CITIZEN SCIENCE:
THEORY AND PRACTICE

Supporting the Upscaling of Citizen Science to Address Global Challenges

MEETING REPORT

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ABSTRACT

In May 2024, a workshop was held as part of the European Citizen Science Association (ECSA) 2024 conference in Vienna to explore the creation of transnational communities to upscale citizen science, to address global issues as outlined by the European Union Horizon Missions and their objectives. This report summarises the discussions and issues that were raised during the workshop, from the point of view of a range of different actors in the citizen science discipline. This includes success stories of projects that have upscaled to an international scope, their methodologies for doing so, and the challenges citizen science initiatives face when attempting to contribute to global-scale challenges. The examples shared demonstrate a range of approaches when upscaling citizen science projects, giving rise to discussions regarding project management, shared learning and practice, citizen science tools and resources, scalability and context, and data interoperability. The success and challenges revealed will provide a clear roadmap for current and future citizen science practitioners, especially those with the ambition of upscaling their efforts to tackle challenges at national, regional, or global levels.

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KEYWORDS:
Upscaling; assessment; interoperability; sustainability; society; open science

TO CITE THIS ARTICLE:
Sprinks, J.C., Dowthwaite, L., Ceccaroni, L., Kiessling, T., Fraisl, D., Maccani, G., Leal, A.S., Gras-Velazquez, A., Liconti, A., Azevedo, K.P., Das, K., Parkinson, S. and Malta, M. 2025. Supporting the Upscaling of Citizen Science to Address Global Challenges. *Citizen Science: Theory and Practice*, 10(1): 23, pp. 1–11. DOI: https://doi.org/10.5334/cstp.837

INTRODUCTION

In the past decade, advancements in digital technology have made the world a more connected place, resulting in a surge of citizen science (CS) projects and platforms that allow volunteers to take part in research through a range of participatory models (Newman et al. 2012). Supported through either traditional funding systems (The European Commission's Horizon 2020 for instance) or other initiatives such as private foundation or corporate support, CS activities have made a significant scientific contribution by creating new and complementary datasets that enhance existing methods (Chandler et al. 2017b). This contribution goes beyond the science addressed, having the potential to impact a number of societal needs and foster open, inclusive, and democratic science approaches (Wildschut 2017). As such, CS has been touted as an approach to support larger frameworks, for instance in providing data, engaging the public, and generating the societal changes needed to achieve goals such as the Sustainable Development Goals (SDGs) and the Horizon Europe European Union (EU) Missions (European Commission 2024).

By upscaling to a transnational level, CS could collect, analyse, and exploit a vast amount of data, achieving a higher impact through creating a multinational community of citizen scientists. However, upscaling is complex, and scaling CS requires careful consideration of a range of processes (Branon 2019) involving institutional and policy change, activities replication at broader geographical scales, and cultural and societal change. As such, a range of different approaches have been taken by CS projects in an attempt to upscale their activities and address broader goals.

Whilst previous and existing support and investment mechanisms have proven adequate for the needs of larger CS initiatives, especially those that can justify the costs through their broad reach and resources, they have not proven suitable for all projects. Many CS activities are small in scale and experimental in nature, with current financial processes not well adapted to their needs (Ilse et al. 2023), and have failed to upscale over the longer term. To address this issue, frameworks and systems have been developed to support CS at different scales, emphasising flexibility (Newman et al. 2011) and incorporating social, scientific, and socioeconomic perspectives (Kieslinger et al. 2017). Such recommendations have, to-date, failed to trickle down into more traditional funding processes, the effect exacerbated because such projects are often those that can have the greatest societal impact (Mačiulienė et al. 2021), lending themselves to consider broader, perhaps even global, needs and expectations. Furthermore, whilst the potential of CS to bridge the gap between science and society is well-known (Sauermann et al. 2020), it can be difficult to fully realise it in a measurable way. Despite demonstrating the will to do so, CS practitioners often do not fully appraise their activities' full impact beyond the science involved because of lack of expertise, supporting resources, and time (Sprinks et al. 2021).

The CS domain is potentially entering a transitional period. The first wave of activities ignited by the digital age has proven the scientific power of the approach and its potential to engage the public in scientific investigation (de Sherbinin et al. 2021). The next wave of CS has the potential to take a broader and more inclusive approach. A better understanding of societal challenges, their relationship to global issues, and the CS role in addressing them can be achieved by fully appraising the potential impact beyond the specific scale and science involved (Wehn et al. 2021). An opportunity thus exists to learn from existing CS activities that have successfully upscaled beyond their original context.

