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Reframing Citizen Participation: Turning Barriers into Guiding Enablers

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Abstract

Citizen science is increasingly recognized as a potential catalyst for sustainability transitions, climate action, and behavioral change by fostering collaboration between scientists and the public. While it offers benefits such as mutual learning, awareness raising, and improved outcomes, sustaining long-term diverse engagement remains a challenge. Research to date has largely emphasized data outcomes and initial participation, often overlooking the relational, social, and practical dimensions crucial for continued involvement. A disconnect persists between researchers' data-driven goals and participants' personal motivations, compounded by insufficient training and institutional support for engagement. This paper presents a novel framework for enhancing citizen engagement, drawing on a state-of-the-art literature review and focus group insights from the H2020 I-CHANGE project. It identifies enablers for and barriers to participation, reframing the latter as opportunities for support. The findings are organized into four themes: (1) call for participation, focusing on intrinsic motivation and local relevance; (2) project design, highlighting inclusive tools and communication; (3) a collaborative process, emphasizing trust, clarity, and support; and (4) participation benefits, including meaning, recognition, and social connection. This study underscores the need to build trust, foster relationality, and align expectations. It proposes practical engagement criteria and calls for deeper exploration of the relational foundations of citizen science.

Keywords: citizen science; barriers; effective engagement; enablers; participation; research design; assessment criteria

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1. Introduction

To address the urgent degradation of the environment and meet the EU's 2050 climate neutrality goal, it is vital to foster sustainability transitions as inclusive, structural societal shifts where citizens are empowered to drive and shape a just and equitable future. Citizen science has been identified as one of the key mechanisms that can help promote climate action and behavioral change toward sustainability [1–6]. Citizen science refers to a practice in which scientists and citizens collaborate to produce new knowledge for science and society [7]. It engages the general public in research activities, such as gathering data,

monitoring environmental changes, and contributing to scientific research. Citizen science can also be a powerful tool to raise community awareness about issues and capacity for meaningful action [8].

The potential of citizen science in promoting societal change lies primarily in the active engagement of its participants. Involving citizens in research can potentially benefit sustainability transitions, including mutual learning between scientists and stakeholders, improved scientific outcomes thanks to context-specific data, and greater adoption of findings [9–11]. Forms of citizen engagement vary according to the objectives of a given project. They can be (1) contributory, when participants primarily gather data for research; (2) collaborative, when participants gather, interpret, or analyze data with the researchers; and (3) co-creative, when participants are involved in all stages of a research project from planning to collecting, analyzing, and interpreting data, as well as disseminating the results [12,13]. However, the mode of participant involvement will also affect the effectiveness of the project in promoting change. Hall et al. [14] argue that to enhance the societal impact of scientific outputs and the experience of participants, citizen science research teams need to reimagine their approaches to engaging volunteers and monitoring participation.

Planning participatory science projects is inherently challenging, particularly in recruiting a diverse range of citizens to participate and sustaining their engagement throughout the project [15,16]. Although publications on citizen science have increased significantly in recent years, most analyses remain theoretical or conceptual, offering limited practical guidance for implementation [17,18]. A persistent disconnect between the researchers and citizen scientists further constrains engagement [14]. Researchers' worldviews, personal characteristics, and lack of training in stakeholder communication can impede collaboration [19–22], while institutional structures often provide inadequate support for participatory work [23–26]. Moreover, researchers frequently adopt a transactional, data-driven perspective, overlooking participants' emotional and personal motivations [14]. These barriers contribute to missed opportunities and uneven participation.

Despite the expanding literature on citizen science, key gaps remain in understanding, managing, and evaluating effective citizen engagement [14,18,27]. Furthermore, the evolving nature of social relationships in citizen science, and community engagement in general, makes continuous evaluation, researcher self-awareness, and self-reflection vital for success in participatory research [28]. Most studies on engagement in citizen science continue to privilege quantifiable outputs, such as data contributions, over qualitative insights into participant motivations and experiences across projects [23]. For instance, barriers are rarely anticipated or proactively addressed; the focus tends to be on initial participation, overlooking long-term engagement, and limited attention is given to the practical and social factors that shape participants' experiences. Findings in other fields involving community or stakeholder engagement can help address these shortcomings in citizen science and guide the development toward a more systematic approach to effective citizen participation.

We conducted a state-of-the-art literature review on citizen engagement, extending beyond the citizen science literature, to identify key barriers and enablers of sustained involvement. While research on public participation has a long history across diverse fields [17,19,29–31], each body of literature offers distinct perspectives with transferable insights for understanding engagement. By adopting an interdisciplinary approach, we deliberately crossed conventional academic boundaries to develop fresh perspectives on citizen engagement in multi- and transdisciplinary contexts. To ground our findings in practice, we incorporated findings from focus groups with citizen scientists from the Living Labs in our collaborative I-CHANGE project (https://ichange-project.eu/). The project developed new, equitable citizen science approaches for Living Labs to raise awareness and co-create pathways toward a more sustainable, climate- and health-conscious future. Together, these

sources informed the development of building blocks and criteria for planning citizen science projects, spanning the full arc of engagement from recruitment to dissemination.

To help researchers better understand participation from the citizens' perspective, we focused on the barriers to and enablers for successful citizen engagement, paying special attention to long-term engagement and underlying factors that could enhance retention. The questions we asked were as follows: (1) How can we overcome the overall barriers to engagement for citizen participation? (2) How can we enable long-term participation of the citizens? (3) Finally, how can practical aspects be addressed to foster positive experiences in citizens' engagement? Although citizen science literature is rapidly growing, we suggest that a broader view of factors influencing citizens' participation may offer new insights for engagement. This paper first outlines our methods, then presents findings on barriers and enablers of successful engagement, and concludes by introducing our proposed enabler criteria, discussing emerging implications, and offering guiding questions to support researchers in applying the criteria in practice.

