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Citizen Science Addressing Challenges of Sustainability

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Abstract: Practices for the engagement of citizens and other research and innovation (R and I) stakeholders in science can be found aplenty in the existing literature, all along with principles, guidelines and tools providing meaningful guidance for practitioners in research funding and performing, organizations (RPFOs) and helping them achieve high quality and responsible citizen science projects addressing sustainability challenges. Such guidance, however, is scarce when it comes to setting up and running transdisciplinary citizen science eco systems, where projects can be systematically initiated by different stakeholders and carried out in a dedicated supportive environment. Based on literature review and series of semi-structured interviews with quadruple helix stakeholders in Lithuania, this paper provides a current overview of the perceptions, concerns, motivational factors, and obstacles with regard to participation in citizen science activities.

Keywords: quadruple helix stakeholders; public engagement; co-creation; eco system

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1. Introduction

Citizen science (CS) is a relatively new and rapidly evolving discipline and community of practice. Citizen science is strongly related to transdisciplinary research, in which not only the combination of multiple scientific disciplines, but also the collaboration between different stakeholders is essential to solve major scientific and social problems. Currently, there are more than 3000 active and searchable global CS projects listed on the SciStarter website (https://scistarter.org, accessed on 15 October 2021). Science Europe (2018) [1] recommends mobilizing citizens for science from the very beginning of the research process in order to enhance the impact of EU research and innovation programs, and the European Citizen Science Association's [2] strategy sets a clear goal to contribute to sustainability development. Citizen science (CS) can effectively serve policy making initiatives and processes by providing evidence and useful insights to support regulatory compliance with a transparent and participatory way at national and EU levels [3]. While some academics hope that CS can increase scientific knowledge production ("productivity view"), others emphasize that it may bridge a perceived gap between science and the broader society ("democratization view") [4]. Citizen science is considered as the main driver to facilitate and foster more inclusive societies, in a sustainable way, by generating innovation towards addressing major societal problem [5]. The scope of today's sustainability problems is evident in the seventeen UN Sustainable Development Goals [6]. The impact of CS on sustainability transition can emerge trough problem identification or agenda setting, resources mobilization, and generation of socio-technological solutions for sustainability problems. Such problems may relate to aspects of the quality education, gender equality, good health, sustainable cities and communities, and other aspects of sustainable welfare. Addressing challenges of sustainability CS needs to increase activity of participation and socio-cultural diversity and to involve different stakeholders` groups. The European Union (EU) provides financing instruments that could foster and upscale the economic sustainability of CS initiatives. However, many national funding structures

do not have schemes for required financial support. A number of policies have been discussed at international and national level in recent years, although policy makers and stakeholders (including public authorities) still lack an appropriate readiness level in understanding the innovations brought forward by the citizens' inclusion. The main task of this research project is to define and discuss perception, concerns, preconditions for engagement, and motivations of quadruple helix (QH) stakeholders for actively engaging in CS activities. Based on a literature review and a series of semi-structured interviews, this paper provides insights about obstacles and opportunities of CS in Lithuania and contributes to the wider literature on transformation processes for more sustainable socio-technical systems.

2. Research on Citizen Science

Citizen science (CS) is defined as collaboration between the general public and researchers/universities, also engaging other stakeholders of QH [7]. CS increases the transparency of scientific outcomes, public trust in science, raises awareness about socio-political problems, and enables citizens' advocate for changes [8,9]. The majority of the existing academic literature focuses on the level of awareness about CS and possibilities to engage the society in research [10,11]. By involving citizens in science, professional scientists can obtain additional resources for production of scientific knowledge [12]. Research on CS discusses how citizens could be involved in all stages of the research process, allowing one to shape the direction of the research and influence more effectively positive changes in society [13]. Understanding the complexity of CS process by involving different stakeholder groups is of critical importance for sustainable initiatives. The current research projects on CS make efforts to identify the conditions or motivations that may foster or hinder citizen involvement [14–16]. The knowledge and holistic picture about the critical factors can be extracted through case studies in different countries and contexts, thus the researchers test different dimensions and possibilities at conceptual and practical level [17,18].

Another stream in CS research focuses on how CS can help address sustainability problems [19,20]. CS can help to identify and structure the problems and advocate for socio-political change. Technological innovations in the field of renewable energy, green transport system, public health and other areas have to be integrated with social systems to reach sustainability transition [4]. Such processes require changes in norms, values, behaviors and motivations [21], often depending on supportive policies and regulations [22].

