data collected, discussed and analysed
- Scientific literacy, skills and competences; formal and informal science education; critical thinking and fighting against misinformation
- Confidence of the public in research outcomes and institutions
- Transparency towards society, social inclusion and employability
- Mutual learning between science and society

1.2 Scope of this Challenge Paper

According to the programme of the Mutual Learning Exercise (MLE) 'Citizen Science Initiatives - Policy and Practice' (CSI-PP), the overall goal of this second topic in the series is **to identify and discuss practical examples and best practices of citizen science and its impact**.

This challenge paper starts by giving a brief overview of the role of CS in Research & Innovation (R&I). It presents the main barriers to implementation of CS activities, including scientific, engagement, data or policy challenges, and reflects on the need to demonstrate the impact of CS projects at different levels. Besides, it highlights the key aspects of the implementation cycle of a CS project in connection with the main challenges identified, so as to understand the wide range of possibilities available and the barriers faced. This report represents the starting point of the upcoming workshops taking place on the 7th and 14th of March 2022, where 11 successful projects selected by the participating Member States will be analysed to identify good practices and impacts, and reflect on what works and what does not work, as a part of the MLE. As there are no correct answers and one solution may not fit all, potential mitigation actions and examples of existing mechanisms to support the implementation of CS projects across Europe will be examined to inform decisions on potential actions. The analysis of the different variables made in Topic 2 will also set the basis for further work in the upcoming MLE topics.

[7] Open Science | European Commission (europa.eu)

2. THE ROLE OF CITIZEN SCIENCE IN RESEARCH AND INNOVATION

2.1. Citizen Science: Open Science into practice!

CS is part of the European Commission's Open Science Policy. Open science is more than open access to scientific publications and research data; it also includes opening up the R&I system to society, creating co-ownership with citizens, and making R&I more relevant and responsive to the needs, expectations and values of society. Open science means sharing knowledge, data and tools as early as possible, not only between researchers and between disciplines, but also with society at large. Open Science also has the potential to increase the quality and efficiency of R&I, enhance creativity and increase transparency of, and trust in, the science ecosystem by engaging all relevant stakeholders including citizens and civil society (CSOs, NGOs, citizen associations or citizen groups, etc.). Active engagement with citizens and society has the potential to improve research and its outcomes and reinforce societal trust in science, and it is deliberately democratic.

The overall objectives of CS within the 'Science with and for Society' part of Horizon 2020 was: 1) to build effective cooperation between science and society, 2) to recruit new talent for science and, 3) to pair scientific excellence with social awareness and responsibility so as 4) to ensure a more responsible science and to enable the development of policies more relevant to citizens and society at large, contributing to participatory democracy. More specifically, this support to CS aimed to integrate society in science and innovation issues, policies and activities in order to merge citizens' interests and values and increase the quality, relevance, social acceptability and sustainability of R&I outcomes in various fields of activities.

Across the Horizon 2020 Work Programme, more than 300 projects are estimated to encompass some degree of CS initiatives, of which 52 are supported by the SwafS (Science with and for Society) part. A wide range of scientific disciplines are covered, such as environmental monitoring, biodiversity, food systems, circular economy, sustainable cities, nanotechnologies, climate change, the social sciences and humanities. In view of this increase in CS projects, an important question is the type of implementation modalities that are needed to support such activities to continue enriching an inclusive R&I ecosystem – which is relevant and responsive to the needs, expectations and values of society. In the new framework of Horizon Europe, the following legal provisions provide opportunities to open up the R&I system to citizens as a cross-cutting priority:

- Art 2.5: 'Open science' means an approach to the scientific process based on open cooperative work, tools and diffusing knowledge, including the elements of article 14;

- Art. 7.11: The programme shall promote co-creation and co-design through engagement of citizens and civil society;
- Art 14.4: Other open science practices shall be promoted and encouraged, including for the benefit of SMEs;
- Art. 39: The work programme may provide for additional incentives or obligations to adhere to open science practices.

The current increase of CS projects in the EU clearly shows the growing participation of society in research and science. However, scientists, research organisations, and funding agencies are still discovering the benefits of further spreading the collaboration between scientists and society, and a lot of barriers for its implementation, at the institutional and at the implementation levels, are still to be overcome. There has been a significant rise in social participation in research indeed, with citizens becoming engaged in the process of co-creating the knowledge produced. However, this is not meant to be just a passive role, but, as a society, we are called to actively contribute to scientific agenda setting, and to produce and analyse new scientific data to inform evidence-based policies better aligned with society. This entails a real change of paradigm! In order to co-create new ways of tackling societal challenges, we need to involve those most affected - the citizens themselves[8] - through great research and practice-innovative and an ever-growing field, that is, CS.

