CITIZEN SCIENCE:
THEORY AND PRACTICE

Libraries As Emerging Hubs for Citizen Science: Insights from Borneo Adventure 2025

COLLECTION:
GLAM

RESEARCH ARTICLES

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ABSTRACT

Libraries are increasingly recognized as important facilitators of citizen science, providing accessible platforms that connect researchers, communities, and scientific knowledge. This study examines the Borneo Adventure: Citizen Science in Action 2025 program, a library-led initiative coordinated by the Librarian Association of Malaysia, in collaboration with public and academic libraries and community partners in Sarawak and Sabah. Using a mixed-method approach, the study analyzes 320 participant responses through quantitative surveys and qualitative thematic analysis. The findings indicate strong positive perceptions of citizen science, with participants recognizing its contribution to scientific knowledge and its alignment with library roles. Qualitative responses further describe a reported progression from initial awareness to increased confidence in participation, supported by hands-on activities and guided facilitation. Participants also perceived libraries as inclusive learning hubs that enable collaboration, knowledge sharing, and community engagement in scientific activities. The study identifies key opportunities and participant-reported outcomes arising from program implementation, including strong interest in continued participation, potential to expand the program to wider audiences, and self-reported shifts in environmental awareness and engagement with science. These findings highlight the evolving role of libraries as enablers of participatory science and suggest their potential to support inclusive public engagement within emerging contexts. The study contributes empirical evidence from the Global South, offering insights into how library-led initiatives may facilitate citizen science participation and support community-oriented approaches to scientific literacy and sustainability in underrepresented Global South contexts.

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INTRODUCTION

Citizen science is widely defined as the active participation of non-professionals in scientific research, contributing to scientific literacy, environmental awareness, and broader democratic access to knowledge. Existing literature highlights its growing role in enabling public engagement in data collection and knowledge production across diverse fields, including biodiversity monitoring, environmental management, health, and urban studies (Bowser et al. 2013; Wehn et al. 2021; Todowede et al. 2023; Ambole et al. 2025; Lotfian et al. 2021). As citizen science continues to expand, it has evolved into collaborative approaches addressing complex societal challenges such as climate change, water quality, and biodiversity loss, while also raising important considerations related to governance, data quality, and evaluation (Bowser et al. 2013).

Within this context, galleries, libraries, archives, and museums (GLAM) have increasingly been recognized as facilitators of participatory science (Cigarini et al. 2020). Libraries, in particular, are uniquely positioned to connect researchers and communities through their accessibility, public trust, and educational mandate. In Europe and North America, libraries have integrated citizen science into their services through community programs, data-collection initiatives, and digital platforms that support public participation (Cigarini et al. 2020; Pimentel and Gomes 2024; Kaarsted et al. 2023; Mumelas and Martek 2024). These developments reflect a broader shift in the role of libraries from information providers to facilitators of collaborative and experiential learning. However, existing literature remains heavily concentrated in Western contexts, with limited empirical evidence from the Global South, particularly in Asia, where institutional structures, resource availability, and community engagement practices differ significantly.

In Malaysia, although there is growing interest among librarians in engaging with citizen science, its integration into library practice remains in its early stages. It is shaped by institutional, resource, and policy constraints (Nurfarawahidah et al. 2023). Moreover, there is a lack of program-based studies that examine how such initiatives are designed, implemented, and experienced by participants in local contexts. This gap highlights the need for empirical research that not only documents outcomes but also provides insights into how library-led citizen science initiatives function in practice, particularly in supporting community engagement, scientific literacy, and sustainability agendas aligned with the United Nations Sustainable Development Goals (UN SDGs) (SDG 4: Quality Education and SDG 15: Life on Land) (Fraisl et al. 2020).