In response to this opportunity, a workshop was held as part of the European Citizen Science Association's (ECSA's) biannual conference in May 2024 to explore current practices regarding the upscaling of CS and to inform the EU Horizon Europe CROPS (Curating, Replicating, Orchestrating and Propagating Citizen Science across Europe) project (Sprinks et al. 2024).[1] The workshop was motivated by the need for a better understanding of the potential contribution of CS to global concerns such as the EU Missions, and the role upscaling can play in facilitating this. Drawing on the experience of a range of actors in the CS discipline, learnings from current best practice, challenges, and future directions regarding the upscaling of CS and its relationship with global issues were discussed. This work reports the outcomes of a co-design session that comprised interactive discussion and idea-sharing. The final aims of the workshop were to inform transnational communities that will continue the discussion and to share best practices regarding CS upscaling; participants thus included researchers, CS coordinators and practitioners, policymakers, and volunteers in CS projects.

THE RATIONALE AND ORGANISATION OF THE SESSION

The workshop was hosted in person at the University of Natural Resources and Life Sciences in Vienna, Austria (Figure 1). Entitled "Creating Transnational Communities to Support the Upscaling of Citizen Science," the session considered existing successes, challenges, and potential of upscaling CS, looking at examples from across the discipline. The projects discussed represent a range of scientific topics and approaches, with differing needs and requirements, demonstrating the breadth of potential in terms of contributing to global concerns. More

than 30 people attended the session, from Europe, the United States, and South America, indicating the growth of interest in the subject. Participants included researchers, practitioners, community leaders, and representatives from large-scale funding systems, with interests across the CS discipline with a range of global objectives.

The workshop was 90 minutes in length, and started with a brief introduction to the CROPS project and an overview of the EU Missions and their objectives (European Commission 2024).[2] CROPS aspires to inform and evolve the EU Research & Innovation system so that it can adequately support the transition of CS from small-scale to Europe-wide scope, moving it towards a modern, open-science approach. Participants were separated into groups of between 6 to 10 persons, and each were given a specific EU Mission to consider. A series of interactive discussion and co-creation activities followed the introduction, focussed on participants' concerns regarding the opportunities and barriers to upscaling CS projects. The aim of collecting this information is to inform future transnational communities created by CROPS to support the process. Participants were advised that the overall aim of the workshop was to inform support structures regarding the upscaling of CS, but beyond that they were free to discuss any topics or themes they felt were pertinent. To ensure any insights developed from the workshop were fully shared, participants were invited to be founding members of the CROPS transnational community, with access to all CROPS resources that support the upscaling of CS. This article provides a review of the topics discussed by both the CROPS partners and the workshop participants, and the main recommendations for future actions for the upscaling of CS initiatives.

Figure 1 Participants of the CROPS (curating, replicating, orchestrating and propagating citizen science) workshop at ECSA 2024. Credit: James Sprinks (Earthwatch Europe). All participants gave consent to the sharing of photographs and data collected.

WORKSHOP FINDINGS

During the discussion sessions of the workshop, each group was asked to record key themes and topics on sticky notes for further discussion. These notes were collected at the end of the group work, and grouped thematically for further discussion (see Figure 2). These themes inform