Practices for the engagement of citizens and other R and I stakeholders in science can be found in existing literature [10,11] all along with principles, guidelines and tools providing meaningful guidance for practitioners helping them achieve high quality and responsible CS projects in many distinct disciplines [2]. Such guidance, however, is scarce when it comes to setting up and running sustainable ecosystems or transdisciplinary hubs, where projects can be systematically initiated by different R and I stakeholders and carried out in a dedicated supportive environment.

3. Sustainable Citizen Science Ecosystems

Today's research performing and funding organizations (RPFOs), including universities across the European Union (EU), are tasked with many significant, yet extremely complex tasks including: to promote excellent research and transparency with regards to decision making; to secure scientific integrity; and to provide a fertile environment for stakeholder interactions that will benefit their entire ecosystem. In recent years, the European Commission have made significant steps in this direction, by introducing and embedding RRI (responsible research and innovation) keys (ethics, societal engagement, gender equality, governance, and open access/science and science education) in their governance structures and operating models. However, the systematic collaboration with all different groups of societal actors (e.g., citizens, communities and third sector organizations)

is far from exceeded. The CS approach is based on circular and complex connections between science and society and operates as quadruple helix ecosystem. Based on CS community building principles, the CS ecosystem supports a multi-layered interaction with all stakeholders' groups' representatives from civil society, researchers, academic institutions, policy makers, and various industries. The important barrier to overcome by developing CS projects is the identification of right stakeholders in different sectors that can take advantage from the planned CS outcomes. Strengthening communication about the value and opportunities of CS is another big challenge to overcome. Policy makers often have different interest, motivations, expectations and understanding towards the achievements and outcomes of the citizens' science activities and efforts [23]. From industry/business perspective, CS could be considered as a possible competitor against well-established large-scale platforms which gain profit from people's data. The major concerns about CS from the universities and researchers` perspective are around critical barriers, namely data, awareness, and synergies [24]. The strong focus and risk lay also in quality assurance, regulatory framework, and all-inclusive schemes for citizens' contribution, as described by the European Commission open access policy. New technologies such as mobile phones and the internet give citizens an increasing set of tools to help with research and allow them to participate in physical as well as virtual space [25]. However, inclusion of specific groups in research meets obstacles, since a significant number of people among these groups have low digital skills or even limited relevant resources to access the provided tools and material. Another problem from university perspective is that CS has been predominantly pursued within the realms of the natural sciences [26]. Activities and projects following social sciences and humanities (SSH) topics and approaches are less easily discernible in CS practice, although they may be fueled by some genuine and challenging questions [27]. This paper provides an overview of the current situation in Lithuania, offering answers to questions of awareness, key opportunities and challenges for CS, required institutional changes or political decisions, and other related problems with respect to CS initiatives.

4. Research Methodology

The qualitative research illuminated the practices and interpretations around the perception of CS in Lithuania and the role of quadruple helix stakeholders by establishing sustainable CS eco system. The chosen qualitative research methodology provided new data on QH stakeholders` perceptions or validated the data discussed during the literature review. The findings are based on 12 semi-structured expert interviews conducted from January to April 2021 with the QH stakeholders in the CS ecosystem. Expert interviews have some significant advantages over other methods of data collection. First of all, this type of survey is uniquely aimed at obtaining reliable data since respondents` competence is very high [28]. Another advantage is due to the fact that "respondents are highly qualified in the analyzed question, it eliminates the need to use additional screening and clarifying questions aimed at revealing true, but hidden from the interviewer respondent views" [29]. Interviews during the survey involve an exchange of opinions between an interviewer and a respondent, thereby generating additional value through new knowledge and new content. Principles and value of implementation of problem-centered expert interviews are presented in number of methodological guidelines [30,31]. According Doeringer [31], the method of expert interviews contributes to a deeper understanding of asocial field of action and supports theory building for further research.