Addressing this gap, the Borneo Adventure: Citizen Science in Action 2025 program was implemented as a collaborative, library-led initiative involving the Librarian Association of Malaysia (PPM), public libraries in Sarawak and Sabah, academic libraries from Universiti Teknologi MARA (UiTM) and Universiti Malaysia Sabah (UMS), American Corners Malaysia, and the environmental organization Sekitar Kita, with support from the U.S. Embassy Kuala Lumpur. The program was designed as a structured, two-day engagement combining introductory sessions on citizen science concepts with hands-on activities, including biodiversity observation using iNaturalist and community-based water-quality testing. Librarians played multiple roles within the program, serving as project leaders, trainers, and facilitators, coordinating sessions, guiding participants, and supporting the use of digital tools. These roles were complemented by the involvement of subject-matter experts serving as trainers and invited speakers, including academic lecturers, researchers, and citizen science practitioners. Their contributions provided specialized knowledge and practical insights, and helped align each module with the program's learning objectives. This collaborative model reflects an integrated approach, combining library-led coordination with domain-specific expertise to enhance the program's overall quality and relevance. Building on the earlier Bridging Worlds: Libraries as Connectors in Citizen Science (2024) initiative, the program expanded its scope to engage diverse groups of participants, including students and local communities. The selection of Sarawak and Sabah reflects their ecological significance and the importance of engaging communities in environmental monitoring through accessible, library-based platforms.

This study examines participants' perceptions and experiences following the Borneo Adventure program, including their reported awareness, confidence, engagement, and perceptions of libraries' role in supporting participatory science. In addition, the study explores the opportunities for future engagement that participants identified following the program. By documenting this case, the study contributes empirical insights to the global discourse on GLAM-based citizen science, particularly within a Global South context, and highlights the potential of libraries as accessible platforms for community-based scientific engagement.

To guide this study, the following research questions (RQs) are addressed:

RQ1: What are participants' perceptions of citizen science following their participation in the program?
RQ2: How do participants perceive the role of libraries in supporting citizen science initiatives?

RQ3: What opportunities and perceived outcomes for engagement emerge from the implementation of the Borneo Adventure program?

LITERATURE REVIEW

Citizen science has become an increasingly recognized approach to public participation in scientific research, enabling individuals and communities to contribute to data collection, analysis, and dissemination across diverse disciplines (Bonney et al. 2016). It is widely associated with the broader movement toward open science, emphasizing inclusivity, transparency, and collaborative knowledge production between experts and non-experts (Hecker et al. 2018). At the same time, scholars have noted that citizen science remains a diverse and evolving field, with definitions and participation models continuing to expand across different contexts (Haklay 2018). Empirical studies have shown that citizen-science initiatives can contribute to large-scale datasets while also supporting environmental awareness, scientific literacy, and community engagement (Fraisl et al. 2022).

In recent years, attention has increasingly turned to the role of cultural and educational institutions, particularly galleries, libraries, archives, and museums (GLAM), in facilitating citizen science. These institutions are recognized as important intermediaries that bridge science and society by providing trusted, accessible, and community-oriented spaces for engagement (Cigarini et al. 2020). Museums have long employed participatory approaches through exhibitions, digital collections, and interactive platforms to foster public dialogue and environmental awareness (Ridge 2014; Pierroux et al. 2020). Libraries, while more recent entrants into this space, are increasingly positioned as key enablers of citizen science because of their roles in promoting information literacy, lifelong learning, and equitable access to knowledge (Bridgeman 2023).

A growing body of research in Europe and North America has explored how libraries can serve as facilitators or hosts for citizen science activities. In Europe, initiatives associated with the LIBER Citizen Science Working Group and Public Libraries 2030 have demonstrated how libraries support community engagement in environmental monitoring, astronomy, and local history projects by providing infrastructure, training, and access to digital tools (Cigarini et al. 2020). Similarly, Vohland et al. (2021) highlight how citizen science initiatives integrate research activities with public engagement and learning, particularly through structured collaboration between institutions and communities. In North America, programs such as the Citizen and Community Science Library Network, supported by SciStarter and Arizona State University, illustrate how libraries can facilitate citizen-science participation through community partnerships, digital platforms, and training initiatives.

