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Challenges and opportunities of technology use for coordinators of animal-related citizen science projects: a scoping review

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Citizen science coordinators are increasingly using digital technologies such as smartphones, web platforms and social media to engage participants and execute projects. However, this could bring unintended social consequences that may affect the sustainability of, and engagement in projects. These impacts are not yet well documented. Following the PRISMA framework, we performed a scoping review to understand the challenges and opportunities experienced by coordinators arising from technology. Using terms for technology, citizen science/community-based projects and biodiversity/animal monitoring we searched across Web of Science, Proquest and Scopus. Articles that did not report on any animal-related citizen science projects or use mobile phone technologies, applications, websites or social media were screened out. 153 studies were included in the data extraction which involved identifying information on coordinator experiences, technology use and study design. This data was analysed using descriptive statistics and thematic synthesis. Social media was the most commonly used technology (n = 80, 52%), and adoption and implementation of technologies were predominantly top-down decisions with little consultation with communities. Benefits of technology reported across the studies included customisation capabilities and facilitating public awareness and group organisation at low cost. Challenges reported included accessibility across geographic areas, conflicting goals between coordinators and participants, and issues with data quality and quantity. The review highlights a need to build technology engagement with communities, increase consideration of local community contexts, especially in the Global South where very few studies considered community needs, and explore technological solutions towards improving data quality. These changes would help to foster greater engagement, promote inclusivity and shared stewardship, and increase the value of citizen science data for participants and coordinators.

KEYWORDS
biodiversity, community-based monitoring, data quality, inclusivity, mobile technologies, stewardship

1 Introduction

Citizen science projects can contribute substantially to halting biodiversity loss and animal conservation, particularly in regions of the world where data are scarce (Johnston et al., 2023). These projects enable extensive ecological monitoring through networks of observers, and the amount and rate of data they generate can be accelerated by the increasing availability of digital technologies and growing internet accessibility (Mazumdar et al., 2018; Sanabria-Z et al., 2022). Technologies such as smartphone applications, web-based platforms or social media (Braz Sousa et al., 2022) allow project coordinators (i.e., scientists, managers and organisers that are involved in creating and directing citizen science projects, and the recruitment, training and management of volunteers) to create large distributed communities and exchange information efficiently, thus enriching collaborative research (Sheard et al., 2024).

Many citizen science projects are primarily scientific, where participants take on passive roles as data contributors (Christine and Thinyane, 2021). Despite this, there are still positive outcomes for participants (Ballard et al., 2024; Peter et al., 2021; Deguines et al., 2020). However, these benefits are variable and could be much greater and more assured if project coordinators give more attention to participant outcomes in how they design and execute projects, build engagement and manage data quality and quantity. Understanding the perspectives of coordinators could enrich engagement in, and sustainability of, projects, but this has received very little attention in the literature (Golumbic et al., 2025). Furthermore, increasing technology use can bring unintended social consequences for coordinators such as cultural misunderstandings, inflated expectations and misreading of power dynamics (Stevens et al., 2014). Thus, it is important to understand the impacts of technology adoption for coordinators and the considerations they undertake when designing and implementing projects; this is yet to be examined in a systematic way in the literature, which limits our ability to design projects that can optimise community engagement and data collection.

We used a systematic scoping review to synthesise evidence on how digital technology is being applied in citizen projects and the challenges and opportunities they provide for coordinators towards building and engaging communities and gathering quality data. The findings of the work will help to inform better outcomes for coordinators, enhance project success and potentially promote improved community and environmental outcomes.

2 Methodology

The PRISMA framework (Page et al., 2021) was followed to undertake the systematic literature review. This involved:

1. Defining the search strategy and protocol: We searched Web of Science, Scopus and Proquest to find relevant peer-reviewed journal articles. These databases were selected based on the functionality to filter for article types, publication dates, length of search terms allowed and coverage of results. Searches were conducted in English and included components for technology, citizen science/community-based projects and biodiversity/animal monitoring (Supplementary Table S1). These terms were developed and tested across the databases to ensure the relevance of results. To determine what technologies are used in citizen science, analysis of the literature suggests that conservation technologies such as camera traps and drones may create challenges for projects by increasing financial costs and requiring technological expertise or training of participants (Sheard et al., 2024). However, technologies such as smartphones along with applications, websites and social media, are now commonly used in citizen science (Mazumdar et al., 2018; Sanabria-Z et al., 2022), thus moving "project design towards simpler and mass participation approaches" (Sheard et al., 2024, p. 2). Consequently, our focus was on the use of smartphone-related technology, with the expectation that our review would show a wide uptake of these technologies. Searches were restricted to papers published in the period 2017 to 2023 to ensure we captured the most recent technological advancements. Grey literature and conference proceedings were excluded as our aim was to develop a conceptual explanation rather than an exhaustive search (Thomas and Harden, 2008). From this step 3,251 studies were identified.
2. Collecting and Screening the Literature: Results were uploaded into EndNote and duplicates removed, resulting in a total of 1986 records. Abstracts and titles of these records were screened on Covidence, a systematic review management software. This assessed their eligibility based on whether they reported on any animal-related citizen science projects. 350 articles passed this initial screening, and of these 346 studies had their full texts retrieved; four studies could not be retrieved as they were behind paywalls. The full texts of the retrieved articles were evaluated against the inclusion and exclusion criteria (Supplementary Table S2). The co-authors conducted a secondary review of a subset (12.4%) of the full texts to confirm consistency in this process. Finally, 153 studies (Supplementary Table S4) were included in the extraction and analysis (Figure 1).
3. Data Extraction and Analysis: Data extraction involved screening the articles to extract information on coordinator experiences, technology use and study design against a set of questions (Supplementary Table S3). This information was tabulated in a Google Sheets and analysed using a mixed-methods approach, which consisted of descriptive statistics by identifying percentages to derive frequency from the short-answer questions, such as identifying how often technology is required to be used in projects, and the types of stakeholders responsible for verifying data, and by following a thematic synthesis approach (Thomas and Harden, 2008) for the free-text questions. Thematic analysis was only conducted against the extracted free text rather than the entire texts since the aim was to focus specifically on coordinator considerations within the studies. Furthermore, due to the large volume of data, we first developed descriptive themes and then drew out analytical themes to provide explanations or hypotheses. This was done through an inductive approach where observations on patterns and themes were identified from the extracted free text, rather than from any pre-existing theories. These themes were grouped and renamed as they emerged.

3 Results

Social media was the most commonly used technology (n = 80, 52%), with Facebook being the most popular. Smartphone apps were generally used for data collection, and social media for the recruitment of participants, while websites were the preferred medium to share information. Although the iNaturalist platform

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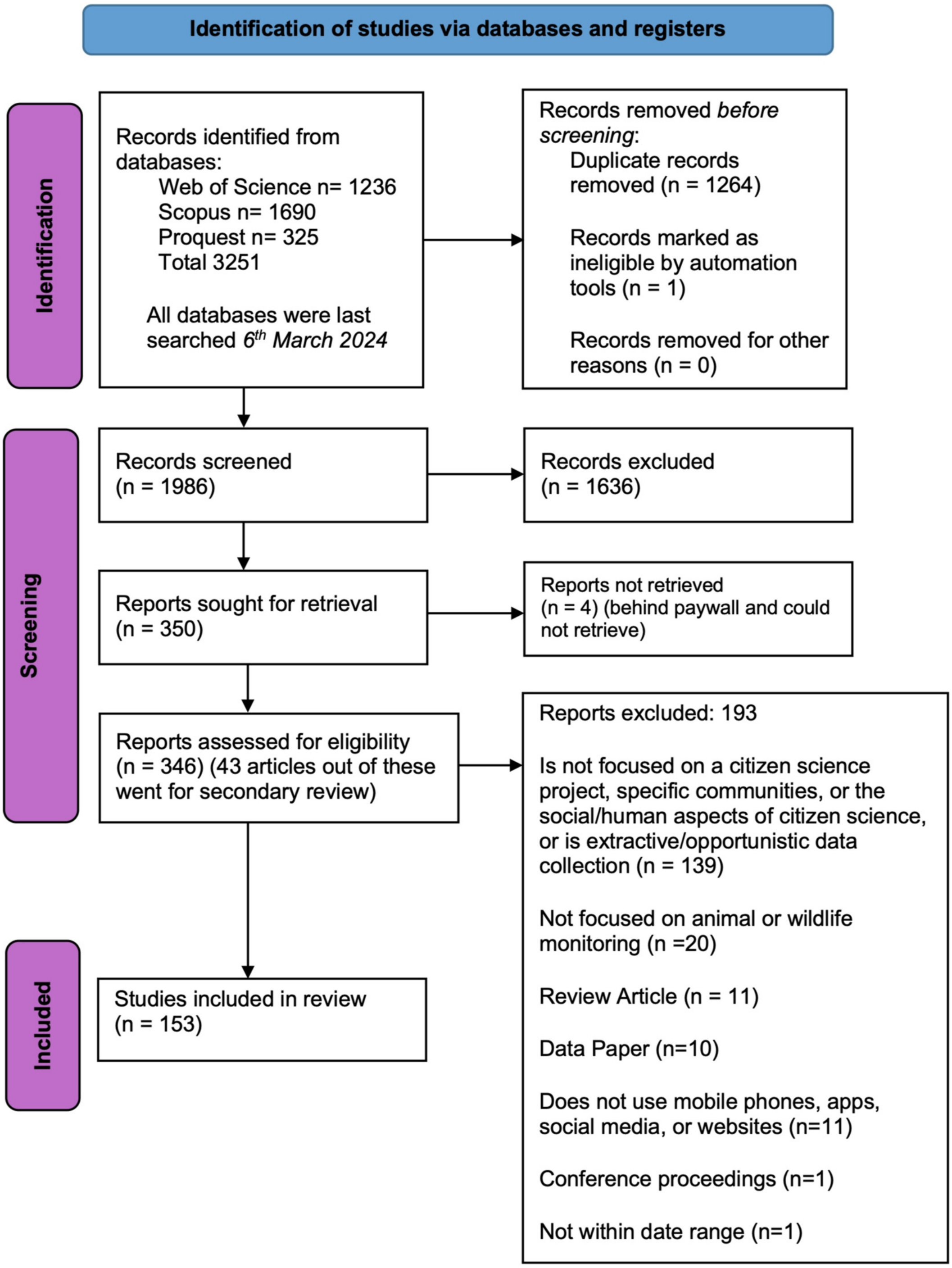

