

Evaluating the Social Health & Wellbeing Benefits of CaSTCo Citizen Science: Full report

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Executive summary

Citizen science provides a range of benefits to participants. We explored this through three approaches: a review of the scientific literature, a survey of CaSTCo-trained volunteers, and a case study of the 'photovoice' methodology used by volunteers in the Wensum catchment, Norfolk.

The scientific literature shows that there is a wide range of potential benefits from citizen science participation. These can be divided into:

- Increasing knowledge, skills and science capital;
- Benefitting health and wellbeing;
- Forming and strengthening meaning and connection; and
- Increasing empowerment by supporting the development of values, motivation and action.

Evidence for these benefits can vary in quality, and further research is required to gather evidence for some benefits. For freshwater citizen science, the benefits often align well to the motivations of participants in being involved, which is likely to support greater recruitment and retention. Intentional design of citizen science is important to maximise the benefits for participants.

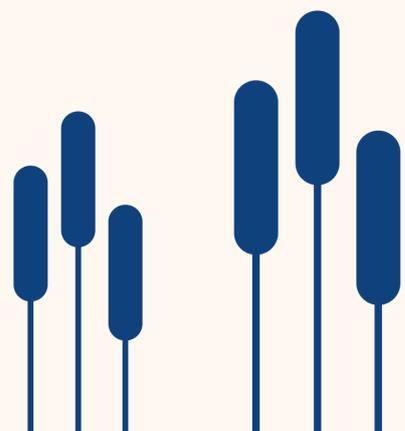
Our survey was circulated to all CaSTCo-trained volunteers. We received 86 responses (estimated 25% response rate). Strikingly we found that respondents were predominantly older, white and with high educational qualifications. In general, participants gained a high level of benefits, especially in: learning more about their river, gaining new skills, boosting their pathways to nature connectedness, benefiting from being part of a community, and feeling empowered to care for their river.

We report on the Photovoice case study, which was a Participatory action method in which participants in one catchment created and curated a set of captioned photos illustrating their experience in CaSTCo. Overall, this benefited the project because it:

- Publicises the insider perspective of tackling environmental threats;
- Encourages discussion, strengthens partnership and community;
- Helps foster reflection on personal connections to the issue;

Drawing on the three sources of knowledge, we recommend that:

- Evaluation of participant benefits is built into the design of freshwater citizen science programmes to grow best practice.
- Greater emphasis is placed on benefits in communications to volunteers to boost recruitment and retention.
- More co-design with potential participants to intentionally build participant benefits into the design of the activities, to complement scientific data collection.
- Projects are designed to reach more diverse audiences, to enable a wider range of people to gain benefits from participation, and further research, using surveys and qualitative research methods e.g. interviews, should be conducted to ensure that all have the potential to gain benefits.



1. Introduction

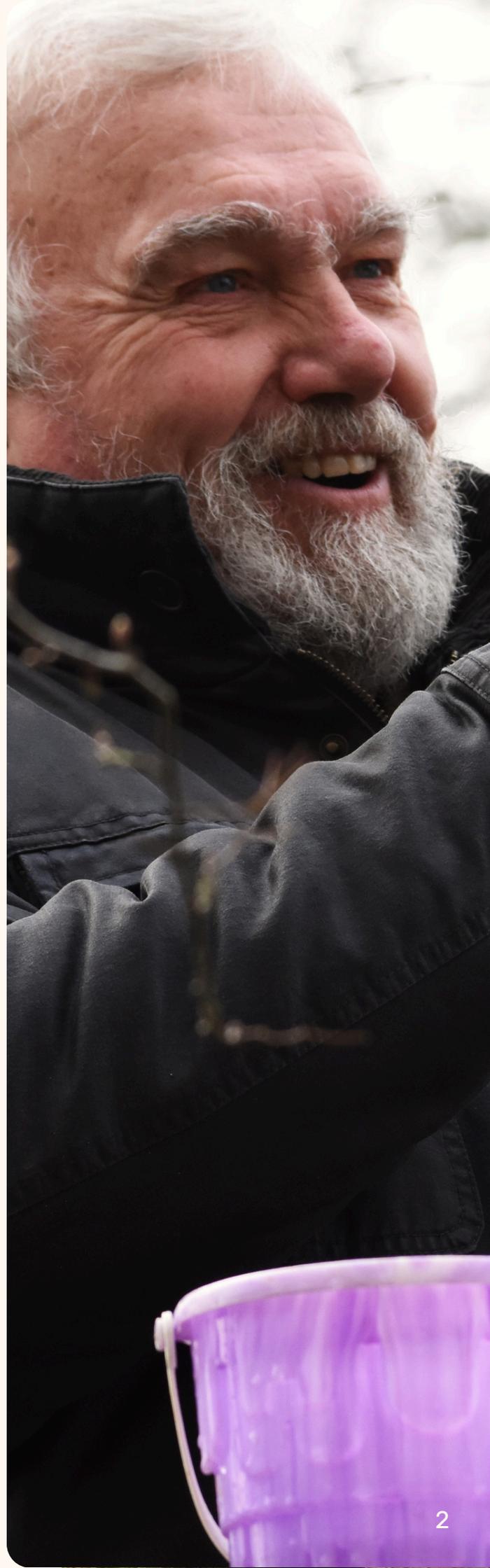
Citizen science is a valuable source of data for environmental monitoring. However, citizen science has many more benefits than scientific data – it benefits society by informing effective decision-making, and also benefits participants directly through their involvement. Here, we evaluated the benefits to participants taking part in river water monitoring.

This study was commissioned by Anglian Water as part of the multi stakeholder Catchment Systems Thinking Cooperative (CaSTCo) project. CaSTCo is creating a national standardised framework for how citizen science can be integrated with professional monitoring to generate impactful data and decisions for rivers.

Here, we use a relational wellbeing approach to examine and evaluate individual, community, and nature health and wellbeing benefits of being a CaSTCo citizen scientist. First, we conducted a review of the literature to explore the current evidence for participant benefits, especially in freshwater citizen science. Second, we issued a survey to all CaSTCo citizen scientists to elicit a view of the CaSTCo citizen scientists' experiences. Third, we present a case study using the PhotoVoice method to elicit further responses from the citizen scientists. PhotoVoice is a participatory action method grounded in democratising science and facilitating community action, and provides a qualitative evaluation to complement the results of the survey. Finally, we brought together these three evidence streams in a discussion of the findings and provide our recommendations for future investment in freshwater citizen science.

“It just makes you happy, doesn't it?”

Quote from a Wensum River citizen scientist while walking out to his monitoring site.



2. Literature review

There is a growing evidence base for the benefits of participating in citizen science. We undertook a literature review of evidence to answer our three central questions:

1. What are the multiple benefits of participating in citizen science?
2. What are people's motivations to be involved in citizen science, and specifically, freshwater CS?
3. What is the evidence that people benefit from their involvement in freshwater CS? e.g. pro-environmental behaviours, learning outcomes, wellbeing, education.

We used a rapid evidence assessment approach to search the scientific literature for key papers and grey literature, from 2017 onwards, that show the benefits of participating in citizen science (Appendix 1). Having identified 21 key papers (Appendix 1), we then used a forward-and-reverse 'snowballing' approach from those papers to identify which papers they cited, and which cited them, so as to expand our evidence base for this review. Literature regarding citizen science has been largely focused on the benefits to the projects of using citizen science for scientifically sound data collection. There is growing literature on 'impact planning' to maximize desired impacts of citizen science projects (Pateman and West, 2023). Overall, there is a comparatively small amount of literature evidencing the wider benefits to the participants of engaging in citizen science (Walker et al., 2021). We reviewed this literature to gather a baseline understanding of this important area.

This understanding is important as well-designed and well-run citizen science projects have a power to go beyond data collection and/or engagement and outreach. A key challenge of our time is an ongoing environmental and biodiversity crisis alongside a growing disconnect from nature for many people (Pocock et al., 2023; Eichholtzer et al., 2023; Oh et al., 2024; Martin et al., 2020; Schuttler et al., 2018), which are supported by continuing social structures and policy (Weiner, 2024). As water quality and biodiversity are inextricably linked (NWT, 2021), volunteers monitoring our freshwaters is an important way that citizen science can play a role in addressing this complex challenge: at best it can benefit participants, support pro-environmental behaviour change, and provide evidence to support action by decision-makers. As the use of citizen science proliferates, the resulting engagement in biodiversity by participating volunteers can bring about improved health and wellbeing (Martin et al., 2020; Weiner, 2024; Richardson et al., 2021). This increases willingness to change behaviour (Peter, et al., 2020; Lauren et al., 2016; Eichholtzer et al., 2023) and the added social connectedness means sharing new knowledge and spreading of pro environmental behaviours (Eichholtzer et al., 2023; Lauren et al., 2016; Weiner, 2024; Bonney et al., 2015). This in turn, can lead to social and political capital that could affect real, environmentally positive change (Walker et al., 2021; Weiner, 2024; Bonney et al. 2015).

Through understanding the multiple benefits and challenges derived from engaging in citizen science activities, we can design citizen science projects that harness the co-benefits available (Oh et al., 2024).

The multiple benefits of participating in citizen science

Here, we focus on the benefits to participants. There are many potential benefits to participants of taking part in well-run citizen science, these include personal satisfaction and enjoyment, educational and skills gain, increasing empowerment and self-efficacy, creating social connections, and improving well-being through connecting with nature (Bonney 2016). The breadth of individual potential benefits is demonstrated by one recent paper that identified 70 proposed benefits, outcomes and impacts of citizen science, and grouped them into nine 'pathways to impact' (Pateman & West 2023). Combined with Pateman's extension of this work in Pocock et al. (2025), we can group the benefits for participants into:

- Increasing knowledge, skills and science capital (i.e. wider participation and engagement in science);
- Benefitting health and wellbeing, e.g. through connecting with nature, undertaking physical activity, and taking part in enjoyable activities;
- Forming and strengthening meaning and connection, including connection with place, and connection with others in communities; and
- Increasing empowerment, by supporting development of values, motivation and action.