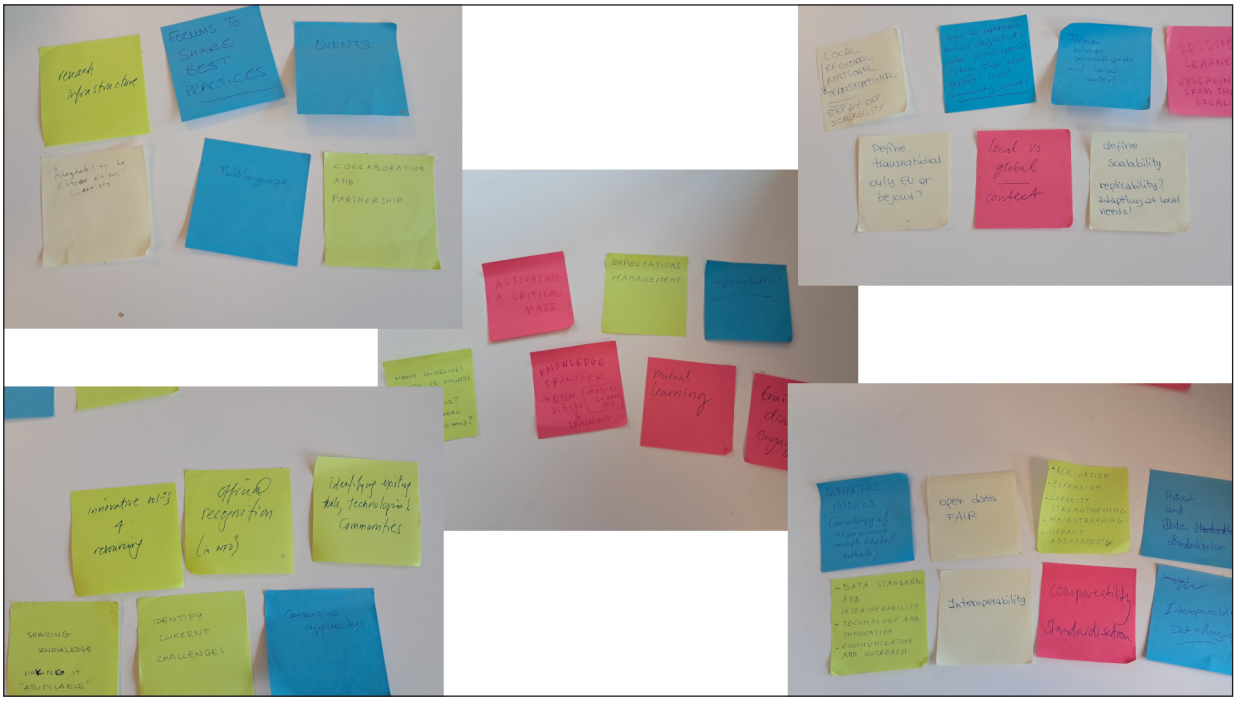

Figure 2 Themes and outputs raised at the workshop, ordered into the groups described in the text.

the following discussion sections, with the authors synthesising comments from the workshop with the goal of increasing our understanding of upscaling, its potential and challenges, and its role in addressing global concerns.

CITIZEN SCIENCE PROJECT MANAGEMENT

The themes discussed during the workshop revealed a range of different concerns and opinions regarding CS upscaling. At the forefront was the importance of project management, how it might be challenged, and necessary adaptations at larger scales. Discussions focussed on the need to manage expectations regarding project outcomes, activating a critical mass of participation to expand, producing guidelines for project development, and providing training, mutual learning, and knowledge transfer mechanisms.

Effectively managing expectations of all involved parties regarding research output ownership, access, and perceived benefits is crucial in CS (Guerrini and McGuire 2022). Discrepancies between these expectations and the actual outcomes can significantly impact projects, especially at different scales (Haumann and Smolarski 2021). Such concerns also extended to include the management of participant numbers, and it was pointed out that larger-scale projects that require mass participation tend to have lower retention rates and could suffer a data bias related to population density (Pocock et al. 2019). With the critical mass of participants required to make a project successful, the need to understand participant motivations and behaviour becomes even more crucial for improving engagement and retention (Hart et al. 2022). To address some of these issues, it was suggested that any frameworks or communities created to support CS upscaling should consider lessons from other fields. By doing this, for example in the fields of marketing and customer satisfaction, CS practitioners could tailor their approaches to enhance engagement and broaden project awareness, enabling an upscaling of activities (Koedel et al. 2024) that could address global concerns.

Whilst a range of frameworks and guidelines exist regarding CS implementation (García et al. 2021), a need was expressed to adapt or create examples that include upscaling and the potential to contribute to national, regional, or global objectives. Examples specifically mentioned different phases of CS projects such as project creation, defining research questions, and deploying upscaling approaches (Yadav and Darlington 2016); design principles for CS tools (such as data collection and analysis apps and platforms), including iterative development processes (Herodotou et al. 2018); and guidelines focussed on participant motivations and different viewpoints of stakeholders/participants (Minkman, van Overloop, and van der Sanden 2015). Whilst these resources emphasise the importance of user engagement, technology integration, and the needs of different CS initiatives, they tend to be targeted towards the design stage, or in-the-moment deployment, rather than taking a long-term approach. Therefore, there is a space for guidance considering the evolution of a CS project beyond its original scope, targeted at larger scales with broader scientific aims.