While these studies demonstrate the expanding role of libraries in citizen science, the evidence remains heavily concentrated in Western contexts. Research from non-Western and developing regions is comparatively limited, particularly in Asia. Existing studies indicate that citizen-science initiatives in the region are often driven by universities and nongovernmental organizations (NGOs), with limited systematic involvement from public and academic libraries (Haklay et al. 2021; Nurfarawahidah et al. 2023). Few empirical studies have examined how libraries in Southeast Asia integrate citizen science into their services or collaborate with community and research partners to build capacity. This gap reflects broader inequalities in citizen-science scholarship, where perspectives from the Global South remain underrepresented in global networks and academic publications (Kullenberg and Kasperowski 2016). Addressing this imbalance is essential to ensuring that citizen science develops as a more inclusive and contextually grounded global practice (Lewenstein 2022).

In response to this gap, this study provides empirical insights from Malaysia by examining a library-led citizen science program within the Borneo Adventure initiative. Rather than making broad claims of impact, the study focuses on participants' perceptions, experiences, and reflections on their engagement with citizen science and the role of libraries in facilitating such initiatives. By situating the Borneo Adventure case within the broader discourse on GLAM-based citizen science, the study contributes to ongoing discussions on how libraries function as mediators of participatory research and enablers of community engagement in emerging contexts.

THEORETICAL FRAMING

Frameworks inform this study of public participation in scientific research and informal, free-choice science learning. Typologies of citizen science distinguish contributory, collaborative, and co-created models, and locate public involvement along a continuum of engagement (Bonney et al. 2016; Haklay 2013). Within this framing, the Borneo Adventure program is best understood as a contributory-to-collaborative initiative in which participants engage with science through informal, hands-on activities and guided facilitation rather than formal instruction, and may thereby develop awareness, confidence, and interest. Libraries, in turn, function as trusted, community-embedded settings for public engagement with science that lower barriers to participation and connect researchers, community partners, and the public (Cigarini et al. 2020). This

perspective informs the interpretation of participants' perceptions reported in this study and is consistent with recent evidence on embedding citizen science within library services (Cox et al. 2026).

METHODOLOGY

RESEARCH DESIGN

This study employed a mixed-methods approach, combining quantitative survey analysis with qualitative thematic interpretation to examine participants' perceptions and experiences in the Borneo Adventure: Citizen Science in Action 2025 program. The research focused on understanding key dimensions of participant engagement, including awareness of citizen science, perceived confidence in participation, perceptions of libraries' role, and the opportunities and potential for future engagement arising from program implementation.

The mixed-methods design enabled the integration of quantitative trends and qualitative insights, providing a more comprehensive understanding of participants' reported knowledge, attitudes, and engagement following participation in a library-led citizen science initiative. Quantitative data captured overall patterns of perception, particularly regarding the relevance of citizen science and libraries' roles. In contrast, qualitative data provided deeper insights into participants' experiences, including self-reported changes in attitudes or intended behavior, motivations for continued engagement, and perspectives on program expansion and sustainability. By combining these approaches, the study offers a multi-dimensional analysis of citizen science engagement, linking measurable perceptions with lived experiences and enabling a more nuanced interpretation of participants' experiences and perceptions within a library-led context.

CONTEXT OF THE STUDY

The Borneo Adventure: Citizen Science in Action 2025 program was implemented as a collaborative initiative involving the Librarian Association of Malaysia (PPM), Sekitar Kita (a non-governmental organization focused on environmental education), Universiti Malaya, Universiti Teknologi MARA (UiTM) Pahang Library, Universiti Malaysia Sabah (UMS), the American Corners Malaysia, and public libraries across Sarawak and Sabah. The U.S. Embassy Kuala Lumpur supported the program and built on the earlier initiative, Bridging Worlds: Libraries as Connectors in Citizen Science (2024).