These benefits are not independent, and they interact, so that individual short-term outcomes lead to a range of longer-term outputs for the benefit of the environment, science, individuals and society, especially through influencing decision-makers and action (Pateman & West, 2023). Looking at these benefits from a wide perspective, Walker et al. (2020) describe a framework of different 'capitals' and how citizen science contributes to human and community capitals, thus empowering behaviour change, leading to improved environmental, human and societal health.





The evidence for benefits from participating in citizen science

There are a large number of scientific papers that discuss the benefits of citizen science. Evidence for some benefits are strong, but many potential benefits are inferred rather than evidenced (Walker et al. 2020; Haywood 2014). This is especially the case for longer-term impacts that are harder to research (Pateman & West 2023). Furthermore, Warner et al. 2024 find that currently there is limited evidence of the impact of citizen science on water resource management globally.

Benefits that have strong evidence include the building of human capital through: educational benefits and awareness raising; development of skills in scientific data collection; and decreased risk of events, such as flooding, through raised awareness of vulnerabilities (Walker et al. 2020; Peter et al. 2019).

Of course, lack of evidence is not evidence that these benefits do not exist, but they do indicate that the evidence base for these benefits should be strengthened (Haywood 2014).

Key studies demonstrating the benefits of freshwater citizen science

Several studies have specifically studied the benefits of participating in citizen science in freshwater environments. Some key studies are summarised below:

- von Gönner et al. 2024: volunteers taking part in stream monitoring had greater knowledge of streams and drivers of change and greater monitoring skills compared to a control group. The citizen science was particularly effective for participants with high intrinsic motivation and for those with low prior knowledge.
- Walker et al. 2020: a review of 549 publications on citizen science in water sciences to examine the personal benefits and motivations and the wider community benefits. They focus on which of these are evidenced as actual benefit and how these relate to community capitals.
- Thornhill et al. 2019: focusing on the evolution of citizen science in freshwater science and the involvement of volunteers as contributors, collaborators and co-creators of freshwater science.
- Scholvinck et al. 2022: Citizen science is helpful in improving water quality, but to fully realize the success available, citizen science projects should be designed with the understanding of the effects of the project on the citizen scientists. The citizen scientists should be co-creators of projects.
- Pocock et al. 2018: citizen science is a potentially valuable tool for sustainable development but is less utilised in developing countries. Examining the benefits and barriers, it is recommended that investment and commitment are made to overcome barriers and derive the benefits to nature, people, and society.

Increasing knowledge, skills and science capital

Citizen science is an important tool to support learning and knowledge gain, through self-discovery, learning new skills and learning from others (Phillips et al. 2019; Phillips et al. 2018). For instance, participating in river citizen science led to increased knowledge about rivers (von Gonner et al. 2024). This benefit is strengthened when feedback and interaction is built into the project (Peter et al. 2019). A 2002 Factsheet, Why Volunteer Water Quality Monitoring Makes Sense, puts this clearly:

Through monitoring, volunteers learn how the quality of surface and ground water is affected by our actions on the land and how we can protect our water resources. In turn, [they] help to educate the local community on water quality issues... Through volunteer water quality monitoring programs, CE associates are able to identify what local citizens are interested in learning more about, be it water conservation or pesticide management.” (Addy, 2002).

Through citizen science, participants can gain and enhance skills in data collection, communications or teamwork. Through this, they have more trust in their own data (Pelton et al. 2015). This can contribute to increased job prospects (Edwards et al. 2018), which potentially makes environmental and scientific jobs more accessible to a greater diversity of people.

Taking part in citizen science can help to develop participants' understanding of the scientific method, which could lead to greater trust in science and a clearer understanding of the use of scientific data in decision-making (Bonney et al. 2016), e.g. the role of measurement uncertainty or the importance of using validated methods.





Benefitting personal health and wellbeing

Enjoyment is one of the reasons that people often state for being involved in citizen science (Tiago et al. 2017; Lowe et al, 2025), hence it is an inherently beneficial activity.

Nature connectedness is an increasing area of study as ‘there is growing evidence that disconnection from nature leads to poorer mental health and well-being’ (Eichholtzer et al., 2024:526, Martin et al., 2020; Richardson et al., 2021; Pocock et al., 2023). Nature connectedness predicted greater happiness, greater levels of feeling that life is worthwhile, and lower prevalence of illbeing (Richardson et al., 2021). Furthermore, in health and psychological sciences, there is growing research and policy interest in the potential for using the natural environment to enhance human health and wellbeing (Higgins, 2025; Husk et al., 2016).

Intentional engagement with nature positively supports nature connectedness - it is not solely about time in nature (Richardson et al. 2021; Coventry et al. 2019). Crucially, field-based citizen science is demonstrated to enhance nature connectedness (Pocock et al. 2023). Increased nature connectedness also seems to support the development of pro-environmental behaviours (Pocock et al. 2023; Martin et al., 2020).

Field-based citizen science can potentially support increased physical activity, and some projects have been specifically designed to boost physical activity (Naik et al., 2024). Some evidence shows that citizen science supports mental wellbeing (Pocock et al. 2023; Oh et al., 2025; Coventry et al., 2019), but this benefit is enhanced by sustained participation and the inclusion of social connections through citizen science (Oh et al. 2025).

Forming and strengthening meaning and connection

Social connection and the desire to feel a part of a community is often listed as a motivation and, particularly in studies in relation to health and well-being, increased social connection is proposed as a possible benefit of participation in citizen science (Walker et al., 2021, Leahman et al., 2020, Pocock et al., 2023).

Citizen science can strengthen a sense of community amongst volunteers (Kountoupes & Oberhauser, 2008; Walker et al. 2020), although this has not been widely researched. Social experience, such as observing and learning from others, plays an important role in influencing citizen scientists to take on stewardship (Church et al. 2025).

Cooperation amongst participants is important for building community but also builds into a virtuous cycle of increased motivation and hence participation in projects (Pelacho et al. 2025). Many citizen scientists want to share and discuss their results with others, so building social capital through these connections (Pelton et al. 2015).



Importantly, citizen science can help strengthen a sense of connection to place (Haywood et al. 2014), leading to greater expression of care and stewardship from participants (Toomey et al., 2020; Dunkley, 2018). Some citizen scientists develop an attachment for their volunteer sites “as a result of their volunteer efforts and this attachment is manifested in both personal feelings for these natural areas and a readiness to defend them from negative changes” (Ryan et al. 2001; see also Weiner 2025).

‘Nature-based citizen science and volunteerism provide a platform for public involvement that fosters connections to nature and a sense of ownership over local and community ecosystems that can ultimately benefit the health, wellbeing and resilience of people, communities and the environment’ (Weiner, 2024:214).

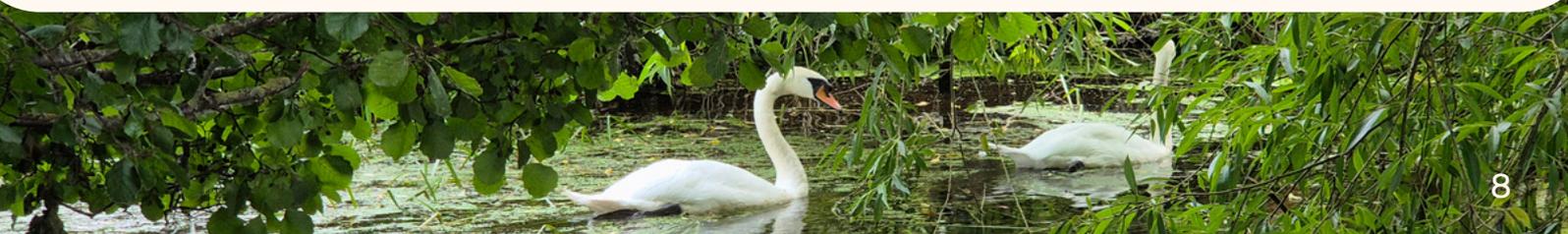
Increasing empowerment, by supporting development of values, motivation and action

Project organisers can use citizen science as a way to raise awareness of environmental issues (Marshall et al. 2012) to support action. Aligned to this is the fact that an important driver for those who participate in citizen science is wanting to help nature and contribute to science (Alender 2016; Tiago et al. 2017).

Citizen science can foster an increased connection with a sense of place, which leads on to impact environmental action (Toomey et al., 2020; von Gönner et al. 2024). Indeed, the importance of citizen science being valuable is an important driver for many participants (West et al., 2021).

One great benefit of citizen science is that once awareness of issues is raised, citizen science can be a form of direct action in which members of the public are aware of and can influence decision-making (Suman et al. 2023; Walker et al. 2021). This can enhance people’s motivation and build their sense of influence and ownership, leading to greater sense of environmental stewardship and their desire and ability to advocate for change (Kelly et al. 2019). Participation can lead to individual impacts with people changing to more pro-environmental behaviours, e.g. for water citizen science, this includes using rain barrels, altering farming practices, or wastewater re-use (Walker et al. 2021).

Citizen science can also support public empowerment: it can enhance ‘the capacity of the local public to participate in...decision making’ as well as support advocacy and behaviour change as participants share their acquired knowledge (Walker et al. 2021). It can lead to better environmental governance, both through the provision of data, e.g. providing evidence of pollution sources (Collins et al. 2023), but also by enabling the inclusion of local knowledge in environmental governance (Alvarado-Arias et al. 2025; Gurnell et al. 2019). Potentially this leads to increased trust between public and authorities to lead to action for freshwaters (Skarlatidou et al. 2024; Walker et al. 2021).