2. Materials and Methods

The literature review was conducted to provide guidance for the engagement of citizen scientists. To understand factors influencing participant engagement in citizen science, a preliminary rapid review of citizen science literature was conducted (not included in this paper), which revealed a need for a broader literature review that extended to other fields involving community and stakeholder engagement. This study used a state-of-the-art literature review to identify barriers to and enablers for community engagement to help improve citizen science activities and participant retention.

Barriers highlight vulnerabilities in the process and what hinders progress, while enablers identify what facilitates it and reveal opportunities for improvement. At the same time, many enablers are the direct inverse of barriers. To be able to develop a more systemic guidance for citizen engagement, in the second phase of the analysis, the identified barriers were reframed as potential enabling opportunities. At the end, the findings were formulated as enabler criteria for participation to help in project planning (Figure 1).

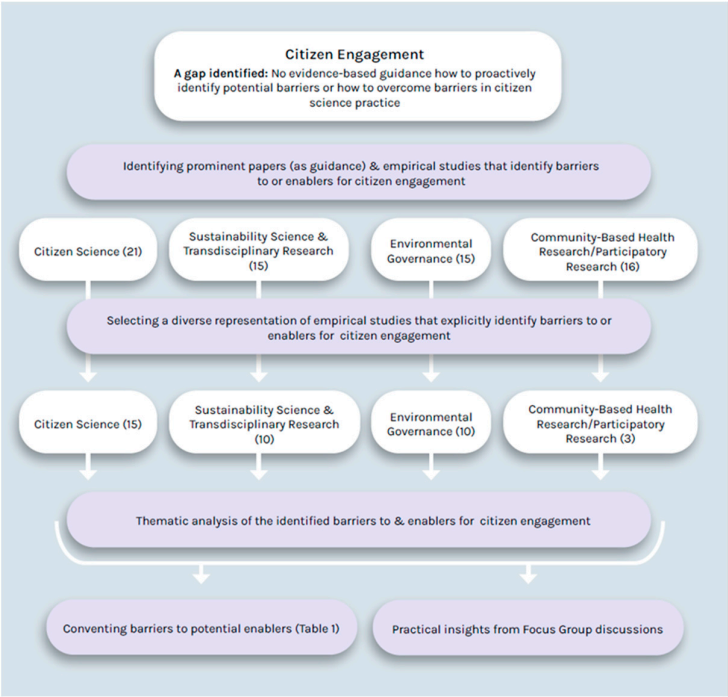

Figure 1. Flowchart for the research process.

2.1. Literature Review Method Introduction

We conducted a state-of-the-art literature review, as described in Jesson et al.'s study [20]. The authors used their expert knowledge to limit the search, using citations and scanning key journals and search engines (Google Search and Scopus), based on known key focus areas, known leading expert authors, and the central literature that was considered relevant. The focus was broadly on citizen science, sustainability science, environmental governance, transdisciplinary research, community development/urban planning, social psychology, and health promotion literatures. The selected keywords, relevant to participation and engagement in citizen science aiming to promote social change, were used in various combinations to make sure that the most recent, yet less cited, literature was also included. The keywords included were citizen science, citizen/stakeholder engagement, awareness creation, behavior change, barriers, enablers/drivers, power, trust, motivation, values, etc. The papers used in the final analysis to provide empirical breadth for the identified barriers and enablers were published before 2022. To ensure the continued timeliness, value, and validity of the findings (data triangulation), we conducted a separate environmental scan of the citizen science literature published between 2022 and 2025.

To establish a broad baseline of barriers and enablers, a structured review of 38 articles based on empirical studies was conducted. The selected articles were identified as representative to help create an overview of the most pressing issues related to effective citizen engagement in a citizen science project. They were analyzed in collaboration by 9 experienced researchers, guided by a questionnaire of 17 questions. The identified barriers and enablers were compiled, and the findings were coded thematically, identifying diverse factors affecting participation. The identified factors were further analyzed, clustered, and sorted into thematic groups, which, in turn, were categorized into structural, procedural, and personal barriers [21]. The data were analyzed utilizing NVivo.

2.2. Converting Barriers to Enablers, Focus Group Findings, and Data Triangulation

To turn barriers into opportunities to help improve engagement and compensate for limited focus on enablers in the literature, we reframed the identified barriers as opportunities for action. For instance, "lack of understanding of what volunteering involves" [22] was converted to clear roles and expectations (Figure 1: bottom left).

The initial review was used to guide citizen science activities within the I-CHANGE project. After these activities, focus group (FG) discussions were conducted in the autumn of 2024 among the participants of four I-CHANGE Living Labs, in the cities of Amsterdam (FG1), Barcelona (FG2), Bologna (FG3), and Hasselt (FG4). There were 3 to 5 participants from the citizen science projects in each of the focus groups. The main objective of the FGs was to assess the impact of participation in various citizen science activities regarding possible changes in their awareness and actual behavior. The focus group discussions also explored citizen scientists' perceptions of their involvement in the citizen science activities. The FG findings were used to enrich the findings from the literature review with recent empirical examples (Figure 1: bottom right).

The identified criteria were validated and further expanded by comparing literature review results with the focus group findings and recent papers on citizen science published after our original literature review was completed (data triangulation). While the more systematic barrier and enabler identification consisted only of 38 papers, other relevant documents and more theoretical papers assessed in the context of this literature review are included in the Results and Discussion.