The interviews were conducted face-to face by the authors, and recruited experts from the following stakeholders' groups: scientists and university representatives (4), NGOs' managers (2), public administration (2), business representatives (2), and following guidelines of a "maximum variation sampling" strategy [32]. Experts are considered knowledgeable of a particular subject and were identified by virtue of their specific knowledge, their community position, or their status [33]. The subjects matter experts

were identified according to the following criteria: education, skills, position, possible influence on decision making, competencies related to the research topic, interest in the field of CS or RRI (responsible research and innovation), visibility in Lithuanian science environment, and publications in the field or activities in the field of innovations. The sample size was defined defining on the size of the pool of potential interviewees and following methodological guidelines and recommendations of Baker, Edwards [34], Mason [35], etc. Conversations were recorded using digital voice recorders and then transcribed. The participants verbally agreed to be part of the research project and were not compensated for their collaboration. Pseudonyms are used throughout the paper to protect their privacy. Some interviews were conducted in the Lithuanian language. All participants are Lithuanian citizens. When quotes from these participants are cited in the paper, they appear in English. They have been translated by the authors, who are bilingual. Interviewers asked questions to trigger discussion about each of these topics, and then followed the flow of the conversation. Researchers used supporting strategies such as abstraction and deduction whilst conducting qualitative analysis, and the interpretative analysis of content. Similarities and differences between the identified relations and variables were highlighted, also distinguishing extreme, non-typical cases. Using an iterative approach to the hermeneutic circle, we evaluated the findings against the literature and conceptual framework. Data were analyzed in the context of participants' ideas, arguments, and opinions in order to deepen the researchers' understanding of the analyzed issues.

5. Qualitative Research Results: Establishing a Citizen Science Ecosystem in Lithuania

Lithuania is an interesting case study for CS due to geopolitical situation and its status as a former Soviet state now in the EU. Lithuania has all of the preconditions to become a testbed for exploring the potential of CS. The country has relatively high level of the infrastructure of information technologies, high level user accessibility (high-quality Internet accessible not only in cities but also to 98.7 percent of rural areas), and small number of well-educated inhabitants (2.7 million). Other factors are Lithuania's business-friendly regulations and active central capital industry, as well its vibrant tech culture. Several knowledge-based clusters have been established in the capital in the last few years, bringing together such high-tech industries as biotechnology, laser technology, IT, telecommunications, electronics and precision mechanics, nanotechnology, and medicine. However, in Lithuania, as well in other post-soviet countries, people seem to put lower value and respect on science. To add, as a post-soviet country Lithuania does not have a developed citizen engagement, and the relationships between business and science are also weak.

The qualitative research was structured around four major categories, identified during the literature review: awareness/relations/experience with CS, motivation factors to participate in CS activities, resources and support needed for establishing CS eco system, and value of CS for sustainability and science progress. Each topic was related to the structured interview questions (two to four questions to each topic). The preliminary overview of the questions is following:

(1) How is CS understood and implemented in Lithuania?
(2) What are the main enabling and hindering factors for CS activities?
(3) What is the role of different QH stakeholders by establishing CS ecosystem?
(4) What are the motivational drivers for CS initiatives?
(5) What is the value of CS project for sustainability?

The researchers processed the content collected from each of the interviews, identified affinities across participants, and then distilled a collection of ideas and core insights in accordance with the conceptual analysis framework. Several sub steps were involved starting with researchers familiarizing themselves with the data (reading and re-reading), defining key themes and providing a coherent narrative using quotes from interviews to explain the relation between the major categories, defined during the literature review and from the interview data (minor categories).

5.1. Awareness/Relations/Experience with Citizen Science (*as a Person or Organization*) *and the Role of University in This Process*

According to the respondents, the concept of CS should be clearly defined in the first place: *"it was really not easy at first to understand the concept, primarily because we don't have many examples of CS in Lithuania" (D); "In essence it's the invitation of general public to participate in scientific processes" (E); "No experience with CS, but science communication is one of my stronger sides" (B); I am a citizen and a scientist. But those two concepts come together in one place (F); "by reading scientific publications, talking with more experience colleagues around the world–I'm starting to understand the main building blocks of CS, it's benefits and related risks" (A); "perceptions are actually very different in the academy and public"* (F). The interviewees are aware about the concept of CS, but the majority of them do not have experience in CS projects and would be happy to conduct them. In addition, the respondents from universities have more clear understanding about CS relating the term to "open science", RRI, co-creation and other related constructs. They also indicated the emergence of the term CS more often in the last years, first of all linked to H2020 calls. The respondents mentioned the importance of aligning understanding about meaning of CS and science in general for society. The scientists and university representatives, as well as community managers, described different collaboration and co-creation activities between citizens and scientists and indicated challenges connected to such collaboration: *"The process of collaboration with scientists is very important for communities. We try to connect with different universities in Vilnius. However, we feel that there are many institutional restraints-researchers have to have permissions to conduct such activities. Also, I feel that researchers are busy doing other things and don't always have time to co-create with local communities" (E); "We had several projects where public opinion was important. And right now, one of the projects we're running is that we need expert opinion on the proposed solutions, on the proposed innovations, and we interact with people who have certain skills…" (F); "I have prepared project applications where this term has also been used. For example, to map the recreational places that occur naturally in the city so that the citizens can mark them on the map themselves" (G); "I think that eliminating citizens is no longer possible. Because citizens are involved everywhere" (E).* All stakeholders also agree that *"the university should still be the initiator of the collaboration" (I).*