2.2. Citizen Science: Making R&I more responsible… but how?

CS can be interpreted as a strategy to increase the quality and interactions between science and society, and it aims to achieve a better alignment of R&I with the culture, needs, challenges and expectations of our societies. It is a powerful tool to work at the local level with communities and tackle the most prevalent challenges faced by the European regions and territories. At a research level, CS has the potential to activate processes that can have an impact on several dimensions of the Responsible Research and Innovation framework, in connection with the 10 Principles of Citizen Science, including:

- **Public Engagement**: Activating the engagement of citizens, together with the quadruple helix of stakeholders[9] (academia, public sector, private sector, and civil society) - whenever needed and possible - within the R&I ecosystem to increase the project impact.

[8] Moedas, C. (2018). Foreword. In S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel, & A. Bonn (Eds.), Citizen Science: Innovation in Open Science, Society and Policy (pp. v–vi). UCL Press. http://www.jstor.org/stable/j.ctv550cf2.2

[9] Schütz, F., Heidingsfelder, M.L., Schraudner, M. (2019). Co-shaping the Future in Quadruple Helix Innovation Systems: Uncovering Public Preferences toward Participatory Research and Innovation. She Ji: The Journal of Design, Economics, and Innovation, Volume 6, Issue 4, Winter 2020, Pages 567-568. https://doi.org/10.1016/j.sheji.2019.04.002

- **Open Access**: Making science accessible, free of charge and without restrictions. Opening up citizen generated data, considering the FAIR principles, shifting our traditional way of doing science into an open, fairer and inclusive one.
- **Ethics**: Ensuring that research is connected with the 10 Principles of Citizen Science and that it considers ethical principles, including aspects such as the recognition of the participation of citizens and avoiding generating false expectations in terms of expected outcomes.
- **Science Education**: Strengthening the relationship between science and society, boosting formal and informal education through training and participation in science, increasing scientific literacy and critical thinking, and fostering STEM careers.
- **Gender**: Promoting gender balance in R&I and the inclusion of sex and gender aspects in R&I and in all participatory activities and the language used to engage girls and women into the projects.
- **Governance**: Fostering the connection with decision makers for the official uptake of citizen generated data and to inform evidence-based policies.

CS is generally an ideal means to democratise science, build trust in science, and leverage the vast societal intelligence and capabilities to conduct excellent R&I. To fully reap these benefits and to mainstream CS across the ERA, important challenges need to be tackled, including the promotion of career and incentive systems embedding these approaches within institutions; training and capacity building; development of data infrastructures and platforms to support cross European activities; international mutual learning activities; design and adoption of indicators to measure outcomes; and support mechanisms at European and national level. **But how can we put this into practice?**

2.3. Key messages

- Open Science, Citizen Science and RRI are key approaches to align societal needs with scientific objectives and tackle major societal challenges, especially those greatly impacting citizens.
- Citizen Science actively contributes to Open Science and RRI and can be understood as an intrinsic part of it.
- R&I can benefit from Citizen Science approaches in meaningful citizen participation in science to produce new knowledge and advance towards participatory democracy.
- A more responsible Citizen Science needs to be aligned with responsible funding programmes to ensure project implementation and sustainability.

- Institutional changes are needed to foster research incentives and mainstream CS into the European Research Area.

3. CHALLENGES & BARRIERS REGARDING THE IMPLEMENTATION OF CITIZEN SCIENCE PROJECTS

3.1. Nobody said it was easy!

CS is a challenging endeavour indeed, and it poses difficulties at all phases of implementation - from project design to stakeholder engagement, data collection and analysis, as well its outcomes and results, the required inter-disciplinary skills needed – in addition to, its sustainability. For instance, engaging citizens poses a series of challenges such as: How do we engage citizens from all social realities and thus ensure inclusivity? Which key motivation mechanisms can we use to ensure citizens will gather data during the needed data collection process? How ethical is it to use rewarding mechanisms to engage citizen scientists? How do we ensure the data collected is not biased? CS is still an innovative field of knowledge that needs further recognition within society and the traditional scientific community. Moreover, a CS project needs to be tailor-made and it grows step by step through its implementation. For instance, when mapping the stakeholders, you can find a new key actor which can enrich and enlarge your research objectives and outcomes, and thus you may need new engagement strategies and mechanisms to be put in place.

The most important challenges and barriers when implementing CS projects are briefly described and classified by a series of categories below including Challenges for Scientific Recognition, for Career Scientists, for Citizen Engagement, for Data Quality, for demonstrating Impact, for Project Sustainability and for the National Funding Schemes.

3.2. Challenges & Barriers for Citizen Science Implementation

These challenges and barriers for implementing CS projects are the result of a co-creation exercise conducted during the "Citizen Science Cluster Workshop 2019"[10] (Brussels, 12th December 2019) within Session 1: "Challenges on how to enable Citizen Science to play a fuller role in Research and Innovation". During the MLE Session on the 7th and 14th March 2022, the validity of these challenges and barriers will be reviewed and revised, although it is clear that most of them are still relevant in 2022. New challenges and barriers will be identified, taking account also of the good practices and recommendations that emerged in the

[10] Horizon 2020, Citizen Science Cluster Workshop (December, 2019); Report.

subsequent sessions in the December 2019 workshop, as well as the challenges, observations and recommendations that came out of the January 2021 Citizen Science SwafS event, and other relevant work. Mitigation strategies will be defined and their applicability and potential feasibility evaluated.