3. Results and Discussion: Understanding the Key Components of Citizen Engagement

To overcome engagement barriers in citizen science and to enable long-term participation of the citizens, we first needed to establish an understanding of known real-life barriers to and enablers for citizen engagement. An unanticipated output of our analysis was the first study to translate empirically identified barriers together with enablers into a 70-item, ready-to-use checklist for citizen science planners.

Citizen science is often promoted as a tool to drive behavior change or support sustainability transitions. However, many projects are still designed as short-term, one-off initiatives. This is evident in two main ways: (1) limited attention is given to the long-term engagement of citizen scientists; (2) when barriers are discussed, they are frequently attributed to external faults of others rather than challenges that researchers could address. For example,

> *"When it comes to coding and hackathons, technical barriers are very high for the average citizen. This makes it hard to reach 'mainstream' citizens."* [24]

> *"There are barriers to engaging citizens with smart city applications and smart city design. Key amongst them is that most citizens are not sufficiently conversant with using and interpreting data to use it as resource for learning about and modifying their behaviour and environment."* [25]

While these are valid observations, they risk oversimplifying the complex social realities behind participants' decisions about when, where, and why they choose to volunteer their time. Based on our findings, we suggest that harnessing published empirical evidence and established theories from other disciplines can help enhance citizen science practice and make it a more useful mechanism for social change. The findings are not exhaustive but provide a foundation for a more systemic approach to engagement planning in citizen science projects.

To help researchers rethink participant engagement in citizen science, we first introduce a new way of grouping barriers adapted from disciplinary literatures with a long history of citizen engagement (e.g., [21]) into (1) personal, (2) structural or institutional, and (3) procedural barriers. Part of the findings will be discussed in the section on barriers to illustrate the categories. We, then, turn the three barrier categories into opportunities and discuss the rest of the findings, both original enablers and converted barriers, to illustrate how they can help create more inviting citizen engagement. To avoid repetition, different findings are discussed in the barrier and enabler sections. We also added a fourth emerging category of enablers to include identified individual or collective gains that may motivate continued participation.

3.1. Barriers to Citizen Participation

Many researchers conducting citizen science come from a natural scientific background and lack training in social analysis. The strong focus on biophysical and technical aspects of knowledge production was reflected in the lack of a systematic, deeper analysis of the factors influencing participation in much of the citizen engagement, especially in the citizen science literature. Land-Zandstra et al. [26] present a valuable temporal analysis of challenges associated with each phase of citizen science projects, along with practical recommendations for project leaders. However, many of these barriers can emerge at multiple stages, especially in longer-term projects, where participant turnover is more likely.

3.1.1. Personal Barriers

Personal barriers may be external, like family obligations, or internal, such as values, skills, habits, self-confidence, interests, or perceptions. For example, the inability to participate in citizen science alongside one's children can create a value-based barrier [32]. Self-confidence is a good example of an underexplored barrier identified in the literature review. The need for an intuitive, user-friendly technical interface and clear instructions is not just about how individuals choose to allocate their time; some people lack the confidence to try new technical tools or feel hesitant to seek assistance [32–36]. Personal barriers are often shaped by a dynamic interplay of individualistic and collectivistic internal drivers [37]. In general, any participation in citizen science projects is inherently personal, with engagement driven by individuals' connection to the topic or meaningful relationships [14]. If those needs are not acknowledged, they become barriers.

3.1.2. Structural Barriers

There are many different kinds of structural barriers to citizen engagement, including constraints related to societal structures, such as institutional settings, economic arrangements, or legal and administrative structures, e.g., the project design and governance [21]. Concrete examples of structural barriers that may influence citizen engagement include *social or cultural expectations*, such as work and family pressures, other social and civic commitments, *societal socioeconomic inequities* (e.g., childcare or transportation), *inaccessible information* about the project, *alienating dominant discourses* (e.g., too-scholarly approaches, locally divisive topics, etc.), *social pressures*, a *technical focus of the project* (e.g., not perceived as relevant), and *dominance of the scientists* (e.g., project direction dictated by the scientists) [21,38–46].

Technical challenges can also constitute significant structural barriers to participation. Scientists and engineers developing monitoring tools do not necessarily realize that the responsibility for the user-friendliness of a tool is on the designer and the project leads [24,33,37]. In citizen science projects, people are volunteering their time. Evaluation studies reveal that technical interface design is a key determinant of usability-sustained engagement in citizen science. "People said that [tools] needed to be easy, user-friendly and quick to use, and have no problems or glitches in the system" [36]. Identifying and addressing structural barriers would be particularly important for equity-focused citizen science.

3.1.3. Procedural Barriers

Procedural barriers refer to the project process-related factors that may hinder participation. They range from the constraining effects of scientific protocols to the ways in which citizen science activities are designed and carried out. Project processes are often shaped by a habit of using familiar practices, overlooking the need for fundamental change to sustain participant motivation and adapt traditional research practices.

Lack of inclusion and power imbalance. Procedural barriers can be seen in various stages of the research process and how well *community/individual needs are taken into consideration*, such as the mechanisms used for engagement, the accessibility of language during interactions, the degree of participant influence on the project planning, and the appropriateness of the reporting channels for sharing findings [38,39,41]. Disrespecting local expertise and ways of doing things by not taking them into consideration in research implementation and engagement can push participants away [47–49]. Projects aiming to empower may have very top-down approaches, ignoring the needs of the participants, without recognizing power imbalances [50]. Challenges in power relations between the academic scientists

and citizen scientists are not uncommon and can lead to difficult and time-consuming experiences [47].