5.2. Motivation Factors to Participate in CS Projects

The majority of interviewees were willing to participate in CS projects: *"the gap between science and society is getting smaller. Citizens have access to so much information right now. In this context, scientists have to find new and better ways to communicate their ideas" (G).* However, the interviewees questioned the motivation of scientists itself: *"It would be hard to motivate me to participate in the activities of the hub. I have too many other responsibilities related to the projects. Currently, there is no incentive for me. My salary depends on very different factors-publications, participation in research projects and not the engagement of other stakeholders" (G); "there is lack of motivation not from citizens or external stakeholders but from scientists themselves" (H);"Most of the researchers put their wellbeing first and if they cannot earn from their research activities, they will not do it" (B).* Indeed, *"there are always some who would work on CS from their internal motivation, but not in the large scale" (G).* The participants are skeptical in the majority of the cases about the interests of other stakeholders or volunteers to be part of the research projects and highlighting the need for education and proper understanding of the value of CS: *"In Lithuania, citizens have little interest in science, they are skeptical about research, its reliability and results. And I have not yet heard from the citizens themselves articulating an interest in participating" (I); "We grew up without knowing that there was such a thing as CS. For example, you are a scientist, you do research, you are an entrepreneur, you do business, you are a politician, and you do politics. And it was normal that these things should not mix with each other" (K); "In my understanding, the interest of other stakeholders is very low. Here again, one would think that they are invited to do what is not their usual" (I).* It is increasingly difficult for researchers to do research alone without the help of other stakeholders:

"It is hard to get the responses to the surveys we sent out as social scientists. The feedback is very low. People don't want to be involved in those studies–they don't want to spend time on things they don't care about. So, we need to find ways to include citizens not only in data collection and analysis but also in the formulation of research questions. In that way, citizens could feel more empowered and more motivated to participate" (B). One of the interviewees recommended to issue policies for citizens' inclusion in research projects, similar to the policies in EU projects for involving different regions or ensuring gender equality. Of course, financial support for implementation of such policy would be important. The motivation factors for university could be following: *"broader dissemination of your research results" (D); "increased productivity and transparency of scientific outcome"; "increased creativity because of diversity" (B); "excellent opportunity to showcase a different side of our university–more open, innovative and inclusive" (E);"monetary rewards if they engage citizens in their projects" (D).*