3.2.1. Challenges for Scientific Recognition

- The full potential of Citizen Science is still to be demonstrated and needs to gain scientific, political and societal recognition.
- Citizen Science has lower scientific impact than traditional science due to the limited scope of citizen science projects (also in relation to the received funding).
- Scientific disciplines are still limited and are underrepresented scientific fields within citizen science (e.g., SSH, Public Health, Policy Research, History, Anthropology).

3.2.2. Challenges for Career Scientists

- Lack of necessary skills and lack of familiarity to implement Citizen Science projects: need for education and training.
- Lack of interdisciplinary teams (i.e., a Social Scientist to support citizen engagement in Natural Sciences)
- Lack of incentives for scientists to enrol in a more complex and less controlled research scheme.
- Lack of scientific and academic career recognition.

3.2.3. Challenges for Citizen Engagement

- Challenges in increasing the number of participants within the Citizen Science Project.
- Challenges in the implementation of a real engagement of citizens in risk of social exclusion: engage all levels of society ensuring inclusivity in order to "democratise" science.
- Barriers for engagement: poverty, lack of social mobility, gender issues (females underrepresented), ethnic minorities, language barriers, etc.
- Role of citizens limited to data gathering (when they can be involved from project identification and be engaged throughout all Citizen

Science phases following an Extreme Citizen Science Approach[11]).
- Close cooperation with Citizen Science organisations is needed (knowledge coalition) to promote social change. There is a need to move from a top-down to a bottom-up approach.
- Motivation mechanisms are key for sustained engagement during the project: relevant knowledge, access to information, games, entertainment, solving a direct problem they have, creating or accessing a community.
- Are rewarding mechanisms needed? How ethical are they in each case?
- Do citizens participating in citizen science projects have internal biases?

3.2.4. Challenges for Data Quality

- Automatic data validation mechanisms are costly.
- Data is dispersed in several repositories and difficult to access and re-use.
- A data-centric approach is not systematically adopted, making it difficult to assess, measure and compare results and impact.
- Data sharing between projects is still a challenge.

3.2.5. Challenges for demonstrating Impact

- Explore new impact & evaluation metrics that embrace new social dimensions (including ethical aspects and socially responsive research) as well as indicators to demonstrate impact within science, policy, society and economy.
- Use co-creation and participatory settings to develop new evaluation collaborative approaches.
- Create indicators to measure the impacts of citizen science (i.e., ACTION framework[12]).
- Create indicators at the adequate level (local, regional, national, European) that can be easily measured to demonstrate impact.

[11] Haklay, M., and Francis, L., (2018). Participatory GIS and community-based citizen science for environmental justice action, in Chakraborty, J., Walker, G. and Holifield, R.(eds.), The Routledge Handbook of Environmental Justice. Abingdon: Routledge, pp. 297-308

[12] Passani, A., Janssen, A., Hölscher, K (2021). Impact assessment framework. DOI 10.5281/zenodo.3968459

3.2.6. Challenges for Sustainability

- Lack of resources to maintain technological tools (e.g., citizen science apps or web platforms).
- Maintaining engagement (overcoming participation fatigue).
- Financial sustainability to ensure a long-term perspective.
- Upscaling and replicability mechanisms to cover wider geographical areas or other research fields.
- Lack of spaces to learn how to do citizen science, which can be especially relevant to younger generations.

3.2.7. Challenges for National Schemes

- Different levels of maturity of CS practices across countries.
- Limited transfer of knowledge across countries: limits replicability, increases the required efforts, limits maturity of results.
- Necessity of building a strong European network and supporting mutual learning, role modelling, and best practices.
- Different support mechanisms and funding schemes (when existing) in the different countries.

4. THE PATH TO SUCCESSFUL IMPLEMENTATION OF A CITIZEN SCIENCE PROJECT

4.1. Introduction: Which aspects can make a Citizen Science Project successful?

In the face of large and complex societal challenges, it is important to combine knowledge from various sources. The need to regain trust in science among a large part of the population, and to find a new way of collaboration and knowledge exchange between scientists and policymakers, which cannot be taken for granted, emerged in an equally evident way. CS is a tool to face the challenges of researchers, policymakers, citizens and other stakeholders finding out a new, faster and more effective way to cooperate and co-create solutions to societal problems. In other words, CS is the most powerful tool we have nowadays to build "collective intelligence", which also implies a continuous and shared understanding of a particular issue.

CS is also understood as a mutual learning problem-solving approach, with specific transdisciplinary characteristics that makes research as diverse and

inclusive as possible. CS is thus a strong part of the Open Science agenda and it aims to integrate the knowledge produced in diverse social contexts: within concrete scientific disciplines, among scientific disciplines, in the policymaking environment and societal reality. In such a context, mutual learning processes of CS are crucial as a response to the need to capitalise on existing knowledge and wisdom-sharing of society to address complex problems at a local and global scale. CS can significantly contribute to a proper exchange of information and experience on a specific problem, aimed at improving the capacity and quality of the findings and response. It also facilitates discussion to reach consensus on common objectives and expected outcomes with the different types of stakeholders involved in the process. This, of course, requires an effort of sharing and accepting that every actor counts equally, while building trust in all stakeholder groups.