FIGURE 1
PRISMA Diagram of the study selection and screening process.

has capabilities including built-in species identification, only one study mentioned using this (Table 1).

Citizen science coordinators were mostly responsible for creating or setting up the technologies used in projects (Table 2). Only 3% (n = 4) of the projects utilised technologies that combined efforts by coordinators and community members, of which two were tested by a volunteer group and two were social media groups set up by community members that the coordinators used alongside personal social media profiles or project websites.

Participants' use of technology to submit data or find information was predominantly voluntary (Table 3), and verification of the data was mostly done by experts (Table 4).

TABLE 1 Technologies and their uses in citizen science projects.

Technology	Purpose – number of projects (%) Recruitment	Data collection	Facilitating community interaction	Providing information	Identification and verification
Social media (e.g., Facebook, Twitter, Instagram, Flickr)	45 (29)	37 (24)	14 (9)	11 (7)	Not mentioned
Project related smartphone apps	Not mentioned	68 (44)	3 (2)	12 (8)	2 (1)
Project website	7 (5)	47 (31)	2 (1)	28 (18)	3 (2)
Citizen science/Nature specific platforms (e.g., iNaturalist, eBird)	Not mentioned	18 (12)	Not mentioned	Not mentioned	2 (1)

The number exceeds the total as some studies used multiple technologies.

TABLE 2 Stakeholders responsible for technology set-up and creation.

Who creates or sets up the technology?	Number of studies (%)
Only coordinators	92 (60)
3rd party (another organisation)	15 (10)
Citizen scientists/community members or volunteers	7 (5)
Not mentioned	30 (20)
Combined effort of coordinators and community members	4 (3)
Coordinators and 3rd parties or students	5 (3)

Percentage total is above 100 due to rounding.

TABLE 3 Project requirements on technology use frequency.

How often does the project require participants to use technology?	Number of studies (%)
As often as participants wish	99 (65)
During the study period	25 (16)
Not mentioned	25 (16)
One time	3 (2)
At a particular season (e.g., hunting season)	1 (1)

Several studies did not mention how data verification was conducted. The few that did described procedures such as identifying relevance and classifying reports into categories, e.g., based on abundance level of species (Bellido et al., 2020; Gutiérrez-Estrada et al., 2021), devising ranking systems that allocate higher weightings to trained observer reports (Edelist et al., 2020), using other community members' comments on posts to help with identification (Etter et al., 2023), or using iNaturalist's data quality assessment which summarises an observation's accuracy, completeness, and suitability for sharing with data partners (Braz Sousa et al., 2022).

TABLE 4 Figures on who performs data verification in the study.

Who verifies the data?	Number of studies (%)
Experts	61 (40)
Not mentioned	57 (37)
Community members	7 (5)
Algorithms	7 (5)
Experts and algorithms	5 (3)
Experts and community members	2 (1)
External collaborators	3 (2)
Not relevant to the study	11 (7)

3.1 Advantages and disadvantages of technology use for citizen science coordinators

3.1.1 Technology benefits and advantages

Ten descriptive themes were identified relating to the advantages or disadvantages for coordinators that result from using technology (Table 5).