The motivations to be involved in citizen science

Understanding people's motivations (what energises and directs them) to be involved in citizen science, and specifically freshwater citizen science, is key to recruiting and retaining citizen scientists (Lehman et al., 2020; Geoghagen et al. 2016, West & Pateman 2023). The people who step forward to give up their leisure time to engage in citizen science activities do so for a wide range of reasons (Ryan et al., 2001:17). Each volunteer will have differing expertise, interests, commitment-levels, circumstances and skills (West and Pateman, 2016; San Lorente Capdevila et al. 2020). Drawing on psychology and citizen science literature, motivations for participation in citizen science projects have been explored in a variety of ways (Etter et al., 2023; West & Pateman 2016; West & Pateman 2023). Citizen scientists report being motivated to be involved in freshwater citizen science to contribute to research, help protect nature, increase their knowledge and skills in the area, meet likeminded people, be outside or in nature, to have autonomy in sampling timing and location, or to have fun (Peltonen et al., 2015; Walker et al., 2020; Alender 2016). Different motivations will have different impacts on recruitment and retention; for instance, extrinsic motivations such as fear and threat (e.g. fear about pollution) elicit a strong, short-term response, but intrinsic motivations such as helping other people, helping nature, altruism and self-discovery are likely to lead to longer-term retention (West & Pateman, 2016). When participants' interests are "woven into the project design" it should lead to higher quality participation (Alender, 2016) through fulfilment of participants' motivations (Etter et al. 2023).



Evidence suggests that citizen scientists are drawn into volunteering because of their initial interests and values, such as altruism (Agnello et al., 2022). However, motivations are dynamic and evolve over time (Lehman et al., 2020:2; Agnello et al., 2022; Ryan et al., 2001). Citizen scientists are motivated to stay as they gain more individually, and those who perceived individual gains dedicated more time to a programme, visited a greater number of sites, attended more training and contributed to different activities within an organisation' (Agnello et al., 2022). Providing progression in citizen science, such as advancing in methodologies, can support people's retention in projects (von Gönner et al. 2024).

Motivations will also vary between different people. Peltonen et al. (2015) use a framework of leisure time and found three citizen scientist 'personas' come from their survey data.

- the Practical Trooper whose main interest is in the operative measurement and values openness and transparency in decision making and wants to know that the water quality monitoring data will be put to good use.
- the Active Communicator wants to share and compare the data with others. They value community events and training sessions to share and build on knowledge, and the means to communicate with partners and agencies, i.e. through catchment partnership meetings.
- The Communal Nature Lover is interested in taking part in a meaningful activity and nature conservation, spending time in nature, meeting like-minded people, and having a sense of belonging to a community.

The motivations to be involved in citizen science

Citizen science provides a multiplicity of benefits, and participants have a wide range of motivations. Intentional citizen science design can support specific benefits, or align with particular motivations, leading to increased recruitment and sustained retention in projects.

Sustaining long term citizen scientists in a water monitoring project is valuable for people as well as data collection, quality, and peer-to-peer training. The longer a person stays involved in a 'nature protection initiative' the more invested they become and the more likely it is their values and perspective change, instigating pro-environmental behaviour (Martin et al., 2020; Ryan et al., 2001). This can lead to 'social diffusion' and help to create 'a social norm' (Weiner, 2024:61). If the project can build in increasing levels of difficulty, training, responsibility, and engagement to keep a core group of participants, these participants can deliver excellent data as well as helping to train and on-board new members, be instrumental in disseminating information, and be agents of change, having an impact in wider pro-environmental changes and advocacy (Weiner, 2024; Alender, 2016; Pateman and West, 2023; Addy et al., 2016).

Therefore, Weiner et al. (2024) suggest using three questions to understand citizen scientists' motivations and to ensure their experience meets their initial goals: 1. Why did you decide to volunteer? 2. Why make the effort to volunteer? 3. Why continue to volunteer.



It is also recommended to conduct programme evaluations at regular intervals and obtain longitudinal data to ensure the project is continuing to offer benefit to its citizen scientists as they evolve (Agnello et al. 2022).

It is also important to consider: Who has not stepped forward to participate? (Oh et al., 2024). It is challenging to reach those who choose not to participate and discover why (Weiner, 2024:55). Exploring barriers to participation is as important as understanding the motivations. 'Unless CS projects can bring all voices to the fore, not just the wealthy, empowered, educated ones, then the places and people where change is most needed will continue to miss out' (Pateman & West, 2023:10). All citizen science projects should evaluate their inclusivity, identify barriers to engagement, and explore its impact on intended outcomes (Pateman & West 2023; Cooper et al. 2021).

There may be specific motivations for participating in freshwater citizen science. San Lorente Capdevila et al. (2020) pose the idea that citizens may be motivated to monitor water quality because it is 'a basic human need with enormous impacts on health and human being'. We suggest that in the Global North, two other factors have had an impact on citizens coming forward to be involved in freshwater citizen science: The rise of open water swimming (Bates and Moles, 2024; Speare-Cole, 2024) and the concurrent media attention to the quality of rivers (Brookes, 2024; Watershed Investigations, 2025; BBC News, 2025). As a result, it is likely that more people are aware there is a problem and wish to get involved in helping to solve it (anecdotal evidence from CaSTCo volunteer coordinators, Addey et al., 2010, Alender, 2016), but CaSTCo experience demonstrates the value of engaging public in citizen science through catchment monitoring partnerships to build communities of trust and support their motivations for participation.

There is much discussion and good evidence that well-designed and well-run citizen science projects deliver many multiple benefits for science, participants and for stewardship of nature. Due to limited resources, these are not always all kept in focus in project design (Alender, 2016). Understanding the multiple potential benefits of participating in citizen science is key to maximizing co-benefits in program design, so that activities and projects can be designed to boost these benefits and be inclusive to a wider range of people (Parrish et al., 2019; Cooper et al. 2021).

When it comes to mental wellbeing, citizen science can build into the policy response to improve mental health and promote wellbeing and tackle isolation and loneliness: Coventry et al. (2019) concluded that [well-designed] citizen science activities not only have 'a role in raising awareness and changing behaviour, but... also has the potential to confer individual and wellbeing benefits'.

"It is a rewarding activity in which you can monitor a patch of water that becomes 'yours'. You can observe nature across the seasons and take pleasure in the wildlife and environment you spend time in. You can learn new scientific skills and make like-minded friends along the way."

Quote from a CaSTCo-trained volunteer



3. Survey

3.1 Methodology

We used a survey, distributed to CaSTCo trained citizen scientists, to understand the benefits for their participation in citizen science.

We invited all citizen scientists in the CaSTCo project to participate, via emails sent out from the regional volunteer coordinators, from June 15th 2025, through the summer. We note that there may be participation bias, because those willing to respond may have been those most interested in the project.

The content of the questionnaire was devised through several workshops with technical experts within and external to the CaSTCo project. It was determined that exploring forms of connectedness was most likely to elicit the evidence required as well as providing use of validated scales to ensure robustness. The questionnaire was written to elicit both quantitative data (from questions with numerical scales) and qualitative data. A mixed methods approach, like this, was used as it is 'an intuitive way of doing research that is constantly being displayed through our everyday lives' (Creswell et al., 2011). The qualitative questions allowed participants to express their views and gave us a richer understanding of the responses.

We asked questions about demographic characteristics to understand the participant's characteristics. Though these are not necessary for this study, they are of interest to the CaSTCo framework as they are relevant to the wider subject and can add to recommendations for project design as well as provide information for future work on this area. The questions were shaped according to the advice in Pocock et al. (2025).

Survey responses were anonymous and there was an option to opt-out at any time. The study received favourable ethical opinion through CCRI (University of Gloucestershire) and each participant gave informed consent to take part in the survey.



3.2 Results

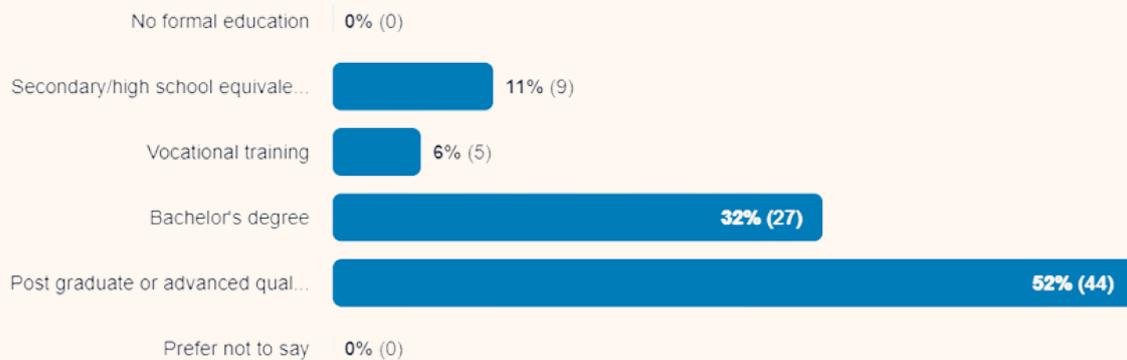
Demographics

The survey was circulated to approximately 350 CaSTCo trained volunteers, and we received 86 responses (25% response rate). We found, in common with other studies of citizen science (Pateman et al., 2021), that volunteers tended to be white, older and have higher levels of formal education. Strikingly, we found that 92% of respondents were older than 55 years old, 80% of the respondents were retired, and 84% had degree-level qualifications (with 50% of the total having postgraduate or advanced qualifications). This highlights a gap that project designers can seek to understand for, as the population loses early retirement, this could impact citizen science numbers.

70% of the respondents were not volunteering on any other citizen science projects. The remaining 30% were split equally between other volunteering, on other citizen science projects or other freshwater projects.