The program aimed to introduce citizen science concepts and promote environmental awareness through biodiversity monitoring and water-quality observation activities. Each program site followed a structured two-day format integrating both theoretical and practical components, with different participant groups engaged on each day.

Day one, with school and college students, focused on introducing citizen science concepts, environmental awareness, and biodiversity observation techniques. The sessions combined theoretical input with hands-on activities using the iNaturalist application. Participants engaged in guided outdoor fieldwork near the public library, where they conducted biodiversity observations, documented findings, and uploaded data to the platform.

Day two, with local community members aged 18 and above, was similar to day one; the sessions integrated theoretical explanations with practical activities. The second module focused on water quality monitoring, where participants were introduced to the importance of water quality and basic testing techniques. This was followed by hands-on activities in which participants collected water samples from nearby locations and conducted water quality testing.

Libraries served as host venues and coordination hubs, facilitating training sessions and supporting participation across different community groups. Data collection was conducted at the end of each session to capture participants' immediate reflections on both the theoretical and practical components of the program.

PARTICIPANTS

Participants in this study comprised librarians, educators, university students, community members, and volunteers from Sarawak and Sabah who attended the citizen science sessions conducted at selected public libraries. Participants were recruited through program announcements disseminated via social media platforms, institutional communication channels, and library networks. Librarians and educators primarily attended the program as part of their professional development and interest in citizen science initiatives. At the same time, students and community members participated voluntarily, motivated by their interest in environmental issues, the learning opportunities, and the prospect of community engagement.

The program was organized over two days, where participants on day one primarily consisted of students, while day two involved local community members aged 18 and above. Librarians and facilitators were also present throughout the sessions to support program implementation and engagement activities. A total of 320 valid responses were obtained through structured questionnaires and open-ended feedback forms administered at the end of each session. Participation in the study was voluntary, and

all responses were anonymized to ensure confidentiality and protect participants' privacy.

INSTRUMENTS AND DATA COLLECTION

The data collection instrument consisted of two components, quantitative and qualitative. The quantitative component comprised a structured questionnaire containing rating scale items designed to assess participants' perceptions of citizen science and the role of libraries in supporting citizen science initiatives. Five items from the questionnaire are reported in this study, focusing on the contribution of citizen science to scientific knowledge, the importance of library engagement in citizen science, the relevance of citizen science to librarians' professional roles, and the alignment of citizen science with libraries' missions and goals (Table 1).

Items Q1–Q3 appeared in a section asking participants to reflect on their views before attending the program, and Q4–Q5 in a section on their views after attending; both sections were completed at the same time, at the end of each session. All items used the same five-point rating scale provided in the form (1 = Poor, 2 = Fair, 3 = Good, 4 = Very good, 5 = Excellent), with higher scores indicating more positive perceptions. Items were developed based on key constructs in citizen science literature, including awareness, engagement, and participation. The instrument was reviewed by members of the research team with expertise in citizen science and library services to check the clarity and relevance of items prior to administration. As the questionnaire was designed specifically for this program, formal psychometric validation and pilot testing were not undertaken, and a single Poor–Excellent scale was used rather than response labels tailored to each item, so ratings are interpreted as the relative strength of positive perceptions. This is acknowledged as a limitation, and future studies could adopt validated or pilot-tested instruments.

The qualitative section involved open-ended questions that invited participants to describe their learning experiences, perceptions of library involvement, and reflections on program outcomes, including opportunities for future engagement and suggestions for improvement. Data were collected immediately after each session to capture participants' reflections on both theoretical and practical components of the program. Responses were gathered through printed forms and digital submissions via Google Forms. All responses were anonymized and labeled (e.g., P1, P2, P3) to ensure confidentiality.

DATA ANALYSIS

Quantitative data were analyzed using descriptive statistics, including frequency distributions, percentages, and mean scores, to identify overall trends in participants' perceptions of citizen science and the role of libraries. This analysis provided a general overview of participants' ratings across key variables.