In this challenge paper, we want to highlight key points that are relevant for the whole implementation cycle of a CS project in order to reflect upon common challenges and different implementation approaches, including aspects in relation to the target citizens and communities to get engaged, levels of participation, inclusivity and diversity aspects, data collection and quality assurance, and the impact generated at all levels by CS projects. Some of these aspects are directly connected to the challenges stated above, which may hinder the sustainability of the projects, and that may be fostered by the required institutional changes in some cases, or by national or European funding schemes and the promotion of joint actions, infrastructures or other support mechanisms. We have organised these aspects in different variables that are explained below in the following subsections:

4.2. Variable 1 - Participation, Engagement, Inclusivity & Diversity in Citizen Science across all phases of the research project

Engagement of stakeholders is at the heart of CS. The way that citizens take part in CS projects can range from an extra pair of hands to gather data to a much more equal partnership where citizens can help to set the agenda, develop scientific experiments, or do analytical work and assess the results[13]. The specific engagement approach will look very different depending on the type of project, who is going to initiate it, what the project objectives are, and what stage of development the project is at. Regarding the participation level, you may ask yourself:

- *Which role do citizens have in the project?*
- *What is their level of involvement in each phase of research (project identification, project design, data collection, data analysis, action, etc.)?*

[13] (Bonney et al., 2009; Phillips et al., 2019).

- *What citizen communities are you targeting to engage in the project? (e.g., children/young people at schools, neighbours, experts, science lovers, etc.)*
- *Are you aware of the different social realities present within the area of your project? How can you involve them in order to ensure inclusiveness and diversity? Do you need to use different engagement strategies?*
- *How many people do you need to involve to ensure a good data collection process? How are you going to decide this?*
- *What are the motivations for citizens to participate in your project?*

Recruiting, involving and engaging citizens in any CS project is a very challenging and time-consuming task, but critical and crucial to project success. But how deep in the project do we want to engage citizens? Will we find citizens motivated enough to participate at an early stage to co-design the project? Are we interested (and brave enough) to encourage citizens to define what science should be done and which questions it should tackle? We need to remember that many people are very happy to participate in a limited, clear and well-structured role, but not everyone wants to participate in the whole research cycle. Some early questions related to the engagement strategy in any CS project include:

- *To what extent do we want to engage citizens in our project? Do we want to co-create the project with them? Is it a project suitable for co-production and the project team knows how to implement it?*
- *Which resources do we have to plan and implement citizen engagement?*
- *Which engagement strategies do we have in place?*
- *Can we adapt them along the way depending on the situation we find in the real world when we start engaging?*
- *Do they need rewarding mechanisms for the participation of different groups?*
- *Do we count on social scientists in our team to talk with and engage our target citizens, or to do ethnographic research if needed?*
- *How do we plan to sustain engagement with time?*
- *To what extent do we aim to be inclusive? (in relation to social realities, age, gender, ethnic minorities, etc.- it is OK to aim at recruitment of people with PhDs if this is the type of problem we are facing)*
- *Do we have resources to be inclusive enough?*

One key aspect of engaging stakeholders is to ensure the diversity of the community around the CS project. There are uncountable benefits not limited to CS. Inclusive and diverse groups of stakeholders tend to be more creative, productive and perform better. Diverse stakeholders can also develop new approaches, add different perspectives, and ensure the results are representative. Participants in science have traditionally belonged to upper literacy level groups. Therefore, one of the main challenges and benefits of applying CS is to engage with different literacy groups who can contribute with their respective expertise to the whole lifecycle of the project and produce new knowledge/findings. The key to be inclusive and involve disadvantaged populations is to **select research questions that matter to them**. It is paramount to consider how to motivate and sustain interest in the projects, and to do that continuous feedback is paramount. In addition, you can use the results of the research project as a way to engage with wider civil society who can eventually become active participants in the project. Results can also be taken up by society or other stakeholder groups for advocacy purposes.

In order to give the chance to the whole of society to participate in science, you may:

- Get information on who your stakeholders are and how they would like you to communicate and engage with them.
- Build trust, raise motivation.
- Ensure that your information is accessible in different formats (e.g., audio, video, text, online, in-person, different languages, etc).
- Plan measures to help you reach culturally diverse stakeholder groups.
- Plan engaging activities and communicate in a way to maximise the opportunities for vulnerable people or people with disabilities.
- Check that the language is not difficult to understand by a non-expert, and of course, never use coercive expressions.
- Think about appealing reward systems (e.g., compensation for time, science education, participation in decision making processes, upskilling, improved employability, recognition in scientific publications, networking, etc.).
- Take advantage of community events and adapt to the available time slots to your target citizens.
- Take into account ethical aspects and avoid raising false expectations. Be clear on the expected outcomes and the scope of the project, and carefully explain the use of the data collected, anticipating possible future uses and misuses.