Inflexibility. Citizen engagement can also be hampered by the rigidity of the project design [48]. The project changes when people leave, things happen in the community, equipment needs adjustment, etc. As long as changes in procedures are justified and meticulously documented and communicated in a transparent and ongoing manner, many of the procedural barriers can be adjusted on the go. The technical aspects of citizen science can introduce additional challenges related to data collection and management, which participants may perceive as complex or difficult to navigate [37]. In their study on participant perceptions in citizen science and crowdsourcing, Mazumdar et al. [51] identified several procedural barriers, including data-related concerns on data protection and privacy standardization, ethical considerations, and the anonymization of participants' information. They also highlighted commercial barriers, particularly when data must be shared across multiple sectors, and barriers around acceptance of citizen science data and confidence in its reliability and scientific credibility.

Many of the challenges initially attributed to personal barriers are, indeed, issues caused by external factors, some of them even outside the sphere of influence of individual participants.

3.2. Turning Barriers into Enablers

Focusing solely on barriers can lead to a negative view of the process and introduce unnecessary blame, hindering the development of effective change strategies. The awareness of potential enablers and the ability to see opportunities in reversing barriers can, in turn, help address the obstacles proactively. While most articles on citizen engagement identified some barriers, surprisingly few of them discussed ways to overcome the challenges or what might have worked well and enabled effective participation. We do acknowledge that engaging people in citizen science will always face some barriers. However, a balanced approach that acknowledges challenges while also highlighting opportunities can help ensure long-term citizen engagement.

Our identified and converted enablers are summarized under the four thematic headings: Call for Participation; Project Design for Easy Participation; Process Planning for Good Collaboration; and Benefits of Participation. In addition to the literature-based results, these sections further introduce insights and recent empirical examples from the focus group discussions in the I-CHANGE project.

3.2.1. Call for Participation to Get Citizens Interested (Personal Enablers)

Citizen recruitment is a crucial phase, a foundation for a successful citizen science project. Here, the key issue is the framing of the project to *raise citizens' interest* in participation. Our findings indicate that this can be enhanced by focusing on internal motivational factors of participants (e.g., their personal or local interests), effective communication, and building connections to local initiatives.

According to the results, it can be very useful to identify how to connect the project to the internal drivers of potential citizen scientists as well as align it with local matters, concerns, or values [26,52–54]. Identified motivations to participate range widely, for instance,

- Emotions of shown environmental effects, willingness to support science, or the welfare of others, and concern for future generations [34,43,52,55,56];
- Learning new skills that can enhance career options [22,33,52,55];
- Strengthening social networks [33,34,57];

- Increasing a sense of empowerment (i.e., having one's voice heard or feeling in control, and having the ability to do something about an issue) [22,43,48,52,53] or similar internal motivations [37,58].

The *framing of the project* may work differently for citizens with varying interests. The findings from the focus groups provided practical examples regarding the need for tailored and targeted engagement strategies to attract diverse participants. For instance, FG4 revealed truly diverse motivations for participation: some citizens were drawn by an interest in data collection and sensors, and others by a desire to understand their environmental impact, while for many, curiosity and the wish to try something new were pivotal. School teachers, in contrast, emphasized connecting with society through citizen science, enhancing students' capacity to influence their own habits (FG4), and extending the educational efforts to the broader community (FG2).

Targeted advertising. Lack of awareness about local projects and lack of information about recruitment processes have been identified as a barrier [22,50,55,57,59]; therefore, explicit and targeted advertising utilizing both formal (local news and social media) and informal (mouth-to-mouth) communication tends to be needed. The FG1 findings further highlight that using multiple channels of communication can improve outreach effectiveness. Advertising can also be enhanced, for instance, by connecting with local influencers, leaders, or change agents who can reach the community through their networks [52,60].

Connecting locally. Overall, building connections to the local organizations and aligning the project with their activities and needs in the early phase is important, not only for driving participation but also sustaining it [50]. This can also help make the project meaningful and trustworthy for the participants from the very beginning [37]. Other options to ensure that the project will be rooted in the local context are to build on existing community projects or to establish a local advisory board [61].

Equity-informed inclusion. Equity plays a central role in sustainability transitions, but has received less attention in citizen science. However, findings from FG2 highlighted that to involve underrepresented groups more effectively, it is important to be explicitly and actively supporting inclusivity in citizen science initiatives. Local partnerships might also help involve actors who, otherwise, would remain excluded [62]. Co-creating the project with local community leaders will further support the overall implementation [48].

3.2.2. Design for Easy Participation to Keep Citizens Involved (Structural Enablers)

Project design plays a critical role in participant retention. Our findings imply that project components, ranging from community engagement to technical tools, can greatly impact the success of the project [63,64]. In general, successful projects that require community input are designed in an inclusive manner: they incorporate communication, collectively define processes, co-design technologies, and co-manage, as well as offer training throughout the project [47–49,58,61]. Simple things can make a big difference in participant retention, such as an intuitive, easy-to-use interface or project goals aligned with community-guided issue prioritization, aligning with local needs [36,47,48,50,52,65].

Meaningful, transparent, and inclusive communication. Properly targeted and well-designed communication strategies embrace inclusivity, for instance, by avoiding scientific jargon to help participants be at ease [57,64,66] or minimizing the separation between the academics and participants [47,49]. The need to create a sense of belonging, shared goals, and clear identities as project members has been identified as a key element [47,53,54,58,67].