Qualitative data were analyzed thematically following Braun and Clarke's (2006) framework. Responses were first read repeatedly for familiarization, followed by inductive coding to identify recurring concepts and patterns. The codes were then grouped into five overarching themes:

1) Awareness of citizen science
2) Perceived confidence in citizen science participation
3) Role of libraries and collaboration
4) Opportunities from program implementation
5) Future engagement and perceived behavioral intentions

NO	RESPONDENTS' PERCEPTIONS	MEAN	MEDIAN	MODE	SUM
Q1	To what extent do you believe citizen science can contribute to the advancement of scientific knowledge?	4.29	5.00	5	1363
Q2	In your opinion, how important is it for libraries to actively engage in citizen science initiatives?	4.46	5.00	5	1417
Q3	How relevant do you believe citizen science is to the role of a librarian?	4.26	4.00	5	1355
Q4	After attending this event, in your opinion, how important is it for libraries to actively engage in citizen science?	4.58	5.00	5	1455
Q5	After attending this event, to what extent do you think citizen science aligns with the mission and goals of libraries?	4.52	5.00	5	1437

Table 1 Respondents' perceptions of citizen science and its relevance to libraries.

Coding was conducted collaboratively by the research team, and themes were reviewed to ensure consistency, credibility, and alignment with the data.

VALIDITY AND RELIABILITY

Triangulation was achieved by integrating quantitative and qualitative data sources. The combination of structured questionnaire responses and open-ended feedback provided complementary perspectives on participants' responses. Credibility was strengthened through collaborative coding and peer review among the research team to ensure consistency in thematic interpretation. Participation in the study was voluntary, and all responses were anonymized. The study adhered to institutional ethical guidelines for research involving human participants.

FINDINGS

A total of 320 participants responded to the study, representing diverse demographic backgrounds (Figure 1). The majority were students (192 respondents, 60.0%), followed by members of the public (58 respondents, 18.1%) and librarians (46 respondents, 14.4%). Smaller proportions included lecturers (11 respondents, 3.4%), researchers (5 respondents, 1.6%), teachers (3 respondents, 0.9%), and library assistants (3 respondents, 0.9%), while 2 respondents (0.6%) did not specify their position. This distribution reflects the strong representation of students and the general public, consistent with the program design in which day one engaged students and day two engaged community members. The presence of librarians also reflects professional engagement, although their proportion relative to students indicates opportunities for further strengthening librarian involvement in citizen science programs.

The descriptive statistics in Table 1 indicate how respondents perceive the role of citizen science in relation to scientific knowledge and the evolving functions of libraries. Overall, mean values across all five items ranged between 4.26 and 4.58 on a five-point rating scale, reflecting generally positive perceptions among participants. The consistency of median and mode values at 4 or 5 further indicates consistently positive responses across respondents.

Respondents reported that citizen science contributes to the advancement of scientific knowledge (M = 4.29), suggesting recognition of its relevance beyond community engagement activities. Similarly, the importance of libraries actively engaging in citizen science received a higher rating (M = 4.46), indicating that participants perceive libraries as relevant facilitators of participatory knowledge creation.