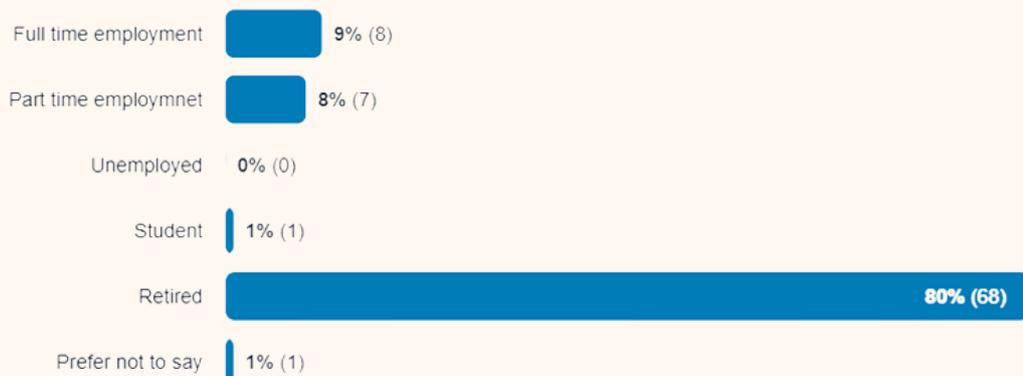
8. What is your highest level of education?

Responses: 85



9. What is your current employment status?

Responses: 85



93% of respondents were White British, and 99% described themselves as 'white'. One reason for this may be because many of the water quality focused CaSTCo demonstration areas are in rural areas, which have low ethnic diversity, and we had low response rates from the more urban demonstration areas.

15. How do you describe your gender?

Responses: 86



The gender breakdown of the survey response was fairly balanced.

Motivations

When asked what motivated them to become a CaSTCo citizen scientist, respondents, via an open response, said that they were motivated by concern for the environment, particularly river pollution and water quality, with many highlighting a wish to monitor conditions and contribute to scientific data. For some, this interest connected directly with existing hobbies such as fishing or wider passions for the outdoors, nature, and wildlife. Others emphasised more personal reasons, including finding meaningful activity in retirement, keeping occupied, or doing something beneficial for their community. A smaller but important factor was recruitment itself, with people drawn in through adverts, editorials, volunteering fairs, or the enthusiasm of project representatives. Overall, environmental concern and interest in water quality were the dominant drivers, but these were often reinforced by personal circumstances, hobbies, and effective routes of engagement.

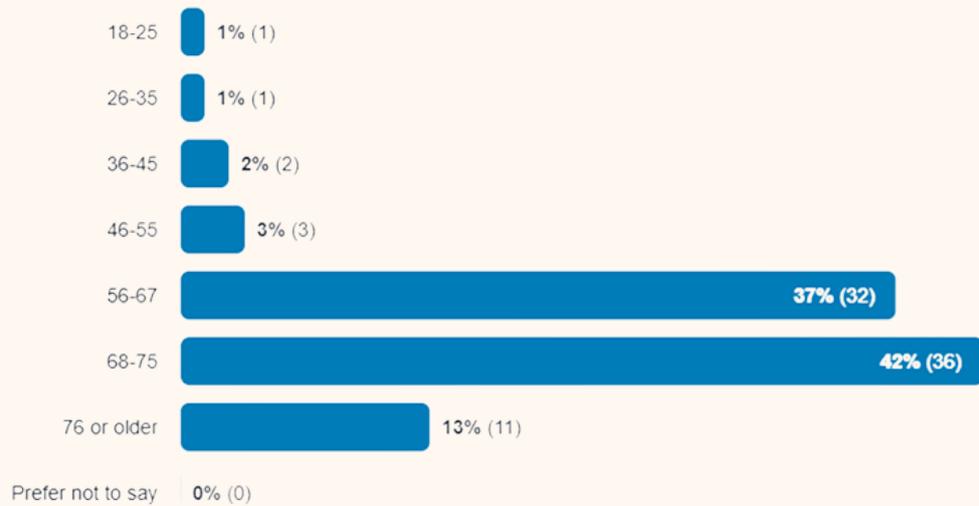
“It's a great way to connect with like-minded people who care about nature, conservation, and their communities.”

CaSTCo-trained volunteer



11. What is your age?

Responses: 86



12. Do you consider yourself to have a disability?

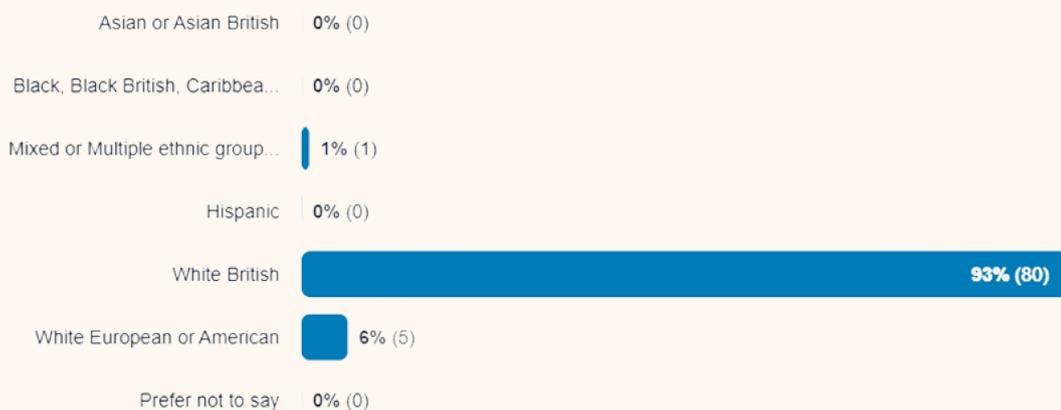
Responses: 86



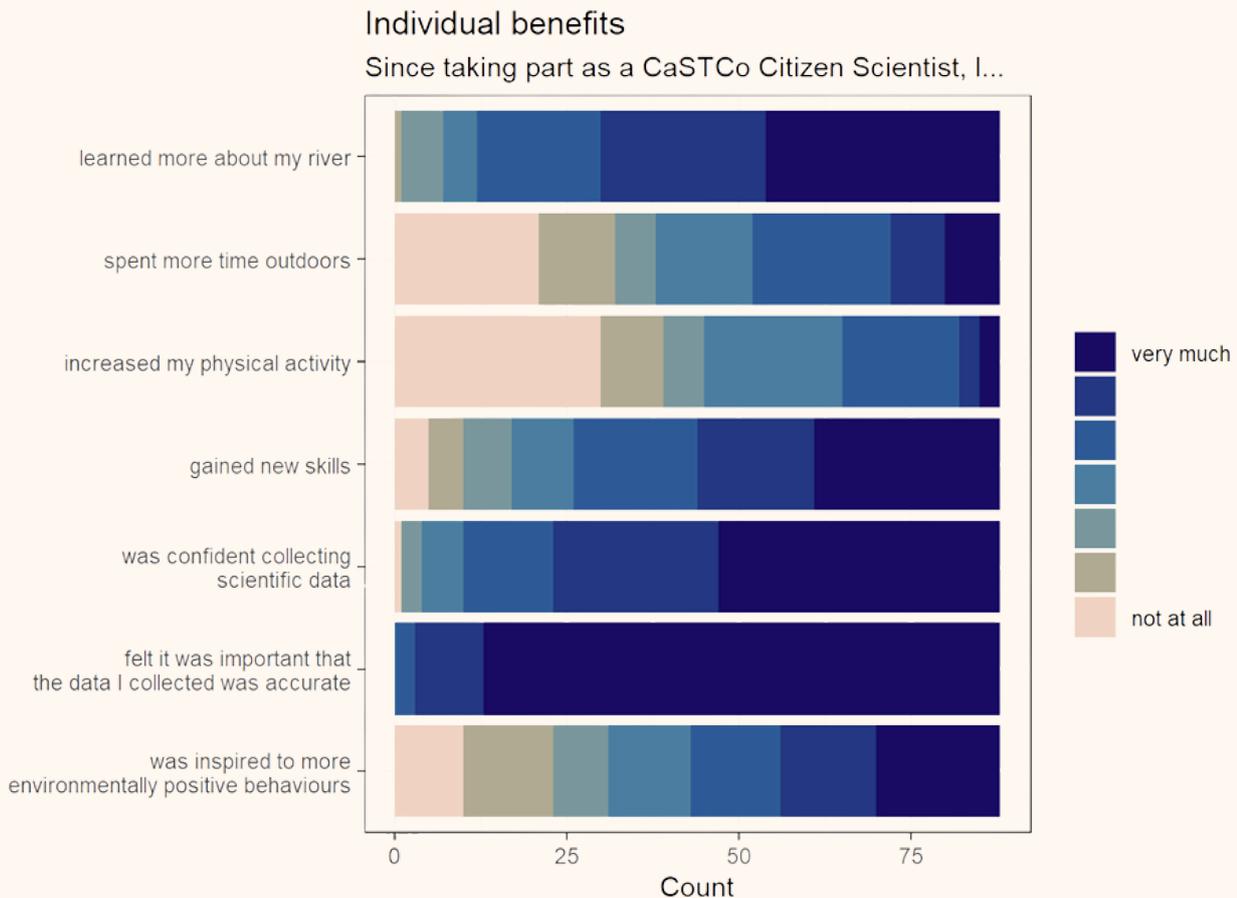
96% of survey respondents would not consider themselves to have a disability. This could suggest that the current program for citizen science volunteers is either not appealing to those with a disability or is not set up to support them. This is confounded by the responses to question 13, 'If yes, does this condition impact on your participation in the CS activity', with one response answering that it does impact their participation in the CS activity.