The *design of citizen science activities* also matters. Planning the activities and their timing with participants reduces no-shows [64]. Identifying the different needs of the participants and making project activities flexible enough to fit with the daily activities of participants and, for instance, the schedules of their families [57]. Similarly, the FG

discussions brought attention to operational limitations of partner organizations. For instance, schools need time to plan well in advance, as their time schedules are often tight and rigid (FG2). It can be beneficial to co-design project components, such as social engagement or outdoor activities, as project evaluations indicate that many people become volunteers to have fun and connect with others [36,52,57]. Organizing frequent events and learning opportunities, as well as regular emailing or apps to update participants on the various activities, may create a feeling of being part of a wider community [32,43].

User-friendliness of technology. When citizen science is based on the use of various technologies (devices, sensors, apps, etc.), it is of utmost importance to ensure a user-friendly interface, easy access (without registration if possible), and focus on ease of reporting [34,36,63,66]. Both FGs and some authors [36,68] emphasize the importance of the technical devices empowering users and working well without glitches to avoid frustration. Standardization of processes and apps can increase comparability of outcomes [48], whereas gamification and various rewards (e.g., points or leaderboards) might be good additions, at least among some target groups, to make the work with technology more accessible or joyful [48,52].

Sufficient training throughout the project is a crucial factor for successful engagement. Hobbs and White identify "not feeling confident or capable of contributing" as a key barrier to participation [59]. Training should be tailored primarily to meet the different needs of the participants and also to enable participation with no prior experience or technology used [34,54,68,69]. Training should occur not only at the beginning of the project, but also throughout, and addressing various levels [57]. Like citizen science activities in general, training can be planned as an exciting and collective experience to enable learning and keep the participants motivated, as well as to enhance social cohesion and a sense of community [33]. Additional guidelines and ongoing opportunities for content-related training empower participants and help keep them motivated [32,64,68].

3.2.3. Process for Good Collaboration to Support Inclusive Involvement (Procedural Enablers)

The interplay between barriers and enablers in a project creates a delicate 'balancing act' that requires careful navigation and negotiation across different community contexts and conditions, while considering the interests, priorities, availability, perceptions, and expectations of researchers and citizen scientists [48]. Various characteristics of the project processes help keep the citizens motivated throughout the project. While the studies tend to focus on the barriers, turning them into enablers opens up a range of opportunities.

Clarity of project administration and logistics. When the objectives, expectations, and roles are made very clear from the get-go, they create a sense of safety for the participants, which, in turn, helps build trust [22,35,64,70]. Actively inviting community inputs and building on joint strengths and resources throughout the project creates mutual benefits [47]. For individual participants, the citizen science workshops and other activities (FG2) were considered as enriching experiences, offering a platform to explore one's habits, stimulate personal reflection, and find new perspectives.

Trust and sense of safety. Facilitating collaborative, equitable involvement helps *create processes that foster trust and safe spaces for interaction*. Overall, respectful conduct, project culture cherishing differences, and incorporating different ways of knowing enhance trust, establishing safe spaces for co-learning [47–50,54]. Interactive approaches help keep people engaged, and trust toward researchers can grow [43]. The FGs confirmed that continuous interaction with the researchers was seen as a crucial factor. Besides the support for activities, it was considered important to receive feedback on the work undertaken and also on the preliminary results [34].

Fostering equity. Sustained investment and commitment should focus on overcoming important social barriers, such as flexibility and timing of sessions to address time constraints, low-cost sessions, and arranged childcare during collaborative meetings [33,48,57,59,65]. Designating approachable and available contact persons, whom participants can approach if they have questions or need guidance, can also help navigate challenging situations [32]. In general, well-organized project logistics are vital to retain participants' motivation and ability to participate throughout the project [22,47,49]. Yet, processes should be flexible enough to meet a range of different expectations and be able to adapt to the changing needs of participants [48,50].

Constant support for participation. One observation that came up only in FG discussions was that participants often have limited background knowledge in the project topics, which leaves them with only a superficial level of understanding if appropriate training is not offered. FG2 participants, for instance, pointed out that clear goal setting and more support to understand the data that is collected would help further motivate the citizen scientists. It is also important to take care of organizing data and ensuring its consistency (FG4). Both FGs and the literature emphasized that more feedback/information about the collection, use of data, and impact of the findings of the citizen scientists would be important (FG1, FG2, and FG3), [34]. In addition, when participants were made more aware of the potential impacts of their citizen science activities on their own community already during the activity, they were able to actively promote it (FG1). Furthermore, frequency in obtaining results or interaction with researchers (FG2) and motivational talks from the knowledge end-users (FG4) has been shown to improve effectiveness in data collection.

3.2.4. Benefits of Participation to Ensure Retention (Emergent Category)

Motivation to participate in research activities emerges from the potential benefits citizens may gain. Therefore, it is important to highlight the benefits of the project throughout the process. Collective psychological processes can also affect participation. For instance, collective guilt about environmental issues and the opportunity for group action can positively influence people's willingness to engage in projects related to addressing a shared concern [71]. Therefore, it is important to consider the gains of the project for the individual participants, community, society more broadly, and environment by making activities meaningful and demonstrating practical application of the data and results, and their use and usefulness [22,33,34,43,48,52,53,55,69,72].

Making activities meaningful and enjoyable. FGs suggested that the reason for participation may be derived from personal desire to do something meaningful with a hobby, to learn new skills, to support science, or to benefit the common good [22,33,53,58,65]. Explicit discussions or further mentoring about potential long-term impacts of the conducted citizen science could clarify the value of their efforts and help retain engagement (FG4). The perceived relevance and usefulness of the project, such as outputs or outcomes benefiting local people or even large-scale climate action, make the donated volunteer time purposeful [22,33,34,43,48,52,55].