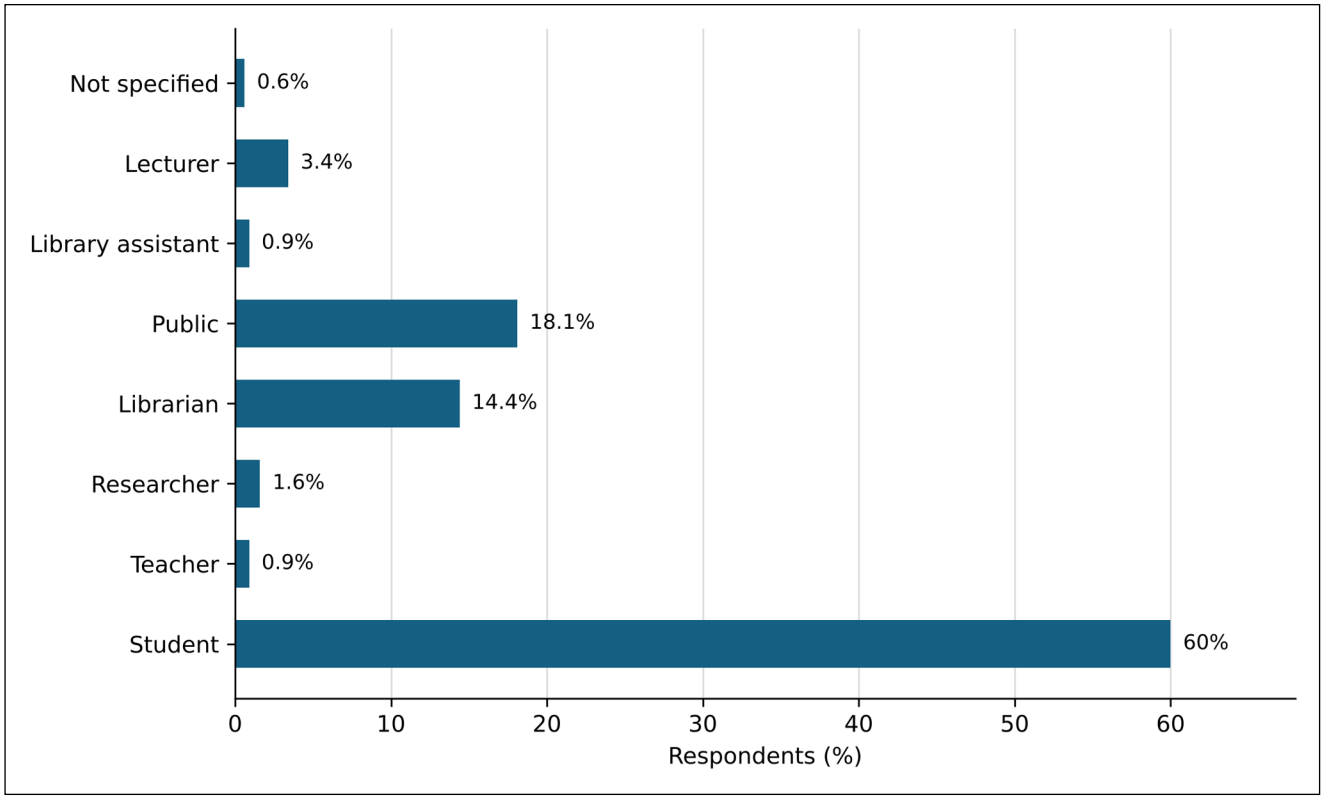

Figure 1 Distribution of respondents.

The item measuring the relevance of citizen science to the professional role of librarians recorded the lowest mean among the five variables (M = 4.26). While still positive, this suggests some variability in how respondents perceive the direct integration of citizen science within librarianship. This finding indicates a potential need for further discussion, training, or institutional alignment to strengthen its perceived relevance within professional practice.

The highest mean score was recorded for the post-event item regarding the importance of library engagement in citizen science (M = 4.58). This indicates that participants reported strongly positive perceptions of the role of libraries in citizen science, following the program. As all items were administered at the end of each session, these ratings reflect post-program perceptions rather than measured change from a pre-program baseline. Similarly, the perception that citizen science aligns with the mission and goals of libraries (M = 4.52) indicates that respondents generally view it as compatible with the broader objectives of library services.

Read alongside the other items, these results suggest that participants perceive citizen science as both scientifically relevant and aligned with the role of libraries. The consistently high ratings indicate strong support for library involvement, while the slightly lower score on professional role relevance highlights an area for further development. Table 1 shows the descriptive analysis for each question.

The findings in Figure 2 indicate that respondents generally perceive citizen science as contributing to the advancement of scientific knowledge. Out of 318 valid responses to this item (two participants did not respond), more than half of the participants (52.8%) selected the highest rating (5 = Excellent), while 29.2% rated it as 4 (Very good). Together, these figures suggest that over 80% of respondents hold strong positive perceptions of its scientific value. A smaller proportion rated it as 3 (12.3%), while only a limited number selected lower ratings.