14. What best describes your ethnicity and/or cultural heritage?

Responses: 86



Individual benefits



Overall, we found that respondents benefited strongly in at least some of the areas that we asked about, especially learning more about their river, being confident in collecting scientifically valuable data and learning new skills. Everyone felt that it was important that the data they collected was accurate. This probably links to their motivation to be trained in CaSTCo methodologies and to the training they received about the importance of rigorous data to support action. There was a broader range of responses to other individual benefits, such as spending more time outdoors or increasing physical activity, but it may have been that many respondents fitted CaSTCo volunteering into time that they already spent outdoors or during their physical activity.

Responses to the question “I have learned more about my river environment” indicate a strong positive education impact. Out of 86 respondents, 86% rated their learning between 5 and 7 on the scale, with 38% selecting the maximum ‘a great amount’. Only a very small minority reported limited learning, and no respondents selected ‘not at all’. However, with a large proportion of the survey respondents being educated at a higher level, and working within the research or environmental sectors, it is likely that this is a reflection of those respondents. Nevertheless, these results demonstrate that CaSTCo has been highly effective at increasing participants' understanding of their river environment.

Responses to the questions around more time outdoors and increased physical activity show less impact compared to learning outcomes. For time outdoors, out of the 86 respondents, just under half (46%) gave mid to high ratings of 5-7, suggesting that participation encouraged some individuals to increase their outdoor activity. However, almost a quarter (24%) reported 'no change'. 54% of male respondents said they spent more time outdoors, compared with only 26% of female respondents.

Responses to physical activity are largely the same as time spent outdoors, with a higher 35% of respondents reporting 'no change' to their levels of physical activity. 41% selected mid-range scores of 4-5, indicating some moderate benefit, but only a very small proportion (6%) reported the highest levels of increased activity (scores 6-7). For men, there was a 30% increase, with only a 16% increase for women. However, for those full time employed there was a 55% increase in comparison to a 26% increase for those retired. This indicates that CaSTCo citizen science activities have the potential to affect working people's (especially men's) physical activity levels positively.

Responses to the question "I have gained new skills", shows that a large proportion of the group (70%) gave mid to high ratings, suggesting that they have gained a good amount of new skills thanks to their involvement in the project. Of those with a secondary education level, 88% report gaining new skills as did 68% of those with a higher education level. Those in full time work reported the highest gain (78%) and More men than women reported skill gain (78% men to 64% women).

88% of responses show that the volunteers have felt confident that the data they are collecting is scientifically robust. 10% of the responses fall in the middle ranges of 3-4 suggesting that these respondents had some insecurities surrounding their data collection. Those in full time employment were more likely to indicate confidence in their data collection and of the 2 participants that identified having a disability, one recorded no confidence at all and one a 5. There was little differentiation by gender, but more women (50%) gave a 7. These scores do indicate that the training and guidance provided is generally good, however, there is a need for more mixed-ability teaching methods and evaluations.

Following on from the previous response, it is clearly important to all respondents that the data they collect is scientifically robust. 85% of respondents answered a 7, 'very much', with no respondents recording anything under a 5. This is a key part of what makes citizen science data so effective.

The responses to being inspired to engage in more environmentally positive behaviours are broadly spread. Of those with secondary education, 44% have been inspired. Of those with a higher education level, 51% have been inspired. 44% of full time employed participants were inspired, with all scoring a 7. 57% of the retirees were inspired and 28% of those in part time employment. Neither of those with a disability reported inspiration and though more men reported inspiration (61%), of the 40% females, 19% or them gave a score of 7.

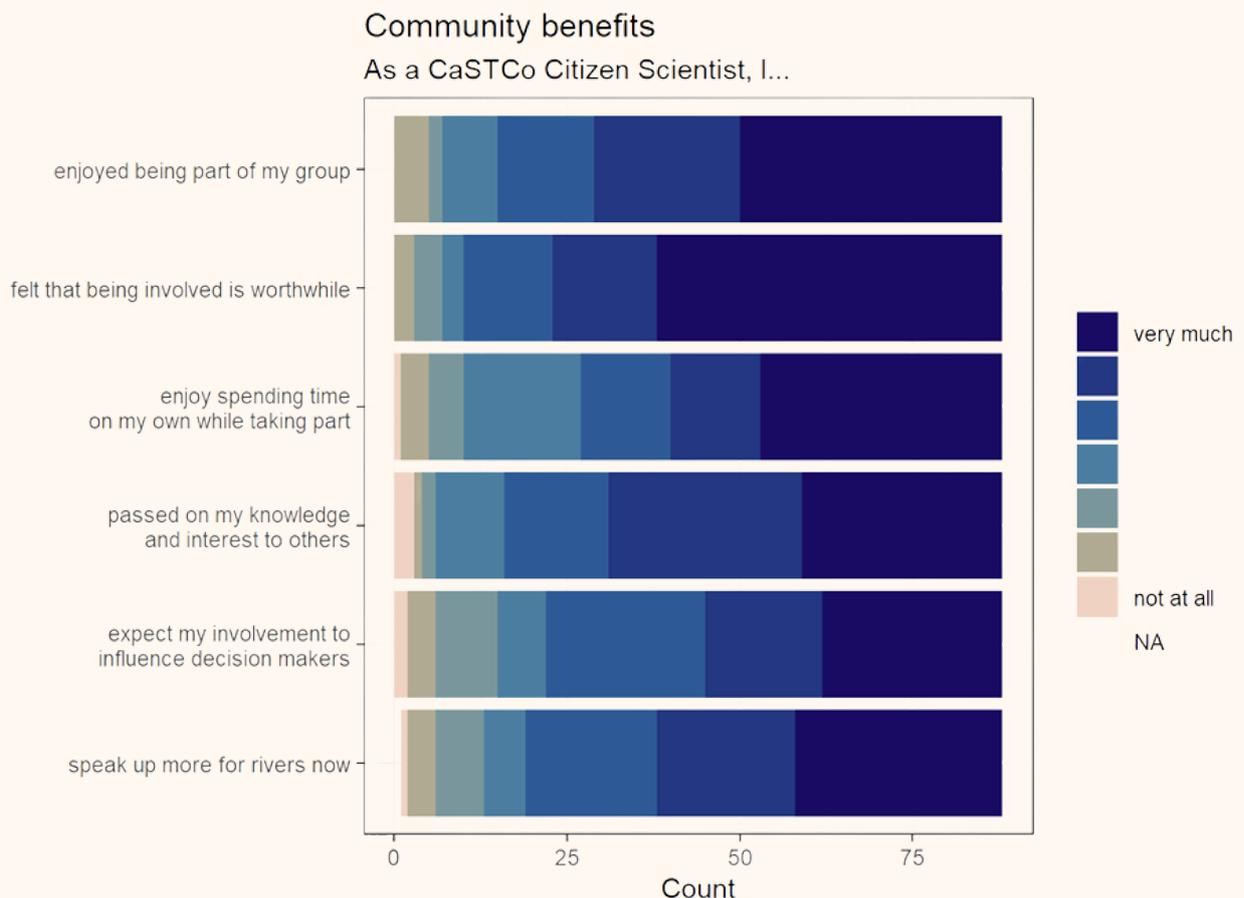


There was also a mix of responses to being inspired to do more environmentally positive behaviours through participating in CaSTCo monitoring. An open question allowed us to explore this further. Overall, that CaSTCo citizen science led to a reinforcement of existing environmental values, but several respondents adopted specific new practices, particularly in water use, waste disposal, and community action. The emphasis was therefore less on radical behavioural change and more on strengthening awareness and extending environmentally conscious practices into new areas.

Several reported concrete lifestyle changes such as *'using my car less, using public transport, minimising consumption of water and fossil fuel energy, not buying goods wrapped in plastic and eating organic produce.'* Others shared everyday household adjustments, for example *'being more mindful about what I flush down the toilet'* and *'using less water in the home.'* A smaller number described community-level initiatives, including organising Himalayan balsam pulling, litter picking, and testing waterways for pollutants, which extend individual action into collective environmental stewardship.

For many, involvement in citizen science did not create new habits but deepened pre-existing commitments. One participant explained, *'I already tried to tread lightly on the earth by diet, consumption etc. This enhances that ethos'*. A few described heightened awareness, such as *'maybe more aware of the content of some household products'* or *'taking more notice of the state of the natural environment'*. Some also linked their engagement directly to biodiversity enhancement at home, such as creating a wildlife pond.

Community benefits



On the whole, the respondents gave a strong positive response to the community benefits of citizen science. Respondents gave an equally positive response to enjoying being part of a group, enjoying spending time alone while taking part, and passing knowledge and interest on to others; this appears to demonstrate a good balance of benefits from citizen science participation. There was a particularly strongly positive response that respondents felt that their involvement in CaSTCo citizen science was worthwhile. In terms of the two sides of impact, respondents had a positive response to both speaking up more for rivers, and expecting their involvement to influence decision makers.

In enjoying time on one's own while taking part in monitoring, 38% enjoyed it very much, 20% chose the middle rating of 4, and 1% chose not at all. More men (94%) responded favourably than women (61%).

For passing on resulting knowledge and interest to family, friends and colleagues, 82% chose 5 or above, with 3% indicating not at all.

I expect my involvement in CaSTCo citizen science to influence decision makers scores are similar: 75% chose 5-7, 2% chose 1. And in speaking up for my rivers more, 79% choose 5-7 and 1% chose 1.

“It's a fulfilling way to make a positive impact on your local environment. You get to contribute valuable data that supports the health of our rivers and supports real scientific research.”