Customisation capabilities can assist coordinators. For example, accessibility of Facebook groups and social media helps create targeted calls for observing specific species (Báthori et al., 2022) and can be used in tandem with biodiversity platforms such as iNaturalist which may be limited in customisation capabilities (Báthori et al., 2022; Chowdhury et al., 2024). Smartphone apps and websites can also be tailored (Vattakaven et al., 2022) by adding dashboards that allow coordinators to share information with decision-makers, restricting access to certain users (Nardi et al., 2023), creating user-friendly and professional interfaces (Wamwenje et al., 2019; Lee and Nel, 2020), incorporating gamification such as rewarding participants for high scores (Vattakaven et al., 2022), and creating region-wise communities within the platform to support collaborative relationships (Pecl et al., 2019). This is augmented by constant updates to technologies that can enhance species identification, and the

TABLE 5 Analytical and descriptive themes for the question "Are there any advantages or disadvantages of using the technology for coordinators?"

Analytical themes	Descriptive themes
Technology benefits and advantages	Customisation and technology updates
	Data collection and knowledge production
	Public awareness and community building
	Costs
Technology challenges and disadvantages	Applicability and reach
	Tech updates and releases
	Participant willingness and activity
	Time constraints and costs
	Data set bias
	Quality of data

accuracy and consistency of the collected data (Tréhin, 2023; Edelist et al., 2020).

Digital technology can also strengthen public awareness and allow projects to grow rapidly. Social media facilitates the promotion of research projects (Davis et al., 2017), enables recruitment (Perry et al., 2022; Kalaentzis et al., 2021; Mohd Rameli et al., 2020), and can be used to post eye-catching pictures and videos that can receive large engagement (Pardee et al., 2023; Weyman et al., 2022; Skelton et al., 2019). Social media is also an informal and low-cost tool reaching multiple people and enhancing group organisation and outreach (Forrester et al., 2021).

Other benefits of technology for coordinators are the ease and speed at which data can be collected (Páll-Gergely et al., 2019; Ožana et al., 2019; Rocha et al., 2017) and expanded across geographic areas (Palmer et al., 2017; Rocha et al., 2017). Authors suggest that the ubiquitous availability of phones, cameras and wireless technologies propagates reach, allowing people to work together effectively (Pecl et al., 2019; Zapponi et al., 2017) and can enable people in less-represented countries to participate in citizen science (Chowdhury et al., 2024). Moreover, technology enables coordinators to obtain high-quality, geographically precise data that can increase confidence in findings (Cranswick et al., 2022; Forys and Hevesh, 2017; Stevenson et al., 2021; Stenhouse et al., 2021; Stenhouse et al., 2020), fill knowledge gaps about animal distributions (Lodi et al., 2023; Macphail et al., 2020), access local knowledge (Nieman et al., 2020), and protect locations of threatened species by masking coordinates (Mohd Rameli et al., 2020; Molls, 2021).

3.1.2 Technology challenges and disadvantages

Despite these multiple benefits, technologies can also present some limitations to coordinators. For example, social media usage varies with countries as well as social, political and corporate pressures, so using a range of platforms may be necessary to capture the required data (Ammendolia et al., 2022). Furthermore, gender imbalances may also occur, e.g., significantly more females than males use Facebook in the US (Martin and Greig, 2019). Other limitations include misspellings and language barriers that can be a challenge for data collection and extraction (Bila Dubaić et al., 2022; Chowdhury et al., 2024), poor battery life of devices which may discourage participation (Boyce and Corrigan, 2017), poor perceptions of participants regarding the importance and relevance of the technology (Schulwitz et al., 2021), and a lack of features needed to support user interaction and communication (Ortiz et al., 2022). Additionally, coordinators are required to maintain the functionality of project platforms in the face of continual changes and updates in technologies (Pecl et al., 2019). Failure to do so can hinder project implementation and limit the users who can participate (Boyce and Corrigan, 2017).

Coordinators may also face challenges from low activity levels and interest in technology use. Some researchers hypothesise that participants may not be keen on using digital technology, especially if its use has been a top-down decision (e.g., a pre-defined use of the technology) that has been put into place by project coordinators without consultation (Arts et al., 2020), or if participants have concerns about their location being tracked (Stenhouse et al., 2020; Pecl et al., 2019). There are also limitations on the form of the technology and data submission procedures, for example, an online community was found to perform better than a mobile app in data collection (Zhang et al., 2021), and sharing pictures was more accepted than filling out forms (Neves-Ferreira et al., 2023). Consequently, coordinators have to invest time in addressing the interests of participants and modifying the project according to their needs, e.g., providing materials, regular postings, maintaining the software, easing the experience of logging observations (Baumbach et al., 2019; Kalaentzis et al., 2021; Taylor and Sammons, 2019). Furthermore, online outreach and processing submissions are time-consuming activities. Developing platforms to handle this requires technological knowledge and may introduce additional costs and compatibility issues between different devices (Platenberg et al., 2020). However, this is much cheaper than hiring professionals to undertake these activities (Encarnação et al., 2021). Consequently, it is recommended that increased government support is required to sustainably finance long-term monitoring initiatives (Oviedo and Bursztyn, 2017).