In summary, participation should be valued at many levels, from occasional contributions to deep engagement in all phases of research. Different people with different life experiences, responsibilities and interests can contribute and add value to different phases in CS projects. Projects should also facilitate the opportunity to move to different levels of engagement and inclusion at different stages in participants' lives. Flexibility is key, and not all target groups may be involved at the same level. In fact, the desired level of participation will mainly depend on the project objectives but will be strongly limited by the human resource capabilities and budget of the research team.

4.3. Variable 2 - Data Quality[14] and Openness

In terms of data type and data collection, precision and accuracy are the most important aspects. In data processing, it is vital to have consistency in data sets over time. For data analysis, data sets must have adequate representation and distribution of the target population or area. Data type will later determine the reliability and validity of the whole data set. Reliability implies long-term stability and consistency of data. The data results should be able to be replicated repeatedly, this is necessary in most CS projects operating large data sets. Reliability also ensures CS is trusted and aligns with policy requirements and citizen's interests. Nonetheless, CS data is valid only if it means what it is supposed to, including accuracy, confidence, completeness, and error-free. When thinking and defining the data type, some questions should be asked:

- *How can you describe the data set being collected (data type)?*
- *Which methods and tools do you use for data collection?*
- *Do you need any physical or technical support, such as an App?*
- *Is your data geolocalised?*
- *What is your current (and foreseen) geographical coverage?*
- *Are you collecting metadata together with your data?*
- *What is the minimum number of participants or of data collected to make the data set scientifically valid?*

Data quality in CS is the most valued normative claim anchored in multiple levels of expectations and a key aspect to claim recognition. Several factors relating to data quality discussions in CS are challenging. First of all, existing CS projects have different incompatible ways of dealing with data quality and sharing data.

[14] Kosmala, M., Wiggins, A., Swanson, A., & Simmons, B. (2016). Assessing data quality in citizen science. Frontiers in Ecology and the Environment, 14(10), 551-560. Wiggins, A., Newman, G., Stevenson, R. D., & Crowston, K. (2011, December). Mechanisms for data quality and validation in citizen science. In 2011 IEEE seventh international conference on e-Science Workshops (pp. 14-19). IEEE. Balázs, B., Mooney, P., Nováková, E., Bastin, L., & Arsanjani, J. J. (2021). Data quality in citizen science. The science of citizen science, 139.

This makes the future reuse of data significantly impacted. Secondly, most CS projects are contributory in approach with no minimum standard or protocol in place. Thirdly, most CS projects have multiple goals, and all must deal with the various legitimacy problems around them. Several questions should be considered when dealing with this issue:

- *How do you ensure the quality of the collected data?*
- *How do you analyse your data?*
- *How do you validate it?*
- *Do you have automatic data analysis or validation mechanisms in place to facilitate and ensure the quality of this task?*
- *How can we increase trust in citizen generated data?*

In addition, the adoption of Open data approaches can highly benefit CS by increasing its visibility and creating opportunities for collaboration, ensuring mutual learning, data consistency and persistence, and securing the legacy of projects and their impacts. Simultaneously, CS is a field that contributes to making research more open and participatory[15]. However, open data faces many challenges such as the lack of a structured approach that advocates for openness, a limited number of free access journals and open licensing of academic publications (and if opened, these represent a high cost that most CS small projects cannot afford). Yet many economic impact studies have demonstrated the benefits of opening up the data, and local data usually does not offer significant information: there are few examples of local government data that creates substantial value for the local community. To overcome this challenge, we may start asking ourselves:

- *Is the produced data open?*
- *Is your data locatable?*
- *Is your data accessible?*
- *Is your data interoperable?*
- *Is your data reusable?*

Implementing CS projects successfully while adhering to the needs of the participants involved is a complex task which requires thoughtful design. Different stakeholders have different perspectives on challenges linked to CS initiatives demanding specific solutions for each stakeholder. One of the solutions to alleviate this gap of knowledge and experience is to develop training sessions or other methods that support participants, while ensuring that desired outcomes

[15] Citizen science and open science – European Citizen Science Association (ECSA) (citizen-science.net)

are accomplished, thus increasing the overall quality of the collected data. Training can also be connected to engagement and reward strategies.