These results indicate that involvement in the CaSTCo project does provide community benefits to most participants. When asked the qualitative question if they expected their involvement to influence decision makers, participants expressed a mixture of optimism and scepticism about whether their efforts as citizen scientists would meaningfully influence decision making. Several believed their contributions would be valuable once aggregated, with one noting that *'data collected should feed into Wales monitoring of rivers... Water Blitz every few months should ensure a degree of accuracy that should be acknowledged and respected and used to better effect the health of Usk.'* Another explained, *'my expectation is that the data that I've collated will end up in a bigger data set to allow observations to be made, conclusions drawn and create consideration for policy decision making.'* Similarly, some participants felt that consistent submissions could reveal meaningful patterns across conditions, such as *'flood, low flow, winter summer... vegetation... animals birds insects etc. How farming on the river side effects the water quality.'* Others highlighted the potential for chemical and physical monitoring to *'contribute to more detailed analysis and detection of unwanted pollution sources.'*

Alongside this hope, doubts were also voiced. One participant stated, *'I hope it will however I am not confident,'* while another was *'not convinced decision makers have the resources or prioritise environment.'* Concerns about data quality also emerged, with one respondent describing the evidence from their demo as *'approximate representations only and... not rigorous and not temporally coordinated therefore are only a snapshot of one sample site at one moment.'*



They added that 'graphs I have seen are misleading and meaningless' and recommended that 'box plots or smoothing graphs (Exploratory Data Analysis, by Tukey) are better ways of presenting the data.' Participants recognised the potential for citizen science data to inform policy and monitoring frameworks, but this was tempered by uncertainty over the robustness of the evidence and whether decision makers would act upon it.

When asked 'if they were to recommend citizen science activities to a friend, what would you say', the participants frequently mentioned the activity as a way to improve the environment (17 times) while accruing skills, knowledge, and being part of a community. The word 'worthwhile' was used 23 times, 'data' 18 times and 'fun' 9 times. The responses were encouraging, stressing that training and support is available and it is a worthwhile way to improve the environment. *'It's a worthwhile activity. You don't need to have scientific skills as you will be adequately trained and supported by the team. it's not going to take a lot of your time'.*

There are several mentions of the benefits to the citizen scientists as well as the environment: *'Great for mental health being out in nature, helping improve data sets...'* and, *'It is an opportunity to take part in activity that enhances health and wellbeing. It contributes to science data that provides a more accurate understanding of the state of the environment and nature,'* and, *'that you are a vital cog in the bigger wheel of improving and safeguarding the environment. It is a great way to engage with the natural world around you and the benefits of spending time outdoors has to be a positive for health and wellbeing'.*

While most responses discuss the satisfaction derived through delivering valuable data, the benefit of being outside and part of a community, and the opportunities to share the data with decision makers, there are two responses indicating feeling of needing to do it because the information would not be gathered otherwise: *'If we as Citizen Scientist do not volunteer to do such work then a lot of the work we do will gone undone, it is up to CS to put forward validated evidence to the decision makers and get environmental policies change for the benefit of the environment we all inhabit'.* Another issued a warning: *'While it can often build a good sense of wellbeing, there is some risk of it contributing to climate anxiety / grief and a level of helplessness when the data seems to be having little impact'.* It is vital that the project designers and the coordinator acknowledge these perspectives and plan to address them in the communication and support the project offers.



When asked what is the most exciting or meaningful experience encountered since taking part in CaSTCo citizen science, 75 participants responded, with the majority of the responses citing an experience of being in or witnessing nature: *'seeing an otter and a kingfisher at the same time'*, *'noting the same stretch of river is different each time'*, or *'I was reassured to see a wide variety of freshwater invertebrates'*. 12 responders mentioned interactions with other people and being to explain the work: *'Interacting with local people living close to my collection point who ask what I am doing'*, *'being able to spread the word'*, and, *'very recently talking to two workmen about the work we (the project) do. They were fully engaged, asking very pertinent questions and I felt they went away more informed'*. Several mention the feeling of collaboration and sense of community: *'Being part of a well-trained team identifying pollution events within our river system'*, *'Meeting other like minded people'*, and *'It wasn't in nature but in the 'group feeling' of being a CS. Part of a groundswell of support with everyone pulling in the same direction with a common goal of improving our watercourses'*.

A few participants mention contributing to a wider perspective of the river, 8 mention collecting meaningful data and 7 say the kit, methods, and live data are the most exciting for them, such as, *'From training as a science undergraduate in the 1970s discovering the change in technology with miniaturised testing equipment and the ability to send real time data for instant analysis'*. While several others find the use of the information and data most meaningful: *'Finding twenty vehicle tyres thrown in the river and being able to clear this up. Finding high levels of Ammonia and Phosphates in the water and being able to find the source of the pollution'*, *'My data helped to identify a pollution source near the rivers head'*, *'calling the Environment Agency with bad news and getting an agent who sounds interested and cares'*, or *'My data has influenced decision making and funding for conservation work by our Parish Council'*. One participant declares, *'I've never worked harder!'*, and 8 participants mention the learning and skills derived as their most meaningful experience. Generally, participants note that they felt what they were doing was meaningful: *'Just overall meaningful'*

Asked how they have benefited by being involved, several participants mention the learning about their rivers, *'Learned some new techniques and know my local river much better and the challenges that affect it'*. The majority list connection with others: *'I feel like I am part of a team and that I am doing a positive thing for nature'*, *'Knowledge, connection, impact'*, *'Met some new and interesting people'*, *'Made new friends, gets my husband out too'*, *'Widened my experiences in nature and science making new friendships'*.

You learn new skills and gain knowledge about water quality, ecology, and environmental issues—all while being outdoors and active.

There are mentions of finding purpose since retiring: *'It has given me some purpose as a retired person'*, and, poignantly, *'Since retiring, I've found it challenging to rediscover a sense of purpose. This has been made even more difficult by my wife's diagnosis of early-onset Alzheimer's. Working life provided daily structure, routines, and a clear sense of direction—things I've missed. Becoming involved with the CaSTCo programme has been a positive turning point. It has helped restore a sense of purpose and contributed significantly to my overall wellbeing'*.

On the other end of the age scale, a participant found purpose another way: *'I was able to use it as experience to get a place on my dream uni course'*. Many cite the benefits of being outdoors, in nature; *'Spending more time outdoors, especially in natural environments, has also had a profound and uplifting impact.'*



When asked what disadvantages have been experienced by being involved in CaSTCo citizen science activities, Of the 75 responses, 57 said 'no': *'no as a volunteer I'd not bother if there were disadvantages'*. 11 listed time as an issue: *'A bit less time for other things. It's a commitment'*. 6 mentioned getting very cold in the winter. One participant expressed concern about lack of improvement: *'The lack of improvement and increasing pressure on our river ecosystems is frustrating. I would like to feel that the monitoring is having more impact on the water companies and government policy'*. One requests more training, stating using videos is difficult and suggesting using group testing initially. 2 participants state the disadvantage of dealing with the public: namely, *'a small minority individuals who oppose the conservation of the site I survey and any work related to it'* and *'one persnickety land owner'*. 2 respondents mention climate anxiety: *'Not really, getting a bad result can be difficult however at least a bad result has been registered'. Better that than it going unnoticed'* and, *'Some surges of climate anxiety and grief as understanding of damage deepens'*.



56 participants responded to the question asking 'Is there anything we have not asked you that you would like to share with us?' and 24 left a response other than 'No'. One participant suggests 'A reinforcement visit to check on understanding and practice would be appreciated', and another asks for more sharing of knowledge of data analysis and tools. While there are two requests for more feedback: 'If some of my figures are questionable I would like to know about it' There are calls for more communication and information on impact: 'I would like to be in contact with more with other CS. doing the same survey. I would like more reports from other areas on the river in order to compare and question. Possibly have gatherings of other CS.to discuss problems or better or more meaningful ways to do the survey', and 'The missing link for citizen scientists is seeing the link between what we do and how river health and water quality are being improved. I understand the need for our stats but don't see what is being done to improve the river..', and, 'I guess what I am trying to say is we do our bit on a weekly basis and it would be good to see how our contribution makes a difference'. These responses indicate a deep interest and investment in the process of the project and in the project design. There are other responses indicating concerns of how the CaSTCo project sits in the political landscape: 'I am frustrated by how much business interests can restrict environmental improvements' and, 'most of the testers I know are intelligent, motivated, busy people. Agency staff can underestimate our capabilities and the time we have available. Not everyone is retired. We can get frustrated testing regularly for a year or two and not seeing many results coming through, let alone action being taken to address the issues identified. There is a patronising thread through much of the Cit Sci work about how much we may be benefitting ourselves - when we are just desperate for someone to do something about the state of the local rivers. Many of us swim in the river and are motivated by wanting to be sure it is safe for us and others - as well as all the environmental concerns.' And, finally, a few comments were simply sharing joy:

'I took up two things in retirement; learning Welsh and trying to protect rivers. A completely unexpected and totally delightful crossover has been finding and becoming involved with people who write poetry in Welsh about Welsh rivers.'

Overall, the survey responses show that the CaSTCo citizen science monitoring has had some impact on time outdoors and physical activity, but has had the biggest impact in personal benefits. Furthermore, those deriving personal benefits are more likely to do more pro-environmental things and speak up for their rivers more.

"...You are a vital cog in the bigger wheel of improving and safeguarding the environment. It is a great way to engage with the natural world around you and the benefits of spending time outdoors has to be a positive for health and wellbeing."



4. Case study

4.1 Photovoice methodology

The PhotoVoice project spanned 12 weeks in Spring 2025 through which there was an introductory lecture, a workshop explaining the method to the citizen scientists, time for the citizen scientists to take their photos, a trip for the students to experience the water testing at the citizen science locations, a final workshop to choose the photos, write captions, and share and discuss within the group, and the final write up/booklet.

4.2 Photovoice project

The CaSTCo Anglian Demonstrator Area collaborates regularly with the University of East Anglia. The Anglian Citizen Science Officer was contacted by the Global Development professor for the Just Transformations to Sustainability course and asked if the citizen scientists would be interested in doing participatory work, giving the final year students needed experience with methods they were studying and the citizen scientists an alternative way to express their views and experiences. Eight citizen scientists volunteered to take part and the Photovoice method was chosen as the most meaningful method to use with them.