Limitations in the data sets can also present challenges to coordinators. For example, data are frequently skewed towards higher population centres and areas where there is an existing

TABLE 6 Analytical and descriptive themes on the considerations on citizen science communities by coordinators.

Analytical themes	Descriptive themes
Community composition	Socio-economic characteristics
	Geographic distribution
	Recruitment of participants
	Relationships between community members
Enhancing representation	Collecting demographic information
	Language
	Easing participation requirements

interest towards certain species (Sanderson et al., 2021; Williams et al., 2017). These biases can be exacerbated by the accessibility of social media in these areas, and its ability to successfully reach interest groups (Delgado-Noguera et al., 2022; Williams et al., 2017). Other biases in data can arise when artificial intelligence is trained with citizen science-contributed open data (for aiding identification), without disclosing how these training sets are used (Vattakaven et al., 2022), or when data comparison is limited at smaller scales and not evaluated against an international framework (Thomaes et al., 2021).

The quality of data submitted is a significant challenge for coordinators. Species identification requires high quality photographs (Chowdhury et al., 2024; Gašparić et al., 2022; Földvári et al., 2022; Nieman et al., 2020; Potsikas et al., 2023; Braz Sousa et al., 2022), and social media posts and metadata can be edited, which makes retrospective assessment difficult (Cranswick et al., 2022). Authors have proposed giving more specific instructions to contributors on how to make recordings and take clear and complete photos (Potsikas et al., 2023; Jäckel et al., 2023), and to standardise the data that are obtained (Van Belle et al., 2024; Bellido et al., 2020; Rocha et al., 2017). Technology may not capture all the data coordinators need, such as species abundance and composition (Johnston et al., 2022; Mohd Rameli et al., 2020), precise time of observation (Pirotta et al., 2022), and technical problems and hardware limitations (Stenhouse et al., 2020), as well as contextual information such as participant demographics and motivations.

3.2 Considerations about communities

We identified two analytical themes (community composition and enhancing representation) and seven descriptive themes relating to the considerations of coordinators in creating citizen science communities (Table 6).

3.2.1 Community composition

Very few papers mentioned or discussed the socio-economic data or the participants. Some studies based on the Global North mentioned that participants were highly educated with a university or other tertiary degree (Braz Sousa et al., 2022; Loerzel et al., 2017; Macphail et al., 2020), and that there is a bias towards White participants of higher socioeconomic status (Ammendolia et al., 2022; Heeren et al., 2021; Martin and Greig, 2019; Ortiz et al., 2022; Palmer et al., 2017; Turnbull et al., 2023). In studies based in Global South countries, sociodemographic data were focused on gender, and some highlighted the disproportionately lower participation of women (Wamwenje et al., 2019; Squires et al., 2021). Lodi et al. (2023) found that most of the members were female and justified this based on their role as natural resource managers within their communities. These findings highlight that there is a dearth of socio-economic data and diversity within citizen science projects, and that benefits obtained from participation may not be accessible to all (Palmer et al., 2017). This is further emphasised by the geographic distribution of participants, who in several studies were concentrated in metropolitan, larger cities and easily accessible and populated areas (Braz Sousa et al., 2020; Rocha et al., 2017; Lodi et al., 2023; Macphail et al., 2020; Rowley et al., 2019; Weyman et al., 2022; Báthori et al., 2022; Ostermann-Miyashita et al., 2023). This highlights a bias of observations towards these areas, where the extent of effort required by human observers is less, rather than in rural or remote areas, where certain species may be present but not necessarily recorded by citizen scientists.

Recruitment processes can also influence the composition of participants. In projects in Global South countries or with marginal communities, participants were predominantly selected by community leaders and the project team (Brees et al., 2021; Crosman et al., 2019; Dam et al., 2023; Dwivedi, 2021), whereas in Global North countries, recruitment is generally through personal engagement, online platforms or events (Griffin et al., 2022; Moro et al., 2021). These methods may lead to bias towards participants with an interest in volunteer work or environmental issues, or those with existing knowledge.

Finally, there is very little discussion on the relationships between participating community members. Only one study asked about the social aspect of data submission in citizen science projects, with "41% of participants contribut[ing] data on their own, 29% with a partner, 12% with children, 8% with a friend, 3% with a colleague, 2% with grandchildren, and 2% with a parent" (Perry et al., 2022).

3.2.2 Enhancing representation

This analytical theme encompasses efforts made by project coordinators to reduce the social limitations to participation and improve representation. Three descriptive themes were identified - efforts to collect demographic information, language and easing requirements for participation.