The results in Figure 3 indicate that respondents generally perceive citizen science as relevant to the professional role of librarians. Of the 318 valid responses to this item, 49.7% selected the highest rating, and 32.7% rated it as 4, suggesting that more than 80% of participants view citizen science as relevant to librarianship. A smaller proportion selected the middle rating, while only a limited number perceived it as less relevant.

The post-event items in Figure 4 indicate that, following the program, respondents held strongly positive views of both the importance of library engagement in citizen science and its alignment with library functions. When asked about the importance of libraries actively engaging in citizen science following the event, the majority rated

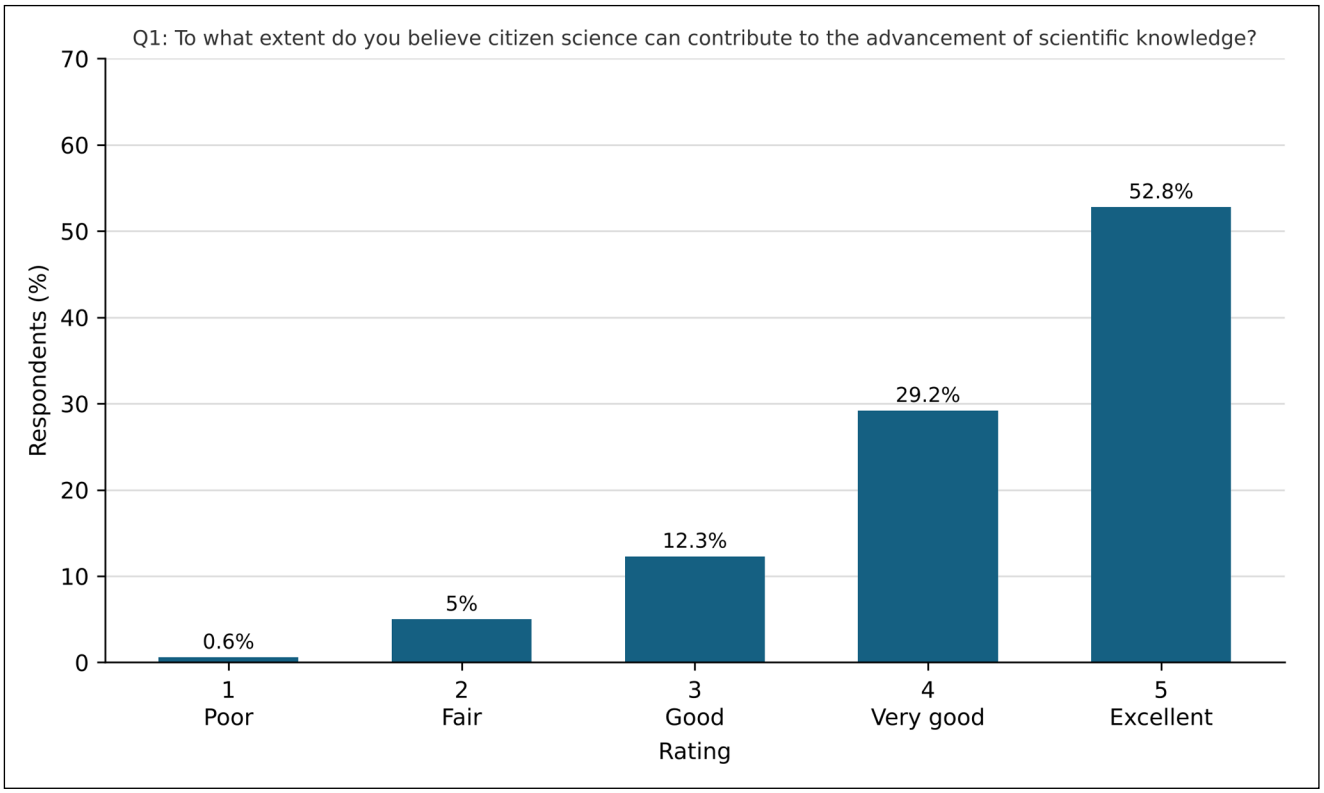

Figure 2 Respondents' perception of citizen science contribution to the advancement of scientific knowledge.