- *Do your participants receive any training to collect data?*
- *Can you think of a method to collect data with your citizens together? (e.g., sensory walks to monitor environmental issues)*
- *Do your citizens participate in data analysis?*

4.4. Variable 3 - Science communication

One of the pivotal characteristics of CS is the public involvement of citizens in scientific research. Communication and dissemination is, therefore, essential to the success of any project and its impact. However, this requires the consideration of many aspects such as the variety of stakeholders and their involvement, the selection of relevant communication channels for each of them, language, co-creation exercises to understand their concerns, and many more. CS embraces a constant dialogue that requires an exhaustive strategy and planning process. In CS no communication and dissemination strategy is static, they must be adjusted and updated according to the life cycle of the project and its specificities. Citizens can also participate in doing Science Communication through CS projects. However, communication represents one of the main challenges for projects due to the amount of time and effort it takes to communicate well with citizens and quadruple helix stakeholders. Not to mention that communication should be monitored and evaluated throughout the whole project, reviewing and updating resources constantly. Thus, it is paramount to set up specific communication strategies to effectively engage citizens, involve policy makers, other scientists and the private sector when required, and to have enough resources and knowledge to implement them.

- *Do you have a specific communication plan to reach your target citizens?*
- *Do you have devoted personnel for this?*
- *Which media channels do you use? How do they relate to the target group?*
- *Do you participate or engage with citizen's public events?*
- *Do you provide regular feedback to the citizens engaged? How?*
- *Do you include Citizen Scientists and other stakeholders to actively act as Science Communicators?*

4.5. Variable 4 - Demonstrating Impacts[16]

The impact of CS initiatives is usually divided into five domains: society, economy, environment, science and technology, and governance. But how can we measure the impact of CS and define valid, measurable indicators? A significant amount of impacts within CS projects are achieved after the data collection phase, while funding is rarely extended beyond this point. Overcoming this obstacle by ensuring larger funds that take into account the amount of time and resources needed to develop a proper impact (social, economic, political, scientific and environmental) framework is of utmost importance for the sustainability and real-life impact of CS projects. CS initiatives need to ensure that all measures taken are meaningful for all stakeholders, where relevant indicators and methodologies are used to identify and monitor the expected outcomes and impacts.

- *What are the most important impacts that you are trying to achieve with your CS project?*
- *Do you have a reliable impact evaluation framework set in place?*
- *In which phases of your project are you doing evaluation?*
- *Do you regularly measure the impact of your project at different levels to demonstrate the achievement of the expected outcomes? How often?*

Despite countless improvements during the last two decades, some actors of the scientific community still remain reluctant to recognise CS as a legitimate scientific approach[17], sometimes fuelled by a lack of profound knowledge about CS real contributions and a preference for data collected by scientists. Besides, academic career paths still rely on publication records in high-ranking academic journals, while the immense time and sources invested in building relationships and co-creation processes with citizens and other actors are undervalued. In order to boost a greater impact and recognition of CS as a scientific field, CS should be recognised as a research method in itself and not only as outreach to engage citizens. Incentives and reward mechanisms also need to be established to encourage scientists to integrate citizens in their research. Some questions related to this issue are the following:

[16] Wehn, U., Gharesifard, M., Ceccaroni, L. et al. (2021). Impact assessment of citizen science: state of the art and guiding principles for a consolidated approach. Sustain Sci 16, 1683–1699. https://doi.org/10.1007/s11625-021-00959-2. Phillips, T., Ferguson, M., Minarchek, M., Porticella, N. and Bonney, R. (2014). "Evaluating learning outcomes from citizen science." Cornell Lab of Ornithology, Ithaca.

[17] Golumbic, Y. N., Orr, D., Baram-Tsabari, A., & Fishbain, B. (2017). Between vision and reality: A study of scientists' views on citizen science. Citizen Science: Theory and Practice, 2(1). DOI: http://doi.org/10.5334/cstp.53

- *Do you receive any type of recognition for doing citizen science at a professional level?*
- *Have you published any scientific papers and/or participated in scientific conferences to present your CS project results?*
- *Do citizens receive any type of recognition for their participation?*

CS initiatives are one of the few fields that help to ensure that scientific agendas are well aligned with societal interests and challenges and thus, it is a field that enhances societal trust in science. CS also encourages all citizens including the so-called vulnerable communities to take a stake in the world around them. As a consequence, CS helps to empower citizens who can play an important role in producing valid evidence to inform scientific-based decisions. The social impact of CS also relates to the democratisation of science by providing access to knowledge production, which therefore creates effective relationships between scientists and society.

- *What is the main social impact that your project is generating, if any?*

CS projects can definitely create a positive environmental impact in: 1) environmental management, 2) evidence for policy, 3) behavioural change, 4) social network championing, 5) political advocacy, and 6) community change. Nonetheless, to really appreciate the impact of CS initiatives, traceability of data usage in policy and science is paramount. This can be achieved by funds that include persistent identifiers to locate specific data and tools to track environmental policy developments and facilitate impactful CS projects.