The majority of the studies did not mention the collection of demographic information of participants. Griffin et al. (2022) suggested that projects should collect data such as age, gender and educational background, although there is a lack of knowledge on how this information can be applied to improve projects. Another area that was occasionally discussed was reducing language barriers and creating opportunities in different languages. Few studies (Ožana et al., 2019; Tréhin, 2023) implemented bilingual assistance in the digital platforms to improve accessibility, Heeren et al. (2021) noted that having materials in different languages, especially Spanish, could promote inclusivity and build connections with Hispanic communities, a key demographic in their project, and Liebenberg et al. (2017) suggested using icons and alias names to overcome language barriers.

TABLE 7 Analytical and descriptive themes for the question "Are there any other considerations by coordinators?"

Analytical themes	Descriptive themes
Participant engagement	Incentivisation
	Contribution to science and society
	Feedback
	Measuring engagement
	Recruitment and outreach
	Influence of external events
Collecting data	Participant experience
	Other challenges

Inclusivity in participation can also be enabled by easing the intensity of participation. Some studies highlighted that the ingrained nature of social media in the lives of people makes it an easier form of participation without needing to sacrifice other personal activities (Ammendolia et al., 2022; Davis et al., 2019). Only one study (Johnson et al., 2021) discussed increasing the roles available for community members to participate in digital platform design and implementation, which are often limited by technical or social constraints. Thus, a well-designed citizen science project can foster inclusivity for different community members, alongside its core purpose of data generation.

A few researchers also discussed having simplified interactions, clear instructions and a low-threshold approach to participation, where there is flexibility on where, when and how often recordings should be made (Oviedo and Bursztyn, 2017; Martin and Greig, 2019; Jäckel et al., 2021; Jäckel et al., 2023) in order to encourage as many people as possible to participate. Martin and Greig (2019) suggested that information for young adults need to be different from that for older populations, as restrictions on their time and access to multiple communication channels means messages need to be "short, relevant and appropriate."

Finally, little is understood on what it means to enhance representation in the Global South, Oviedo and Bursztyn (2017) considered this in the context of the Brazilian Amazon, where data collection needs to support offline modes for remote locations, and smartphones must be waterproof with GPS that can be easily recharged in a motorhome or with a solar panel. Moreover, the cultural significance of different species should also be considered. For example, echidnas are a subject of cultural stories and biological indicators of indigenous Australian communities (Perry et al., 2022), and thus developing engagement strategies that are mindful of these meanings could increase involvement from such underrepresented groups.

3.3 Facilitating engagement and data collection

Two analytical themes (participant engagement and collecting data) and eight descriptive themes were identified relating to other considerations by coordinators in the study design (Table 7).

3.3.1 Participant engagement

This analytical theme explores the methods considered in the literature that may affect participant engagement with citizen science.

Incentivisation through means such as points, prizes and payments has been mentioned in several papers as a way to encourage participation (Boyce and Corrigan, 2017; Campanaro et al., 2017; Zhang et al., 2021; Dam et al., 2023). In particular, studies have found that monetary incentives can motivate participation in the short term (Kewprasopsak et al., 2022; Dam et al., 2023). However, for longer-term engagement, social incentives such as informing participants on the impact of their reporting are relatively cheaper and perform better when volunteers are not paid initially (Kewprasopsak et al., 2022). Authors have also suggested incentivising quality over quantity of records, to adopt gamification techniques such as creating leaderboards or giving badges (Vattakaven et al., 2022), and even to communicate and privately encourage people with low participation (Zhang et al., 2021). However, while external incentives may help, a study by Jäckel et al. (2021) found that this is not necessarily required, and that citizen scientists often have sufficient intrinsic motivation. In particular, a few authors have noted participants being driven by personal motivations such as protecting themselves against mosquitos (Dam et al., 2023), having fun and giving them a purpose (Martin and Greig, 2019), and if participation in the project enhances their job performance (e.g., helping dive operators understand marine environments better) (Buzinkai et al., 2023).

The sense of contributing to scientific knowledge and helping the environment has also been noted by several coordinators as a factor that enables engagement (Ciceoi et al., 2017; Forrester et al., 2021; Etter et al., 2023; Stenhouse et al., 2021; Squires et al., 2021). Empowering and recognising citizens to be a part of the scientific process could enable the long-term sustainability of projects and promote the implementation of conservation policies (Lodi et al., 2023; Pardee et al., 2023). Means of motivation could include providing summaries to participants on how their data have been used through publications or have contributed to particular project goals or conservation decision-making (Macphail et al., 2020). This emphasises the need to give feedback to participants (Braz Sousa et al., 2020; Jäckel et al., 2023; Pardee et al., 2023). A few studies that gathered views of participants mentioned that citizen scientists wanted to receive feedback on how they had been doing (Dam et al., 2023; Macphail et al., 2020), with participants being receptive to both positive and corrective feedback (Jäckel et al., 2023; Kittelberger et al., 2021). While authors have mentioned that providing feedback can require significant time and effort (Macphail et al., 2020; Terenzini et al., 2023), there have been efforts to automate and enhance the efficiency of this through using natural language programs and machine learning (Macphail et al., 2020; Sharma et al., 2019) or providing group level feedback through social media posts, celebrating achievements and latest observations, and articles in magazines and publications (Pecl et al., 2019; Lodi et al., 2023; Campanaro et al., 2017; Pardee et al., 2023).