Photovoice is a community based participatory research method developed in the 1990s by Caroline Wang and Mary Ann Burris. Wang (1997) explains that 'Photovoice has three main goals: (1) to enable people to record and reflect their community's strengths and concerns, (2) to promote critical dialogue and knowledge about important community issues through large and small group discussion of photographs, and (3) to reach policymakers'.

Photovoice is not intended to replace the rigor of ethnographic methods, however, using empowerment education, feminist theory, and documentary photography, it can be a powerful tool to organise advocacy' (Lienberg, 2018). In this context, it was chosen because of its relational approach where the citizen scientists become participants in, rather than objects of, the study as well as its use of image to 'powerfully illuminate' their experiences.



This enables the citizen scientist to realize and express their view, share and discuss this within their group, and present the group views to Citizen Science project designers. This is an example of citizen science programs using both good data and felt experience as a Pathway to Change (Pateman and West, 2023).

Participatory action methods, like Photovoice, are primarily concerned with ‘democratization of knowledge development as a component of social justice’ (Liebenberg 2018:1). Citizen science activities are one of the research methods used in this way. The CaSTCo project has at its core a drive to democratize science and data: *‘Together, we’re demonstrating how citizen science and community monitoring methods can be used alongside professional monitoring to generate and share accessible data of known quality so that the information produced leads to better and more impactful decisions’* (www.castco.org).

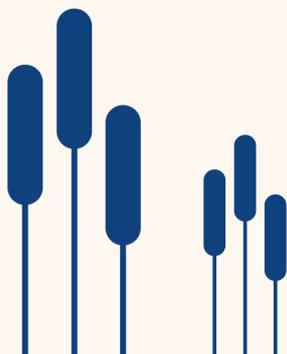
4.3 Reflections

The Photovoice outputs were delivered in a presentation with displayed project posters and an accompanying book (Twigg et al., 2025). The presentations detailed the process and the steps taken, including the experience, felt response and understanding gained of each of the students guiding the project. This approach, in keeping with the nature of the project, powerfully demonstrated the value of expressing, demonstrating and discussing experience and learning.

The students involved described the CaSTCo water quality monitoring project and its aims with a well-rounded understanding. The site visits gave them an appreciation of the issues in the river as well as an admiration for the citizen scientists taking their own time to demonstrate those issues. In applying the photovoice methodology, the students learned that there are usually ‘gaps between theory and practice’ and they demonstrated the ‘importance of qualitative approaches’ in discovering and dealing with those gaps. The students were able to describe the limitations and barriers in communication that ‘didn’t work so well’ and address them with solutions: ‘encourage peer support’ and ‘develop a handbook for CS reference through each step of the process’. Ultimately, the students reported that the use of the Photovoice methodology in the CaSTCo project:

- Publicises the insider perspective of tackling environmental threats;
- Encourages discussion, strengthens partnership and community;
- Helps foster reflection on personal connections to the issue;
- All of which is ‘vital for advocacy and policy change. (Student’s posters)

The supervising professor from the University of East Anglia stated that, ‘This was wonderful for the students to realize they too could have impact’.



The citizen scientists involved were 'passionate and eager to engage'. They engaged in the workshop activities with enthusiasm and reported feeling excited to see what they are doing from a different perspective. All were keen to tell their story. Some were a little uncertain of the tasks to complete in their own time and two admitted it was a 'challenge to think differently' at times. During the workshops, the activities moved from each participant telling their individual stories, to each sharing their photos with their groups for discussion, to collaboratively deciding which photos and captions to include. A sense of collaboration and community was noticeable in the tone and content of discussion, the informal chatting around the snacks, and the sharing of snacks together.

At the end of the last workshop, one citizen scientist stood to say:

'I want to thank you for bringing this to us. We have become very, very good at looking at datasets. This has asked us to look at what we do through a creative lens and that has reminded each of us of WHY we do this. I feel more motivated to continue- Thank you!'

As the citizen science coordinator facilitating and observing the photovoice project, the learnings taken have had a significant impact on the planning of our citizen science programme. The importance of using creativity, expression and discussion to foster a stronger sense of community have inspired the adoption of:

- A new communication system where collaborative discussion can be held as well as including photo sharing, games to write captions for each other's photos, and a space to exhibit other creative outputs;
- A system of peer support to help develop the sense of partnership and community, and to create more opportunity for discussion;
- Regular walks and meet-ups as a time and space to develop this discussion and more co-creation of our monitoring project as we go forward; and
- The online data entry survey has been updated to include a nature-noticing cue to 'look up' from the dataset and see the surrounding environment.



5. Discussion

The literature and studies to date illustrate that citizen science activities have the potential to contribute meaningfully to scientific enquiry, improve participants health and well-being, improve the environment, and influence policy. For the citizen scientists, this is a gain in capital: human, social, natural, political, and cultural (Walker et al. 2020). The literature, case study, and survey evidence that, while motivations for engaging in citizen science monitoring are diverse, they are centred around wanting to help to improve and protect the environment. Furthermore, as participants' motivations are realized, they may develop an awareness of an array of personal benefits, keeping them motivated to stay involved (Agnello et al). In the Photovoice case study we see that looking at their work again, from a different perspective, has the effect of reminding the citizen scientists of their motivations and this reinvigorates them in their efforts.

There is a long history of using citizen scientists to monitor the health of freshwater. The combination of increasingly convenient and reliable equipment and the surge in media attention on water quality has enabled a proliferation of freshwater citizen science projects. These range in focus from engaging citizens in interest to deriving robust, reliable data sets for use by agencies and organizations in decisions affecting our rivers.

Citizen science program designers have an obligation to ensure the project is not extractive, but there is also an opportunity to ensure maximum benefits for the project through ensuring maximum benefit to the participants.

Through boosting social connections, citizen scientists are empowered, and projects are strengthened (Pateman and West, Walker et al., Lehman et al.). As one CaSTCo citizen scientist states, *'being a CS is being a part of something greater than yourself. Working in collaboration with your fellow CS can drive real world change in how our watercourses are managed'*.



It is also evidenced that nature connectedness is enhanced through citizen science monitoring (Eichholtzer et al., 2024; Coventry et al., 2019; Pocock et al., 2023). As expressed in our survey by one CaSTCo citizen scientist, the most meaningful experience encountered since taking part in CaSTCo citizen science is *'feeling that I'm part of nature, immersed in the natural surroundings and the sounds of the river'*.

It is significant that 90% of those surveyed found taking part in CaSTCo citizen science monitoring meaningful. Using methods, such as Photovoice, gives the citizen scientists alternative ways to express their voice while also drawing together as a stronger community. This is empowering. This also provides a way for the citizen scientists to realize their growing connections and benefits.

It is well evidenced that feeling a social connectedness and increasing nature connectedness has a positive effect on health and well-being (Coventry et al; Pocock et al.) and well designed and run citizen projects can offer this. (Eichholtzer et al., Weiner). As evidenced by the citizen scientists on the CaSTCo project, *'Overall, my involvement in CaSTCo has been rewarding on multiple levels, strengthening my environmental knowledge, supporting my local community, improving my wellbeing, and contributing to meaningful scientific and ecological progress.'*

While we cannot conclusively say that the respondents to the survey were fully representative of the CaSTCo citizen scientists, our survey suggests that the 'CaSTCo trained citizen scientists' in the demo projects formed a distinctive demographic of white, mostly retired, highly educated people. This result may have been influenced by the regions selected for the demos, and existing approaches to participant recruitment in the rivers trusts. This demographic may positively influence data quality, and the benefits gained from participating will be specific to the cohort of people who responded to the survey, but it requires further investigation to explore how CaSTCo volunteering can be made more accessible, and volunteer recruitment can be more diverse.

How do we avoid the perception that water quality monitoring is for the privileged few (white, retired and highly educated), and instead use citizen science as a way to engage more people with nature, river stewardship and actionable science?

As a community, we could consider reassessing our recruitment and engagement strategies and build intentional collaboration with groups that represent a wider range of public stakeholders in the river environment, especially in more urban parts of catchments.

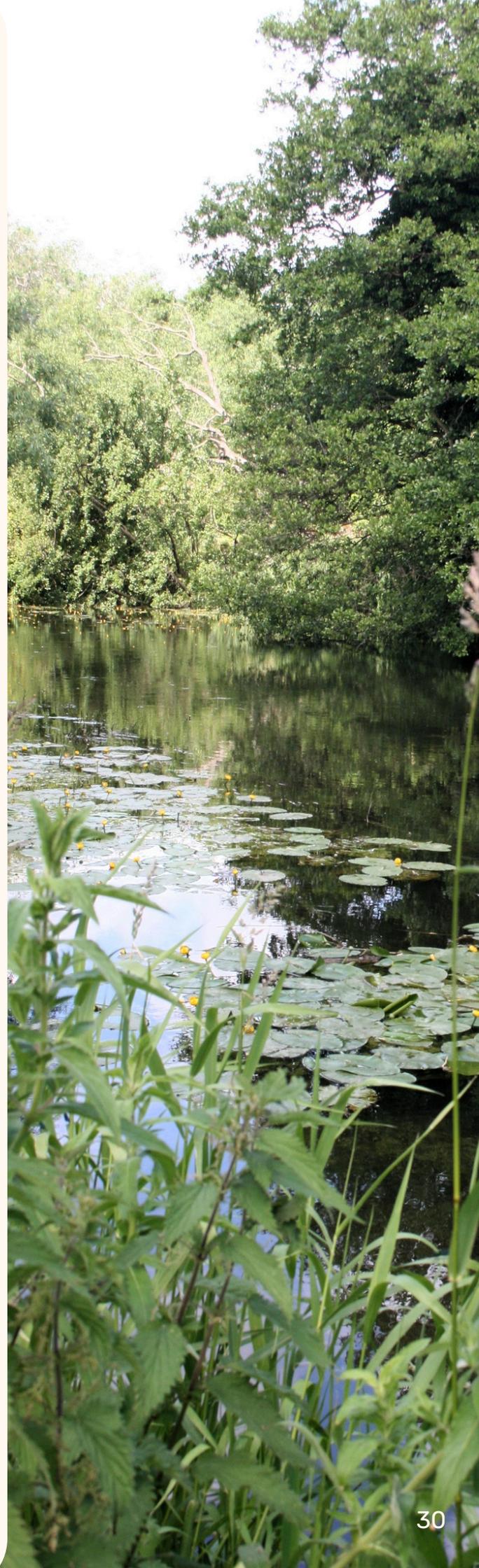
Like many volunteering posts being a CS is being a part of something greater than yourself. Working in collaboration with your fellow CS can drive real world change in how our watercourses are managed.