5.3. Establishing CS ECO Syetem (Resources and EU Support Needed)

Most participants agree that *"citizen science is quite easy to define, but very difficult to implement" (A).* The interviewees defined effective communication and cooperation factors as having the most impact on establishing successful CS hubs: "*there is a need to prepare tools, certain research protocols and communicate your ideas clearly in order for citizens to know how to collect, store and analyze data" (A); "We would definitely need to define the communication's strategy for the hub. I think the first goal would be to disseminate the information within the university–organize trainings, explain to the scientists what it is and how to use it successfully" (A); "two-way communication and dialogue, rather than one-way communication, is the guarantee of success" (B); "The cooperation should not be limited to cooperation between, say, business and academia. …it is important that we reach all sections of society considering the needs of different social groups" (I); "not wider publicity, but wider cooperation, seeing the whole society as potential contributors" (K); "Our institution needs to adapt to changing needs of the society. Science cannot be isolated. We need to find ways to communicate our ideas more broadly. Not only in promotion of our institution" (C).* Many interviewees were concerned about reliability of the research results: *"I see a lot of benefits of CS, but the biggest problem is with reliability. If we, as a laboratory, break that research down into details, that credibility breaks it down into smaller steps" (I); "By collecting the data, simply, the citizens like the ordinary researchers, must know the rules of what and how to record or store, but the responsibility for the reliability of the instrument has to take the scientist" (K).* Interviewees questioned whether or not a citizen's involvement in CS hubs is an effective tool for sustainability: *"I'm quite skeptical in this regard. This could be another lab or hub that is on paper but does not really have any added value. Such initiatives have to come from the scientists themselves. If this another box they will have to tick-the hub will soon be irrelevant. There should be a structure which motivates scientists as well as citizens to become members of hubs" (H).* Indeed, *"such spaces or labs would be a great place for us to meet and learn from researchers. I do believe in progress of science" (F).* Discussing the involvement of citizens in the research process the participants mention different stages of involvement form problem formulating to decision making: *"Perhaps, we could ask citizens to formulate problems because, I think they feel them better" (I).* A large group of interviewees highlighted the responsibility of governmental authorities and need for support from EU institutions: *"The ministries should understand the value of CS and science communication first. I think that this is not yet the case in Lithuania" (C); "We have a really large scientific community and in my eyes there is too little synergy, cooperation between politics and science, because politicians make decisions very far from being supported by scientific evidence" (E);"In Europe, we deal with all the issues first in consultation with the scientists who come up with some analysis of different phenomena, some kind of preliminary suggestions and on that basis, we make decisions. In Lithuania, such processes are not happening at all" (E).* Most participants agree that the scientists have to develop new competencies to implement CS project and change traditional thinking to more open approach in research: *"When I was studying for a doctorate, such things were not discussed in depth yet. And naturally, it will take time for me to learn to look at research and plan it differently" (J).* Also "*a very inert formal higher education and research system" (H)* have to

be changed: *"Having good and active relationships with different stakeholders is what drives our institution further" (D).* It is clear that collaboration can be achieved through communication. The initiation has to start from university side, according the interviewees, but with special focus on society needs. "*For example, a public lecture brings together usually people of similar understanding, perception, education-colleagues, members of the university community. And it is quite difficult to reach society itself, simply society as a whole" (C).* Special training, brainstorming with other stakeholders, financial support, and adequate competencies developed would be highly useful in this process: "*Researchers need to develop additional skills that will allow them to talk on an equal footing with the citizens" (A); "When you go to people, you have to speak normal, simple human language, which isn't always that simple. The whole way of communication, the involvement should be different".* At the moment, the collaboration happens mainly "*for marketing and student enrolment reasons" (B).*

5.4. Value of CS for Sustainability and Progress of Science

Discussing value of CS for society the interviewees pointed out fields of useful application supporting sustainability. One important reason for CS to emerge could be impact on society: *"Any project also has an application/practical side. We are talking about the impact of on society in one way or another" (H)." Citizens are a very big resource "(A)* for identifying sustainability problems and shaping the direction of research towards societal needs: **"***We lose a very large part of the potential contribution if we do not include the people for whom those problems are being addressed" (A).* By being involved in CS projects, citizens can develop their critical thinking skills, enhance scientific literacy and increase their awareness about social problems: *"CS can definitely enable citizens to solve their problems…there are some problems that scientists don't see, simply because their field of activity is different. And citizens see them, live in them and want to deal with them as soon as possible" (L).* Involvement in CS can change the science audience attitude towards science, increase trust in science and help to counteract fake news: *"CS could be used as one of the tools showcasing the process of science, the importance of validated and unbiased information" (K).*

5.5. Outcomes and Limitations

The minor categories present qualitative analysis outcomes and concentrated conclusions from interviews (see Table 1 below).

Table 1. Major and minor categories in semi-structured interviews.

Themes	Major Categories	Minor Categories
Awareness/ relations/ experience with Citizen Science (as a person or organization)	Understanding of CS concept Participation in CS projects Collaboration/co-creation between stakeholders	• Distinction between citizen science and other concepts such as open science, RRI, citizen engagement, science communication, collective intelligence, etc. • Decreasing gap between scientists and citizens due to information accessibility • Aligning understanding about meaning of CS and science in general
Motivation factors to participate in CS projects	Incentives for different stakeholders Incentives for citizens Incentives for university	• Increased inclusion and democratization • Increased creativity through diversity • Meeting changing needs of the society for science communication • Mobilized resources, aggregated technical knowledge and solutions • Increased productivity/