- *What is the main environmental impact that your project is generating, if any?*
- *Is your project contributing to achieve any of the Sustainable Development Goals? Is the data generated useful to monitor the SDGs indicators?*

The CS ecosystem has already identified the benefits of this field in policy and has highlighted them to policymakers at local, regional, national, European and international level. Indeed, in recent years policymakers have started to support these types of initiatives. For instance, the European Commission has included CS into its Open Science Agenda and several environmental policies, and it has funded CS through Horizon 2020 and now through Horizon Europe. It is worth noting that some EU Member States have already developed CS strategies to support national practices, since CS is also a key element to tackle local and

regional societal challenges. Nonetheless, the overall benefits of CS remain largely unknown for most policymakers at all governance levels. Perhaps more programmes, training and capacity building, or networking events showcasing real-life projects with high impact are needed to build trust among societies, the scientific community and policymakers to see its whole potential. To deepen its political impact the following questions might be of interest:

- *Have you engaged policy makers in the project? At which governance level?*
- *Did you manage to integrate citizen generated data in any official database?*
- *Have you produced any policy document resulting from the project results?*
- *Are you measuring and demonstrating your policy impacts?*

Making a difference to science and producing an impact at the economic local level are key motivations for policymakers and citizens. Especially, if policymakers want to materialise the benefits of CS (beyond access to data sources), including transparency, economic impact, social cohesion and democratisation of policy decisions, then CS must be taken more seriously and work together to promote and reach common goals. Setting up collaborations among citizens, policymakers and the private sector (SMEs and industries) will require a certain level of trust, and where this level of trust between society and policymakers does not exist, the private sector can play a key role. Their involvement can also contribute to the sustainability of CS projects by creating new business models that further support the activities.

- *What is the main economic impact that your project is generating, if any?*
- *Did you manage to engage the private sector to support your project?*
- *Are there opportunities for individuals, groups or organisations to start an economic activity (e.g., service)?*

4.6. Variable 5 - Fostering sustainability

After going through all the implementation phases and overcoming the barriers previously stated, the sustainability of CS projects once the funding ends represents one of the most important challenges. It also poses some ethical issues, such as maintaining and giving feedback of the actions to the already established communities of citizens that have contributed to the project. In general, to realise its full potential, CS needs to address its sustainability transitions through: 1) defining exploitation plans and new business models; 2) finding additional resources beyond grant funding; 3) considering how to ensure

the legacy of CS projects; and 4) considering how to scale up or spread[18] the activities, outcomes and impacts of CS initiatives, at the geographical level, but also by replicating the methodology in other communities, or to tackle similar societal challenges. Mainstreaming CS and building new investments to sustain projects may be a natural way to reinforce CS sustainability and its impacts in our societies.

- *Do you have an exploitation plan for your project?*
- *Have you produced narratives and communication materials to bring attention to your project results?*
- *Is your project replicable at a different scale or different geography?*
- *Is it applicable at the local, regional, national or even global level?*
- *Is the methodology valid to tackle other societal challenges?*
- *Are the communities involved willing to participate in the long term?*
- *Can you maintain your data collection and data analysis tools over time?*
- *Can you define a business model out of your project results?*
- *When will the technology need updating, maintenance and complete redevelopment?*

5. The Way to Go: National Initiatives to Promote Citizen Science

National support to promote CS is one of the best ways of reinforcing its practice and mainstreaming CS, building on the investments made to date (from Horizon 2020 and Horizon Europe, to more local or regional efforts). It is a natural way to strengthen CS practices as a whole.

It is thus necessary to start and continue funding dedicated CS actions at the national level to pursue efforts in strengthening networks, reinforcing training and capacity building efforts, helping overcome institutional barriers, pushing recognition, facilitating data infrastructures, organising joint events, contributing to demonstrate CS impacts, and facilitating the coordination and communication among projects in Europe and its Member States. Together with the support from the European Commission, national actions to support CS provide a unique opportunity to test and refine mechanisms to improve the practice of CS.

While several initiatives can be put in place at national level to support CS practices, adequate **infrastructure (as Observatories or Platforms) to build**

[18] Maccani, G., Goossensen, M., Righi, V., Creus, J. and Balestrini, M., Scaling up Citizen Science, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-25157-6, doi:10.2760/00926, JRC122219.

up networks of CS initiatives have become increasingly important in providing support to the projects and its participants, both nationally and in Europe. CS infrastructure make CS projects more visible and accessible for those stakeholders that want to get engaged. Similar initiatives can get in touch and learn from each other, reuse existing resources and maximise their outcomes. National infrastructure and networks can also be used to provide local, regional and national authorities with necessary information on key and emerging topics affecting public agendas. They are also relevant for scientists to access new sets of data and to conduct research, or for CS practitioners wishing to replicate an initiative in another territory. In most cases, however, the greatest challenge for Observatories or Platforms and Networks is to obtain permanent funding. This also relates to funding that usually ends after finishing a specific project without taking into account its sustainability and impact after running the project. It could be beneficial to establish together with public authorities the promotion of national CS observatories/platforms and networks that take into account: 1) technical components, 2) communication strategies, 3) openness and flexibility for a better adaptation to emerging needs, 4) more collaborative and interactive types of platforms, 5) shared resources, 6) networking capabilities, 7) promotion of joint events, 8) contents addressed to citizens to boost their participation in CS activities. These aspects will certainly lead to greater mutual-learning and resource savings in the long run, while contributing to the mainstreaming of CS.