More specifically, issues regarding the type of support and resources CS frameworks provide were also discussed. CS has the opportunity to act as a mutual learning space between researchers, participants, and other actors, democratising science through the provision of collaboratively created research outputs and sharing scientific methodologies and research approaches (Vohland, Weißpflug, and Pettibone 2019). Taking such an approach can facilitate knowledge transfer, and act as a mediator between science, the public, and policymakers (Heinisch 2021). However, when upscaling to larger transnational scales that involve international and global issues, the cultural and political landscape can become more complex. Therefore, support frameworks and the resources they provide need to consider inclusivity, adaptation to country- or region-specific contexts, cultural sensitivity, safety (both in the field and online), and political motivations in their conception (Chesser, Porter, and Tuckett 2020), and how such issues are affected by scale.

LEARNING FROM EXISTING PRACTICES

Another dominant theme of the workshop was gaining an understanding of projects and initiatives that have already attempted to upscale. This involved examining their methods, challenges, and opportunities. Participants recognised the need to identify existing tools, technologies, and communities that can already support the upscaling process. Discussion topics included the provision of official recognition for projects that share their best practices, the importance of making knowledge and existing resources accessible, identifying current challenges, and how to form a consensus of approaches suitable for different contexts.

A range of different pathways have been taken by CS projects in an attempt to upscale their activities and address broader goals. Strategies involving novel communication approaches (Dittmann et al. 2023), data management challenges and technology (Lasky et al. 2021), the use of remote sensing data (Kosmala et al. 2016), and participant engagement (Collins et al. 2023) have all been considered with various levels of success. Therefore, it was acknowledged within the workshop that there is no need to reinvent the wheel, and that the existing body of knowledge should form the basis of any support regarding upscaling strategies. This in turn raises the issue of

accessibility in regards to CS practices. As aforementioned, CS has the opportunity to democratise science and access to data, but often struggles to fully realise this potential (Unterfrauner et al. 2021). To try to improve this picture, participants highlighted the importance of exploring various strategies, including supporting the social connectedness of participants (Howlett et al. 2021), providing more accessible language and illustration (van Dien and Fuchs 2023), and incorporating a diverse institutional involvement (Chase and Levine 2016).

Ensuring the CS upscaling success stories and the resulting best practices are accessible to other initiatives raises an interesting challenge. Whilst learning from previous actions is a key part of all scientific research, the workshop identified the need to balance this with suitable recognition when approaches are replicated. Trust-building between the actors involved in CS has always been crucial for motivation and creating support networks (Gilfedder et al. 2019), and suitable attribution for both practitioners and participants is a key mechanism for fostering productive partnerships (Rotman et al. 2012). The workshop participants raised the importance of standardisation, such as the Public Participation in Scientific Research (PPSR) Core for CS (Bowser 2017), which is a set of global, transdisciplinary data and metadata standards for use in CS projects. It was posited that any transnational communities created to support the upscaling of CS could benefit from providing standardised approaches to communication, project design, engagement, and data management. Through creating this standardisation, a consensus of approaches can be formed within the CS discipline when upscaling, potentially leading to enhanced data quality (Baker et al. 2021), peer learning opportunities (Sharma et al. 2022), and a greater potential contribution to broader scientific and societal outcomes.

COMMUNITY TOOLS AND RESOURCES

Building on the discussions regarding best practices and learning from what has been achieved before, several infrastructures, tools, and communities were identified by the workshop participants that could support the upscaling of CS. Existing research infrastructure, forums, and platforms were identified as places to organise events, provide multilingual support, and supply a range of other resources for upscaling. The importance of ensuring that such mechanisms are adaptable to different types of CS activities and participants became a key talking point.

Regarding larger-scale research infrastructure, platforms such as the European Open Science Cloud (EOSC) were highlighted as environments where CS data can be shared and research services accessed (Celjak et al. 2022). In doing so, potential contributions to larger-scale issues could be realised beyond the initial design of the project. Its existence is perhaps evidence of the position of the EU in regards to open science and global challenges (Almeida, Borges, and Roque 2017). Framing European challenges as the focus, the EU has also developed a number of online platforms designed to facilitate data access and information sharing. These include sharing health-centred portals for clinical trial data (von Aschen and Krafft 2017), and a geoportal to provide access to geographic information addressing environmental policy and disaster response (Bernard et al. 2005). Such platforms not only present an opportunity for CS actions to contribute data towards large-scale objectives but can also highlight gaps in the knowledge that are yet to be fulfilled by traditional methods if their implementation includes an infrastructure that supports the user. Technological challenges such as data interoperability, however, remain barriers to successful implementation (Usländer 2012).