Showing practical application of the collected data. Witnessing the value of the concrete findings is rewarding for the participants. It is also important for the participants to see the results disseminated in ways that are relevant to community priorities and allow new knowledge to be easily applied [43,72]. Writing the results of the projects in a clear and accessible fashion plays an important role in making the citizen science activities meaningful to the participants. Some projects have used a "message of the day" or "volunteer of the month" feature, with additional general or personal information presented [34]. Results should not only be disseminated in the form of scientific publications but also in ways that

are designed to be relevant to community priorities and allow new knowledge to be easily applied [26,32,34,49,52,66].

Creating platforms for sharing experiences and enhancing social cohesion. Activities that foster social interaction and networking, such as online tools (e.g., forums, chat rooms, and other social network apps), enable citizens to share their citizen science findings, have discussions, and ask questions [34], fostering social interactions and networking among participants. At best, the collective actions may "help communities to feel part of a bigger picture" [54] and promote shared goals, such as environmental protection and climate action [34,47,52,53,65]. This kind of interaction also serves as community building by facilitating collaborations, knowledge exchange, and mutual-learning opportunities, promoting overall social relationships and enjoyment [34,59].

Acknowledging the contributions. Acknowledging participants' contributions is important to volunteer retention. The method of acknowledgement, whether formal or informal, may be less important than ensuring that participants receive recognition, appreciation for their identity and representation, or, where appropriate, honoraria throughout the process, but especially in the end. Including the citizen scientists in the publications or other outputs as co-authors or in acknowledgements (by name) demonstrates respect and appreciation. In addition, measures can be developed that the participants may observe or assess their own performance (e.g., with ratings or points). In some cases, financial incentives may help, like long-service badges or discounts [26,32,34,52,66].

3.3. Improving the Effectiveness of Citizen Participation

Because of the increasing interest in citizen science to enhance sustainability transitions, we explored what the existing literature could tell us about fostering long-term participant engagement. There are, indeed, very few studies that study barriers to or enablers for engagement to systematically improve the engagement processes, other than Land-Zandstra et al.'s study [26]. Our analysis emphasizes the need for deeper attention to be paid to citizen engagement: (1) engagement processes are often treated superficially, focusing on barriers rather than opportunities; (2) links between structural and procedural components to enhance participation are rarely addressed; and (3) the practical dimensions of relationality are frequently overlooked. For citizen science to enhance social change needed for sustainability transition, the projects need to gain and retain participant buy-in. Maximizing the retention of citizen scientists requires careful planning and genuine inclusion of participants throughout the project. Instead of focusing just on motivational factors or the typical challenges in logistics, such as time, money, or training needs, we are proposing a more analytical approach to citizen engagement. To highlight potential barriers to and, more importantly, enablers for participation, we developed four building blocks with 70 subthemes, based on our thematic analysis. They offer guiding criteria to support planning and decision-making for effective citizen science engagement, but the criteria can also be used to monitor the effectiveness of the approach (Table 1). The purpose is not to highlight every trick in attracting and retaining participants, but to introduce a reflective yet systematic planning process by providing an overview of the empirically identified components that are known to enhance citizen engagement.

Table 1. Criteria for citizen engagement enablers.

Thematic Focus	Criteria for Engagement Enablers
Call for participation—to get citizens interested (personal enablers)	
Project framing in a way that is interesting for participants, connecting to their internal drivers	1. Aligned with local matters, concerns, or values, e.g., political motivations, welfare of others, creating a better society, helping science, and helping the environment 2. Learning new skills, empowerment, and strengthened social networks promoted
Local connectedness	3. Connections to the local organizations established and the project aligned with their activities and needs early on 4. Co-leadership considered 5. Asked for help to connect with the community (incl. people, best communication channels, and venues) 6. Identified local concerns and priorities
Equity-informed inclusion	7. Identified and involved underrepresented groups 8. Explicitly established socially safe spaces (incl. language)
Targeted advertising	9. Use explicit and targeted advertising, utilizing both formal and informal communication 10. Multiple channels used
Clear initial communication	11. Clear expectations regarding activities, requirements, roles, time use, and performance 12. Language matched to the audience
Inviting action	13. Social interaction facilitated 14. Child or pet-friendly activities
Supportive environments	15. Participation with no experience is supported 16. Safe spaces established (for questions, social safety, etc.)
Design for easy participation—to keep citizens involved (structural enablers)	
Inclusive design and management structures	17. Project co-designed with local community leaders 18. Collectively defined logistics 19. Co-designed technologies and/or citizen science activities 20. Co-management structures
Inclusive process components	21. Project in dialogue with and receiving ongoing advice from community partners 22. Project activities building on existing networks and processes, especially those of the community partners and participating citizen scientists 23. Flexibility as a core operating value, with a balance between the needs of the scientific inquiry and volunteer work established 24. Local knowledge appreciated; different ways of knowing and different worldviews included
Meaningful, transparent, and inclusive communication	25. Properly targeted and well-designed communication strategies; meaningful, transparent, inclusive, and regular communication frequency 26. Scientific jargon and divisive language avoided 27. Clear communication materials