In addition, it is necessary to continue funding dedicated CS actions to pursue efforts in supporting new or ongoing projects, strengthening networks, boosting communication among projects, and supporting newcomers to this field. While **general calls may be one avenue to approach CS** (e.g., by including public engagement, open data, co-creation or transdisciplinary teams in the evaluation criteria), another is to explicitly **mention CS in specific calls**. Some general recommendations for funders running general or specific CS calls include:

- Take into account the implementation challenges stated above to define the scope of the call (and thus the related funding).
- Do not underestimate resources. Like any R&I activity, engaging citizens in research requires time and appropriate resources. The deeper the engagement level requested and the wider the inclusivity and diversity sought, the higher the cost.
- Think of the geographical scope that you want to achieve, if any. This also relates to the number of citizens to engage and/or to the size of the data set to be collected - and thus to the cost of engagement.
- Think of the main objectives and impacts that you want to achieve with the call in the medium to long term and prioritise accordingly.
- Make it simple and trustworthy for practitioners and applicants. If needed, set up webinars to explain step-by-step how to apply, or provide specific guidance for finance departments on funds and calls.

- Consider how non-traditional actors in the R&I space (NGOs, local community organisations, faith-based organisations) can apply and access the funding.
- Define evaluation criteria that are relevant to the implementation of CS practices, taking into account their unique characteristics.
- If using general calls, highlight your interest in using CS methods, or include other aspects such as public engagement or co-creation under the evaluation criteria.
- Think of different mechanisms of financial support to promote the sustainability of CS projects once they have ended. For example, prizes or cascading grant mechanisms can help. Cascading grants are small amounts (in the form of grants or prizes) organised in order to reach grassroot initiatives at the national, regional or even local level. They can help to engage local communities, civil society organisations and other non-traditional or hard-to-reach groups of stakeholders in science.
- Try to understand the institutional barriers faced by practitioners to implement CS activities and support relevant mitigation strategies, e.g., by incentivising and rewarding citizen participation and science communication in academic curricula, among other aspects.
- Think of other ways of supporting the community, for example, by organising national events or thematic workshops, by promoting mutual learning, capacity building and training sessions, by supporting common data infrastructures or repositories, or by contributing to the communication and dissemination of the project results.
- Incubator models are another great example of promoting CS practice since it nurtures projects in different phases of development through coaching, training, and shared learning.

Goals:

- Expand and strengthen the practice of Citizen Science in Member State agency programmes.
- Advance science and resource management through sound Citizen Science project design
- Stimulate partnerships that address mutually beneficial outcomes, expand capacity, and leverage expertise and resources.
- Provide opportunities for meaningful engagement by the public in agency activities.
- Offer opportunities for peer-to-peer learning for agencies and partners.

6. CONCLUDING REMARKS

In this challenge paper, we have reflected on the main challenges faced as a whole by the CS community, including during the implementation cycle of CS projects. Given this complex landscape, mutual learning processes of CS are crucial as a response to the need to capitalise on existing knowledge and wisdom-sharing of society to address complex problems at a local and global scale. CS can also significantly contribute to a proper exchange of information and experiences on a specific problem, aimed at improving the capacity and quality of the findings and response. This, of course, requires an effort of sharing and accepting that every actor counts equally. It is thus vital to share good practices and lessons learned from successful initiatives, demonstrate the impacts achieved, work on the recognition and the institutional barriers to the practice, and deploy new support mechanisms at national and European level, if CS is to be mainstreamed across the ERA.

During the working sessions of Topic 2, on the 7th and 14th of March 2022, we will analyse current national initiatives supporting CS across Europe. The practices of 11 projects selected as successful examples by the Member States participating in the MLE will be examined to understand the different alternatives to implement CS projects and learn from their experiences, considering that there are no correct answers and that one solution may not fit all. The challenges and potential mitigation strategies will be further reflected upon to co-define how our practitioners can be further supported to continue fostering CS initiatives across Europe.

We already know the challenges, now it is time to work on strategies to overcome them. Some key questions are:

- *How can Member States reinforce this approach?*
- *How to encourage exchange between various scientific organisations and between CS practitioners?*
- *Which national strategies are more relevant to support new and ongoing CS projects?*
- *How can we further support the communities?*
- *Which common tools and data infrastructures do we need to facilitate the process?*

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This Challenge Paper provides a first overview on the Mutual Learning Exercise on Citizen Science set up by the Policy Support Facility (PSF) and DG Research and Innovation to provide practical support to Member States in relation to Topic 2 - Good Practices on Citizen Science and their Impact. It starts with a brief overview of the role of Citizen Science in Research & Innovation, to then present the main challenges and barriers for Citizen Science. Following, it reflects on different variables to be considered to make Citizen Science initiatives successful during the whole implementation cycle, including the need to demonstrate their impact at different levels. Finally, it reflects upon support mechanisms that can be set in place at national level for the mainstreaming of CS in the ERA, and for contributing to the sustainability of ongoing projects. This challenge paper represents the starting point of the workshops taking place on the 7th and 14th of March 2022.

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