Aimed more specifically at the CS discipline, discussions also considered platforms that are designed to support collaborative projects involving the public. They serve as knowledge hubs, supporting the aggregation and dissemination of resources, tools, and project information (Liu et al. 2021), and can facilitate data collection, analysis, and sharing through promoting open science principles (Wagenknecht et al. 2021). Through taking a user-centred approach, such platforms can address the motivations of both scientists and participants, and can increase participation (Johnson and Grey 2016), with the ultimate aim being to overcome some of the technical and financial barriers facing CS projects (Russell, Switzer, and Edelson 2011). A number of platforms, including the Zooniverse and CitSci.org, provide technical mechanisms and functionality for data collection and analysis, which in itself can help standardise both the metadata and data produced, and aid interoperability (Lynn et al. 2019). Such an approach, however, raises the issue of balancing standardisation with adaptability, with careful consideration required of both data users and contributors in order to ensure all types of CS activity and their actors are represented (Chandler et al. 2017a).

SCALABILITY AND CONTEXT

On a more conceptual level, issues were discussed regarding the definition of scalability itself, the meaning of transnational (EU or global), tensions between being generalizable but still relevant at a local level and achieving broad objectives whilst acknowledging local expertise and values.

Upscaling is a complex concept that applies to a range of disciplines and contexts, and thus there is a lack of a universally accepted definition, and especially not one focussed on the CS landscape. Within this workshop, the

elements of upscaling discussed can be nicely summarised by Radicchi, Leo, and Haklay (2023): i) scaling up—institutional changes are achieved through modifying CS projects, which can become an integral part of a policy or approach; ii) scaling out—the replication of CS initiatives, according to specific dimensions such as the geographic or temporal spread, the research scope, the communities engaged, the amount of data collected, or the methodology deployed; and iii) scaling deep—CS projects that have an impact on cultural changes and beliefs such as trust in science by the citizens and trust in CS by the scientists. All three types of scaling can be applied to CS, with different support and resources needed in each case.

Perhaps due to the European focus of the ECSA conference, and the origin of the funding received by CROPS, the meaning of the term transnational was also debated. Understandably, the networks and participants present were primarily focussed on European-level interventions, with unified objectives and methods enhancing Europe's ability to shape issues such as climate (Wolff and Zachmann 2015). However, the objectives of the EU missions are global in nature, tackling water and soil health, cancer, and climate change, so a similarly global approach is needed to achieve them, one in which CS can play a key part (Herrick et al. 2018).

With this ambitious aim in mind, a tension was revealed between CS activities being generalizable enough to contribute to broad, global objectives, whilst still being relevant at the local level, and acknowledging the contribution of local expertise. CS has long been recognised as a valuable approach for integrating local or indigenous knowledge into traditional scientific research, particularly in the areas of climate and the environment (Tengö et al. 2021). With the involvement of local communities, comes a range of cultural and societal factors, and strategies are required that promote equitable dialogues and recognise local interests (Eyng et al. 2022). Such strategies also need to create understanding of how local interventions can contribute to global solutions, and increase trust that the data and knowledge is being used in a way that benefits the community (Bedessem et al. 2023).

DATA SHARING AND ASSESSMENT PROCESSES

The importance of sharing data and adhering to agreed standards became a recurring theme, with an understanding that it should be a focus of the transnational communities created to support upscaling. This could include the creation of semantic models, data and interoperability standards, FAIR (findable, accessible, interoperable and reusable) data practices and considerations regarding impact assessment.

The relationships between data, methods, stakeholders, and the communities involved can be complex in regards to CS initiatives, and the creation of CS-focussed semantic models could be an approach to describe concepts, meanings, and interconnections in an understandable way (Hull and King 1987). Examples have been developed for the semantic annotation of biomedical CS systems (Pantoja, Filho, and Santanchè 2024), biodiversity observations and knowledge (Sachs and Finin 2011), and species mapping (Soltani et al. 2024), which has been used to better represent CS systems and their processes.