Table 1. *Cont.*

Thematic Focus	Criteria for Engagement Enablers
Sense of belonging and house rules	28. Shared goals, clear identities as project members, and explicit expectations collaboratively established (incl. behavioral standards)
Design of citizen science activities	29. Family-based activities option has been incorporated as part of expected project duties, where possible 30. Taking partner and participant needs and limitations into consideration in design and planning
Social components	31. Diverse additional engagement opportunities created beyond explicitly scientific activities 32. Process structures in place to foster collaboration and coordination among participants 33. Frequent and regular targeted events and learning opportunities organized
Technical components	34. User-friendly technology and intuitive interfaces 35. Functional, easy-to-use tools; glitches minimized 36. The process and app standardized 37. Technical support available
Training	38. Sufficient training throughout the project 39. Guidelines and additional content-related training made available 40. Online and in-person training organized
Process for good collaboration—to support inclusive involvement (procedural enablers)	
Clarity of project administration and logistics	41. Clear co-established objectives/goal setting, expectations, and roles 42. Scientists and other project members demonstrated that they trust citizen scientists
Flexibility	43. Flexibility in planning (e.g., schedule needs because of family or other social obligations) 44. Adaptability of processes when circumstances change
Trust and sense of safety	45. Collaborative, interactive, and equitable involvement fostered 46. Respectful conduct, project culture cherishing differences, and incorporating different ways of knowing encouraged 47. Project leadership actively creating safe spaces for people to meet and discuss 48. The project is building on community strengths and assets 49. The community is engaged at every step
Fostering equity	50. Sustained investment and commitment focusing on overcoming social barriers, such as childcare, low income, transportation, physical challenges, etc. 51. Approachable and available contact persons dedicated
Constant support for participation	52. Collected data, feedback/information about the collection, use of data, and impact of the effort clearly explained during the activities 53. Help to organize data and ensure consistency available 54. Frequent data collection and interaction with the researchers supported 55. Motivational talks from users of the information provided

Table 1. *Cont.*

Thematic Focus	Criteria for Engagement Enablers
Benefits of participation—to ensure retention	
Activities meaningful and enjoyable	56. Opportunities for group action provided 57. Gains of the project for the individual participants, community, society, science, and the environment made explicit 58. New skills learned by participants 59. Participants' career options enhanced 60. Discussions or further mentoring about potential long-term impacts available
Rewards from participation	61. Participant contributions explicitly acknowledged; participants receive recognition and appreciation 62. Participation measures developed 63. Incentives provided (where appropriate)
Sense of scientific contribution	64. Results of the projects presented in a clear and accessible fashion and designed to be relevant to community priorities 65. Practical application of data and results explained and demonstrated 66. Participants included in publications or other outputs as co-authors or in acknowledgements (by name) 67. Project leadership ensures that the project is perceived or experienced, relevant, and useful
Platforms for sharing experiences and enhancing social cohesion	68. Social interaction and networking, such as online tools (e.g., forums, chat rooms, and other social network apps) for dissemination, supported 69. Social interactions and networking among participants fostered 70. Explicit regular knowledge exchange between the project leads and citizen scientists ensured

In general, it is beneficial to think about the personal, structural, and procedural components of the engagement process as well as what the citizen scientists may gain from participating. Based on our findings (Table 1), initial engagement that builds on participants' personal interests, establishes confidence in their ability to contribute, and builds trust that their input will be valued helps foster long-term participation. Sustaining motivation and involvement over time hinges on both project elements and processes. Project design serves as a critical structural enabler of participant retention in citizen science, with accessible technology, engaging activities, and effective, inclusive communication fostering long-term engagement. Activities need to align with participants' skill levels or include necessary training (e.g., for using technical tools) to prevent early dropout. Indeed, some level of ongoing training to retain confidence was explicitly identified as an enabler. Furthermore, engagement should be designed to be appealing through strategies such as gamification or social activities and offer meaningful rewards to enhance continued participation.

While structural barriers have gained some attention in citizen science literature, procedural barriers are less discussed. However, despite their interconnectedness, structural and procedural barriers have previously not been discussed together in the citizen science literature. Yet, project design plays a critical role in enabling or hindering procedural effectiveness in participatory processes. Accessible and user-friendly technical tools lower entry barriers, facilitating sustained engagement and effective communication structures that support ongoing dialogue and ensure that participants are well-informed. Structurally embedded social activities, in turn, foster community building, enhancing procedural social engagement. Moreover, procedural needs often drive the evolution of structural elements. Flexibility in design and processes is essential for adapting to changing conditions, evolving

roles, incorporating feedback, and supporting inclusive, responsive participation. The concept of *dynamic informed consent* is an example of a structural component that supports adaptive processes by encouraging regular reviews and adjustments to mutual participation agreements to reflect changing conditions, particularly when engaging highly involved citizen participants [73].

In our analysis, two of the possibly most critical challenges that need to be addressed were the misalignment in expectations between the academic researchers and volunteering citizen scientists, and various aspects of miscommunication, ranging from a lack of awareness to a lack of appreciation. We see the two issues connected: the incongruity between the professional data-centeredness of researchers and the personal prioritization of one's leisure time as a volunteer can easily lead to misunderstandings. As pointed out by Hall et al. [14], citizen science is highly personal. This does not mean that scientific principles should be compromised in citizen science, but that social considerations need to be addressed on par with the scientific requirements for positive social change to happen as a result of the project.