Some studies have attempted to capture the engagement or motivation of participants. In their study, Pecl et al. (2019) suggested that recognition for contributions was a low-ranking motivator amongst participants. Etter et al. (2023) observed differences in motivation between participants in different projects such as for "wanting to spend time in nature" and "meeting people with similar interests," while Snyder et al. (2022) found that volunteers contribute more time if they are involved in multiple tasks. It has been suggested that greater capture of demographic indicators within projects would be useful in providing further insights into motivations for participation (Lodi et al., 2023).

Several papers discussed recruitment and methods of outreach to participants as key elements of engagement. In particular, coordinators employed face-to-face seminars, workshops, contests and training visits with participants to engage participants in the project and break "traditional researcher-community relationships" (Grigoletto et al., 2023; Campanaro et al., 2017; Ciceoi et al., 2017; Lee and Nel, 2020). Fostering connectedness between researchers and volunteers can improve outcomes, encourage long-term participation (Braz Sousa et al., 2022; Huang et al., 2022), and help in increasing acceptance of projects (Neves-Ferreira et al., 2023). Other public engagement activities run by coordinators include, webinars, challenges, contests, building an advisory board to help assist in outreach efforts, collaborations with external organisations (Low et al., 2022; Wood et al., 2021), engagement via social media and other regional events (Pecl et al., 2019; Scott et al., 2024; Sharma et al., 2019). In particular, coordinators have found success in appealing to people's motivations (Squires et al., 2021; Macphail et al., 2020) and identifying and targeting the right demographics (Snyder et al., 2022; Taylor and Sammons, 2019; Englefield et al., 2020), and have suggested that appropriate forms of engagement must be considered early on (Trichkova et al., 2021).

Finally, external events such as disease, e.g., the COVID-19 pandemic outbreak (Caputo et al., 2020; Zhang et al., 2021; Magson et al., 2022), holiday seasons (Lodi et al., 2023) and unfavourable weather conditions (Martin and Greig, 2019) can either facilitate interest in or decrease data collection activities.

3.3.2 Collecting data

The level of participant experience and its role in contributing to data collection, identification and consistency has been considered in a few studies. August et al. (2020) mentioned that participants with high recording potential are more likely to be experts, and those that only record common species may not have the required skills for identifying rare species. Similarly, Gould et al. (2024) found that participants with high levels of science experience were 1.5 times more likely to do correct matches compared to those with no scientific experience. In order to improve data, coordinators have advocated for professionals to join citizen science platforms (Braz Sousa et al., 2022), provided professional assistance to contributors (Buzinkai et al., 2023), and included indigenous people in the process (Crosman et al., 2019). It has been suggested that more weight could be given to records from professionals rather than casual participants (Loerzel et al., 2017)and rather than collecting simple demographic information, participants could undertake a self-assessment of their skills and knowledge (Jäckel et al., 2023). While differences in expertise and motivations have been highlighted as affecting data quality (Van Belle et al., 2024; Väli and Magalhães, 2022; Arts et al., 2020), authors have highlighted the need to keep the process simple to maximise participation (Ditmer et al., 2021).

Other challenges coordinators have faced in the data collection process include social conflicts with residents (Oviedo and Bursztyn, 2017), including conflicting goals between participants and coordinators, where participants want to take immediate action and coordinators require time to assess data and implement management strategies (Skelton et al., 2019), accessibility to sites (Páll-Gergely et al., 2019), addressing spatial and temporal biases in data (Weyman et al., 2022; Terenzini et al., 2023; Vattakaven et al., 2022), and managing the workload of overseeing a social-media account with other responsibilities to avoid burn-out (Taylor and Sammons, 2019).

4 Discussion and recommendations

This scoping review has analysed the opportunities and challenges for coordinators undertaking technology-based citizen science projects and the considerations they undertake when designing and implementing projects. Our analysis has informed the following key recommendations on technology use, community building and participant engagement, and data quality and quantity.