The importance of integrating data standards into CS practices was also a topic of discussion. Whilst general standards such as the FAIR data principles (Mons et al. 2017) are already applicable in the CS domain, there is perhaps a space for standards that address CS practices and data structures directly. Their development could be key for enhancing interoperability and data sharing among CS projects, and specific approaches such as the PPSR Core standards are emerging to provide a set of global standards directly aimed at CS. Consequently, they are already being implemented by larger-scale CS platforms such as EU-Citizen.Science and CitSci.Org to support a wide range of CS activities in promoting open science practices (Budnicki and Newman 2021). As discussions developed during the workshop, a dual role of standards emerged, both as a way to bridge boundaries and increase interoperability, and also as a way of ensuring data quality, with experts able to flag data that do not comply with relevant standards or remain unsuitable to answer a specific research question (Ottinger 2010).

Participants raised the topic of impact and its assessment, which broadened the workshop discussion from primary data contributing directly to scientific aims to include secondary information. CS can have an impact across a range of domains, including society, economy, environment, science, and technology (Wehn et al. 2021), but measuring it in a meaningful way remains challenging, with many project coordinators not having the expertise or the resources available to do so (Sprinks et al. 2021). To facilitate the impact assessment of CS, platforms are being developed with the aim of enhancing the consistency and comparability of such endeavours (Sprinks et al. 2022); however, more work is needed to ensure CS initiatives recognise their potential impact. With this recognition, the scaling up of CS to domains and disciplines beyond those originally involved can be achieved, broadening their scope and their impact towards global concerns.

CONCLUSIONS

Overall, a wealth of experience and learning was shared at the workshop from within the CS community, which demonstrated the number and range of factors that need to be considered when upscaling CS (Figure 2).

A key message that emerged was the importance of context, and the recognition of the vast range of different CS activities that exist in terms of their contribution. This is especially true when considering the potential contribution to global initiatives such as the EU Missions, where there needs to be a balance between ensuring the local societal, cultural, and community impacts are recognised, whilst also recognising the potential links with larger issues on a transnational scale. Trust plays a key role in this relationship, with projects and participants needing reassurance that their contribution will not get lost in the pursuit of achieving global impact, and that community needs are not usurped.

On a practical level, any transnational communities created to support the upscaling of CS to contribute to global issues need to understand the range of issue projects face. In addressing them, a range of resources could be invaluable, for sharing existing best practices regarding the management of training, project design, engagement and communication strategies, and data processes and interoperability. Such resources are required to tread the fine line of being both broad enough to encompass all types of CS activity that exist, whilst also being adaptable enough to take into account localised societal, cultural, and scientific contexts. Even with such support and resources available, many CS practitioners may still feel reticent to upscale their actions due to its challenges, and there is a clear opportunity for reflection and further investigation when attempting to aggregate CS actions towards global objectives.

The collective energy and shared learning provided a powerful blueprint for future endeavours, leaving projects like CROPS with a clear vision for future research support. It is essential that the resources, support, and infrastructure that CROPS develops encompass a broad range of requirements, and are adaptable to the variety of CS initiatives that exist.

NOTES

1 More information available at https://crops-cs.eu.

2 More information available at https://crops-cs.eu/images/Publications/ECSA_2024%20workshop.pdf.

ACKNOWLEDGEMENTS

We thank the European Citizen Science Association and the organising committee of ECSA 2024 for supporting the session and giving us the opportunity to include upscaling as part of the agenda. This endeavour would not have been possible without the contribution of the workshop participants, so we thank them for their input.

FUNDING INFORMATION

The CROPS project is funded by the European Union (GA 101131696). Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the granting authority (REA). Neither the European Union nor the granting authority can be held responsible for them.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

JS led on planning and writing, with all authors assisting. All authors assisted with data collection, and the design and implementation of the workshop.

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TO CITE THIS ARTICLE:
Sprinks, J.C., Dowthwaite, L., Ceccaroni, L., Kiessling, T., Fraisl, D., Maccani, G., Leal, A.S., Gras-Velazquez, A., Liconti, A., Azevedo, K.P., Das, K., Parkinson, S. and Malta, M. 2025. Supporting the Upscaling of Citizen Science to Address Global Challenges. *Citizen Science: Theory and Practice,* 10(1): 23, pp. 1–11. DOI: https://doi.org/10.5334/cstp.837

Submitted: 10 January 2025 **Accepted:** 19 June 2025 **Published:** 23 July 2025