Our proposed set of criteria in Table 1 can function as a guidance mechanism to help researchers reframe their mindset and broaden their outcome expectation foci from data and societal change to *relationality*. This explicit acknowledgement and consideration of social factors and relationships needed in citizen science go beyond analyzing the motivation of participants. It also goes beyond co-design and knowledge co-production processes, both of which are strongly supported by our findings and, for instance, transdisciplinary research literature [9,11]. Relationality, in this context, refers to a dynamic state of social integration that shapes how people relate to one another. Community relationships cultivate shared expectations for outcomes, which, in turn, strengthen the capacity for effective collective action (adapted from [74]). If we expect citizen science to change society, significantly greater attention is needed to understand and foster social relationships in citizen science, especially between the researchers and citizen scientists. As Suchman [75] concludes, large-scale or radical interventions frequently fail due to a disregard for the nuanced, situated, and context-dependent nature of human practices. Rethinking how to engage volunteers could start by asking the specific questions in the pre-planning phase, as outlined in the "Quick-Start Guide" (Box 1).

Box 1. "Quick-Start Guide" for engagement planning in citizen science: Ask yourself.

1. How do we find out what personal drivers potential participants might have to become a citizen scientist? (Personal enablers)
2. How do we ensure that the project is designed in a way that it fosters participation? (Structural enablers)
3. How do we design our processes to maximize the sense of safety and social comfort for participants? (Procedural enablers)
4. How can we keep giving participants something that they value? (Enabling emerging gains)

As highlighted in Table 1, essential to fostering relationality are procedural enablers that prioritize trust, inclusion, and mutual respect through transparent, adaptive processes. Building safe, reflexive spaces and responding to participant feedback are key to sustaining meaningful participation (Figure 2). However, fostering such environments within scientific contexts requires humility and reflexivity, which are skills many researchers are not formally trained in. According to Dorcey [76], unexamined assumptions and implicit biases can hinder dialogue and polarize interactions, especially when safe platforms for mutual learning are lacking.

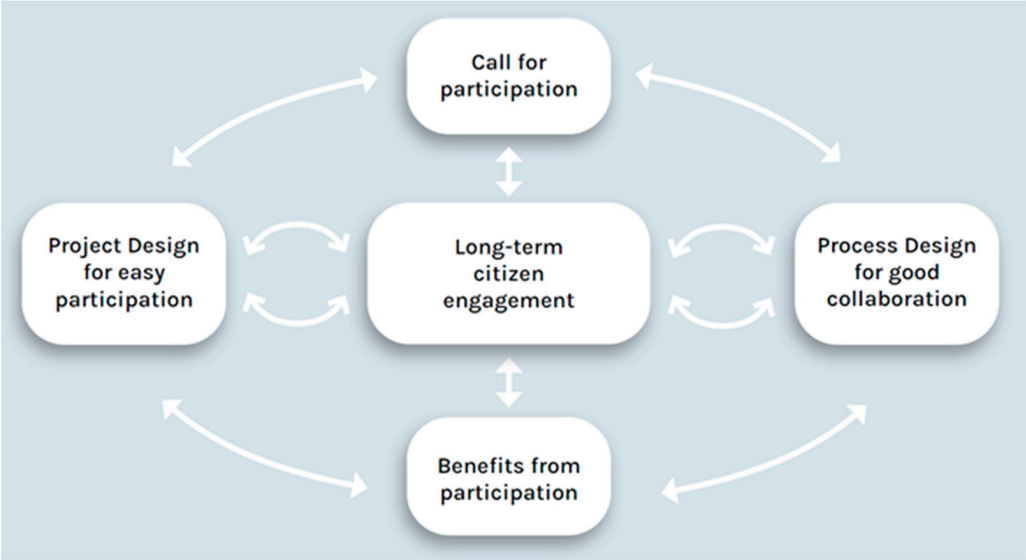

Figure 2. The iterative and heuristic nature of effective long-term citizen engagement.

Our findings highlight that participants consistently emphasize the importance of being treated with respect, equality, and emotional safety, which aligns with the latest studies in citizen science [77,78]. Trust building is not only foundational to effective community engagement but also requires sustained effort and time across all stakeholder relationships [62,79]. As Putnam [80,81] notes, social networks, trust, and a sense of equality are key to fostering reciprocity, enhancing information flow, and ultimately enabling collective action and behavioral change, outcomes that are particularly relevant in citizen science, nudging toward sustainability transitions.

Limitations of This Study

For this analysis, which sought to build a foundational evidence base to help researchers, especially natural scientists, approach citizen engagement more systematically, our approach is sufficient. However, a more comprehensive analysis of barriers and enablers in participation would require an expanded literature review and a larger selection of papers. Likewise, our focus groups were intentionally small to mitigate participation fatigue, and their findings were used primarily to enrich the theoretical paper with empirical examples. While these mini-focus groups allowed in-depth dialogue within a safe space, they did not yield the breadth of insights that a larger sample could provide.

4. Conclusions

This paper presents the first empirically grounded, 70-item checklist that translates identified barriers and enablers of participation into a practical tool for planning inclusive and engaging citizen science. Our analysis revealed the need for a more in-depth analytical and proactive approach to citizen engagement, including attention to connections between structural and procedural barriers as well as practical aspects of relationality, especially the misalignment in expectations between the academic researchers and citizen scientists, as well as various aspects of unintentional miscommunication. We are proposing an approach that proactively addresses potential barriers in a systemic manner to help ensure that the project engages and retains participants while achieving its goals. The criteria can also be used in monitoring and assessing participation in citizen science projects. The value of the proposed framework is the practical evidence-based guidance toward more systemic, equitable knowledge co-production needed for sustainability transition. However, more

heuristic research is needed to assess the effectiveness of both the proposed framework in citizen science projects and their actual influence on social change.

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Abbreviations

The following abbreviations were used in this manuscript:

H2020	Horizon 2020
I-CHANGE	Individual Change of HAbits Needed for Green European transition
EU	European Union
FG	Focus group

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