6. Recommendations

We recommend that:

- Evaluation of participant benefits is built into the design of freshwater citizen science programmes to grow best practice. Mixed methods approaches should be used to gain the benefits of both quantitative and qualitative methods.
- In communications, there is increased emphasis on the benefits to participants because this should help to enhance recruitment and retention.
- Project organisers intentionally design citizen science to strengthen opportunities for participant benefits such as nature connectedness, social connections and connection to place. These should be enhanced with project features like feedback. Specific opportunities include:
 - Offer a range of training and tasks to appeal to the range of citizen scientists and their needs and motivations.
 - Use communication to ensure participants understand the project as a whole and are included, supported, appreciated and feel they are contributing (Eichholtzer et al., 2024)
 - Include the well-being and health benefits in recruitment to encourage a wider participation base (Oh et al., 2024).
 - Consider the barriers to participation and align activities to community priority to further increase participation from those less frequently represented (Patemen and West, 2023).
 - Include a 'nature-noticing exercise' in the monitoring activity to boost nature connectedness (Pocock et al., 2023).
- Projects are designed to be more inclusive and overcome the current bias towards older, white, highly educated people. We should investigate motivations and barriers to other people, including those of working age, from being involved in freshwater citizen science, both taking part as a family or taking part as individuals.
 - Programme design should be iterative and learn from the citizen scientists as well as the data. Take regular feedback to learn and adjust from it. Pay attention to the negative and de-motivating factors and look for who 's voices from the community are not being heard.



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Appendix 1

Search terms

Google Scholar search 1: citizen science, well being, nature connection, community building, ecological knowledge, freshwater monitoring, skill acquisition, social identity

Google Scholar search 2: well being benefits of engaging in freshwater citizen science

Key papers identified through search:

Alender, B. (2016) 'Understanding volunteer motivations to participate in citizen science projects: A Deeper look at water quality monitoring', *Journal of Science Communication*, 15(3). Available at: <https://doi.org/10.22323/2.15030204>.

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Appendix 2

Survey



CaSTCo Well-Being Benefits Evaluation

CaSTCo Social Evaluation of Citizen Science Activity Survey

We invite you to take part in this short survey about your experiences of being a CaSTCo citizen scientist. The results will help us understand the benefits and disadvantages of participating in citizen science, so that we can create better citizen science projects in the future. The survey should take approximately 20 minutes to complete. The results will be made available to all participants.

Participant Information and Consent

You are invited to take part in a survey investigating the wellbeing benefits of being involved as a CaSTCo trained Citizen Scientist. Please read this information sheet to understand what the research is about before filling in the consent form.

What is the research about?

As part of the CaSTCo project, we would like to ask you about your experience of being a CaSTCo trained citizen scientist. We invite you to take part in a survey about your experiences and thoughts on the citizen science work you have done.

Why have I been invited?

We invite you because you are, or have been, trained as a CaSTCo citizen scientist. Your insights will be valuable in helping us understand the social health and wellbeing impacts of engaging in citizen science.

Do I have to take part?

No, taking part is completely your choice.

If you decide to take part, you will be asked for your consent.

What does taking part involve?

A survey at a time that suits you in May/June 2025.

At no point will you be obliged to discuss anything you are uncomfortable with or share anything you don't wish to.

What will happen to my data?

The University of Gloucestershire, as a Data Controller, will ensure your data is stored securely and handled in line with GDPR rules.

You can read the University's GDPR policy here:

<https://www.glos.ac.uk/information/knowledgebase/data-protection-policy/>

How will my data be used?

Your survey will be captured in JCIS, a survey tool that assists with survey analysis.

Your insights will be combined with those of other citizen scientists and included in a report to help shape future projects.

All data will be kept secure and only accessible to the University of Gloucestershire research team. The survey is anonymous and any identifying details will be removed from the report.

How long will my data be kept?

The anonymised data will be stored securely until August 2030 to allow us time to write up the reports.

Will my participation be kept confidential?

Yes, all information you provide during the interview will be kept strictly confidential by the research team.

No personal details will appear in any reports, papers, or presentations produced from this research.

What are the benefits of taking part?

By participating, you will help shape future citizen science projects, making them more meaningful and effective.

What could go wrong?

We do not expect any issues. As researchers, we follow strict anonymity and confidentiality rules. The focus will be on your views and experiences of citizen science.

What will happen to the results?

The findings will be used to write a final report for OFWAT.

We will also publish results in academic journals and may present findings at seminars and conferences and on the CaSTCo website.

Who is funding this research?

This research is funded by Anglian Water, as part of the OFWAT funded CaSTCo project.

Who reviewed this study?

The University of Gloucestershire's Research Ethics Committee has reviewed and approved this study.

Who can I contact for more information?

We're happy to discuss any questions or concerns you may have.

Please contact:

Elle Claiborn, Citizen Science officer at Norfolk Rivers Trust and lead for this research activity on behalf of the CaSTCo project (eclaiborn@glos.ac.uk)

If you do not consent to completing the survey, you may leave it at any time.

1. I confirm that I have read and understood the Participant Information Sheet for the study.

*

Yes

2. I have received enough information about this study and have had the opportunity to ask questions, all of which have been answered fully.

*

Yes

3. I understand that my participation is voluntary. *

Yes

4. I understand my responses will be anonymised in any final write up relating to the project (e.g., reports or academic papers).

*

Yes

5. I agree to take part in the above study. *

Yes

Participant Information

We are collecting demographic information to examine who takes part in CaSTCo citizen science activities.

6. Which CaSTCo project are you involved in? Please select one. *

Anglian water quality
Arun and Rother
Beane
Northwest
Tamar
Teme
Thames
Usk
Other

7. Are you involved in any other citizen science projects?

Yes- freshwater related
Yes- other citizen science
No

8. What is your highest level of education?

No formal education
Secondary/high school equivalent
Vocational training
Bachelor's degree
Postgraduate or advanced qualification
Prefer not to say

9. What is your current employment status?

Full-time employment
Part-time employment
Unemployed
Student
Retired
Prefer not to say

10. What is/was the nature of your studies and/or employment?

11. What is your age?

18-25

26-35

36-45 46-55

56-67

68-75

76 or older

Prefer not to say

12. Do you consider yourself to have a disability?

Yes

No

Prefer not to say

13. If yes, does this condition impact your participation in the CS activity?

Yes, a lot

Yes, a little

No

14. What best describes your ethnicity and/or cultural heritage?

Asian or Asian British

Black, Black British, Caribbean or African

Mixed or Multiple ethnic groups

Hispanic

White British

White European or American

Prefer not to say

15. How do you describe your gender?

Female

Male

Non-binary

Prefer not to say

16. Please briefly describe what motivated you to become a CaSTCo citizen scientist.

Individual Benefits

Since taking part as a CaSTCo Citizen Scientist,

17. I have learned more about my river environment.

Not at all

A great amount

18. I have spent more time outdoors.

No change

A great amount

19. My level of physical activity has increased.

No change

A great amount

20. I have gained new skills.

No change

A great amount

21. I have felt confident collecting data that is scientifically robust.

Not at all

Completely

22. It is important to me that the data I collect is scientifically accurate.

Not at all

Very much

23. I have been inspired to engage in more environmentally positive behaviours.

Not at all

A great amount

24. Please give examples of any environmentally positive behaviours you have been inspired to adopt.

Community Benefits

As a CaSTCo citizen scientist,

25. I enjoy being part of my CaSTCo group.

Not at all
Very Much

26. I feel that being involved in my CaSTCo group is worthwhile.

Not at all
A great amount

27. I have enjoyed spending time on my own while taking part in CaSTCo monitoring.

Not at all
Very much

28. I have passed on my resulting knowledge and interest to family, friends and colleagues.

Not at all
A great amount

29. I expect my involvement in CaSTCo citizen science to influence decision makers.

Not at all
A great amount

30. Please explain your answer.

31. I speak up more for my rivers as a result of taking part in my CaSTCo CS activity.

Not at all
A great amount

32. If you were to recommend CS activities to a friend, what would you say?

Nature Benefits

As a CaSTCo citizen scientist,

33. Whilst taking part, I felt close to nature through my senses.

Not at all

A great amount

34. I noticed the beauty of nature whilst taking part.

Not at all

A great amount

35. I find taking part calming or joyful.

Not at all

A great amount

36. I find taking part frustrating.

Not at all

A great amount

37. I feel that by taking part, I am helping nature.

Not at all

A great amount

38. I find taking part meaningful.

Not at all

A great amount

39. What is the most exciting or meaningful experience you have encountered since you began taking part in CaSTCo citizen science?

40. How have you benefited by being involved in CaSTCo citizen science activities?

41. Have you experienced any disadvantages by being involved in CaSTCo citizen science activities?

42. Is there anything we have not asked you that you would like to share with us?

43. There may be an opportunity to discuss these questions further in an interview. If you would be interested in participating, please leave your email address here.