4.1 Strengthen technology engagement

In 92 (60%) of studies, coordinators were uniquely responsible for the set up and creation of the technology. However studies suggest that top-down implementation of technology without participant involvement may limit engagement (Arts et al., 2020; Benyei et al., 2023; Skarlatidou et al., 2024). Citizen science can be broadly categorised into three categories: contributory, collaborative or co-created (Bonney et al., 2009). Most studies are contributory projects, where participants are only data gatherers. Although participation in such projects can bring benefits (Ballard et al., 2024), active co-creation involving participants can enhance inclusion and widen participation (Senabre Hidalgo et al., 2021), empowering participants and encouraging long-term engagement (Sardo et al., 2024). Particularly, there is very limited discussion or understanding of co-creation of citizen science technologies. While there may be challenges in this such as limited skillsets and knowledge levels (Senabre Hidalgo et al., 2021), participants can be involved at appropriate stages, e.g., design, development or user testing. Consequently, we recommend that citizen science projects consider involvement of participants in technology set-up and creation to improve engagement, sustain interest, and to generate effective and meaningful solutions that have relevance to their context (Pateman et al., 2025).

4.2 Consider local contexts for community building

Very few studies discussed the socio-economic factors, community needs or challenges coordinators faced when interacting with communities. This has been even more limited in the Global South, where few studies only capture gender (Wamwenje et al., 2019; Squires et al., 2021). It is important that citizen science projects are designed to address local community contexts, and this must involve consideration of their skills, interests and motivations, and topics or species of relevance to them (Larson et al., 2020). However, local interests are not always cohesive or perfectly explicit; thus, it is important to acknowledge the potential of co-created projects, which allow for greater local adherence. This can potentially improve public engagement, contribute to knowledge building, enhance appreciation of the environment and democratize the research process (Resnik et al., 2015). A study by Strasser et al. (2023) found that many citizen science projects are heavily dominated by those with a high level of scientific literacy and expertise, suggesting that online citizen science is not democratising science as much as it is claiming. Furthermore, recruitment methods such as pre-selection of participants and usage of online platforms and nature events (Brees et al., 2021; Crosman et al., 2019; Griffin et al., 2022; Moro et al., 2021) may bias towards citizens with knowledge and interest in environmental issues. Thus, it is important for citizen science projects to make greater efforts in capturing demographic and community indicators (e.g., skills, interests, motivations, time availability) to enhance public participation based on social and cultural requirements.

4.3 Explore technological solutions to improve data quality

Coordinators face challenges with the quantity and quality of their datasets (Sanderson et al., 2021; Chowdhury et al., 2024), and very few studies discussed how verification of data was performed (Edelist et al., 2020; Etter et al., 2023). There are several recommendations in the literature for techniques to mitigate this such as, iterative task development, volunteer training and testing, expert validation, skill-based weightings and accounting for random and systematic bias (Kosmala et al., 2016). However, understanding how coordinators addressed data reliability questions can provide opportunities for data reuse and increase the trustworthiness of their studies (Downs et al., 2021). Furthermore, there is very little discussion on how technology can be used in quality assessment, besides iNaturalist's inbuilt features (Braz Sousa et al., 2022). Citizen science researchers must give importance to data quality issues, and future research should discuss how limitations can potentially be overcome and explore how technology can aid in data management and analysis.

5 Conclusion

Tackling the biodiversity crisis requires understanding the perspectives of all the stakeholders involved. Citizen science project coordinators (scientists, managers and organisers) play an important role in the design and long-term engagement of participants in citizen science projects. Increasing use and adaptation of technology can enhance the scientific outcomes of these projects, but this should be done in a way that is sensitive to local contexts and includes explicit consideration of community needs, so that the social value of the projects can also be realised.

Our scoping review of technology-based animal citizen science offers an analysis on the impacts of technology on projects and communities. It found that while technologies afford coordinators with ease of organisation and accessibility across vast geographic areas, their implementation can lead to issues in data quality and quantity and is frequently done through little consultation with communities and understanding of local contexts. This consultation is particularly lacking in the Global South where very few studies took into consideration community needs. Thus, more broadly for citizen science, inclusivity for communities must be promoted to align project goals with local interests, technological solutions towards improving data quality must be identified, and a greater understanding of projects in the Global South is required.

Furthermore, some of the descriptive themes identified in this study could help to inform understanding of the impacts of technology use in projects. For example, consideration of public awareness, costs, applicability and reach, participant willingness, and potential biases in data could all be beneficial in highlighting engagement and the usefulness of the data produced. Mindfulness of such impacts will help to increase the value of citizen science data, promote greater engagement and inclusivity, foster stewardship, and ensure that participants and coordinators alike receive the maximum benefits from projects.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

SG: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review and editing. PW: Conceptualization, Supervision, Writing – review and editing. AH: Conceptualization, Supervision, Writing – review and editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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