		dissemination/transparency of scientific outcomes
Establishing CS eco system (resources and support needed)	Difficulties and challenges to implement CS Need for EU institutions and government support for CS Hubs	• Communication problems and differences in socio-cultural background • Education problems (how to collect, store and analyze information?), preparation of the tools and protocols • Problems of reliability • Need for structural changes, financial support and training • Changing traditional thinking to more open approach in research • Decreasing skepticism against science and strengthening trust in science • Need to involve citizens in different stages of the research process • Lack of volunteer interest
Value of CS for sustainability and progress of science	Identifying fields of useful application supporting sustainability Showcasing good practices examples	• Identifying sustainability problems and shaping the direction of research towards societal needs • Developing critical thinking skills starting from early age (nurseries and schools) with CS projects • Developing skills for thinking outside the "box" and information "bubble" • Enhancing scientific literacy, counteracting Fake news in collaboration with other stakeholders • Changing behavior due to increased awareness about climate change, air pollution, etc. • Advocating for socio-political change, align the interests of multiple publics • Positive change in scientific attitude

The study has several limitations. It was conducted in a Lithuanian capital city in which practices of CS can be different from other places and countries. The research was conducted as an exploratory study with the small number of experts and should be expanded in other stakeholders' groups with different socio-cultural context, and also supported be representative surveys results. Further research is needed on targeted attitudinal or behavioral change, perception differences, ideological motive influence of age, education and income on attitudes and interaction, and many other variables. However, these findings may contribute to the development of practical policies and recommendations as the success of sustainable CS projects strongly depends on the willingness of all actors in ecosystem.

6. Discussion and Conclusions

CS hubs use citizen science as a way of improving the quality, depth, and impact of research; interacting with society in meaningful and deeply transformative ways. However, the readiness and capacity of many RPFOs to implement sustainable institutional changes for RRI remains limited. Our discussion of opportunities and challenges was fo-

cused explicitly to potential contributions of all stakeholders to the development of sustainable CS ecosystems. The results show diversification in some instances which is quite strong with respect to perceptions across the QH stakeholder groups depending on the field of expertise and maturity level in knowledge about CS. The results provide an overview on critical factors that enable or block participation in CS activities including level of civic engagement, readiness of technological infrastructures, availability of financial support, and an adequate culture of stakeholders` collaboration. The complicated network of specific and sometimes contradictory motivational stimuli was identified during the interviews with different stakeholders.

According to research results, the universities' scientists have the clearest understanding of the CS concept and practical experience in collaborating with other stakeholders, so they have to take the leading role in explaining the value and the meaning of CS projects using available platforms and technological tools. In line with expectations of community and NGOs managers or business developers, the universities have also to show initiative by developing sustainable CS projects. The universities have to meet changing needs of society by engaging citizens into research process from the very beginning, seeking mobilization of resources and aggregation of knowledge. The motivation factors to be involved in CS projects differ depending on the stakeholders' group. The main motivation factors for university, identified during the empirical research, are: broader dissemination of the research results, increased visibility, productivity and transparency of scientific outcomes, increased creativity due to diversity, and also monetary rewards for engaging citizens in research projects. EU financial support and adequate inclusion fostering policies, initiated by governmental authorities, would be highly useful by implementing such activities. By establishing sustainable CS hubs, universities have to adopt citizen-oriented communication style and change traditional thinking to more open approach in the research. There is big challenge for universities to act inclusively and encourage collaboration between all stakeholders. The main concerns about successful implementation of CS projects are related to reliability of scientific outcomes. Special training, brainstorming with other stakeholders, and changes in norms and behavior would be the most important enablers by connecting science and society. It can be concluded, therefore, that academic institutions need to introduce new operating models and working methods, initiate concrete and measurable institutional changes and develop new competencies. Discussing the value of CS for society the interviewees pointed out fields of useful application supporting sustainability and highlighted the importance of showcasing good practices examples. Professional scientists should consider the benefits of interdisciplinarity and its broader impact on society. Citizens are valuable resource for identifying sustainability problems and shaping the direction of research towards society needs. By being involved in CS projects, citizens can develop their critical thinking skills, enhance scientific literacy and increase their awareness about social problems. Positive change in perception of science can lead to increased awareness about social problems such as climate change, air pollution, etc. and influence positive changes in behavior.

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