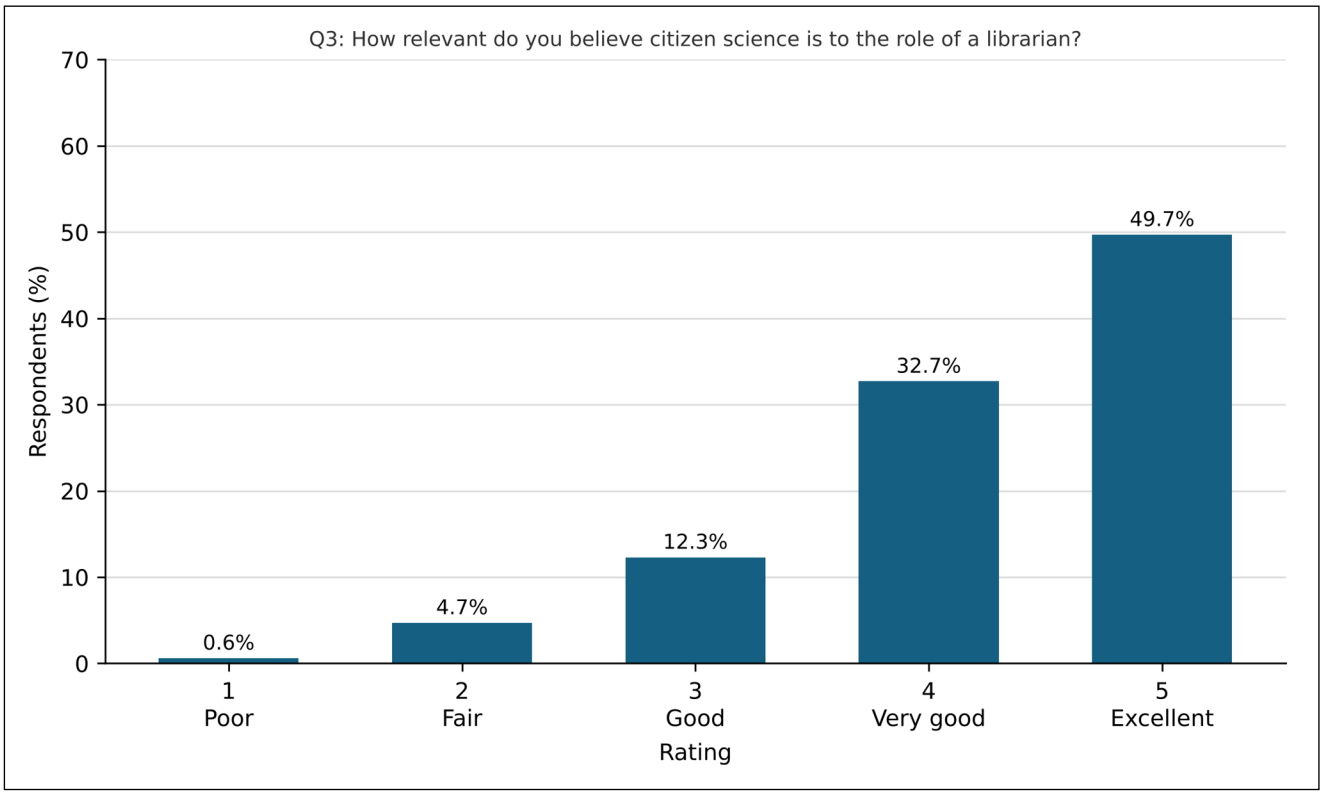

Figure 3 Relevance of citizen science in librarianship.

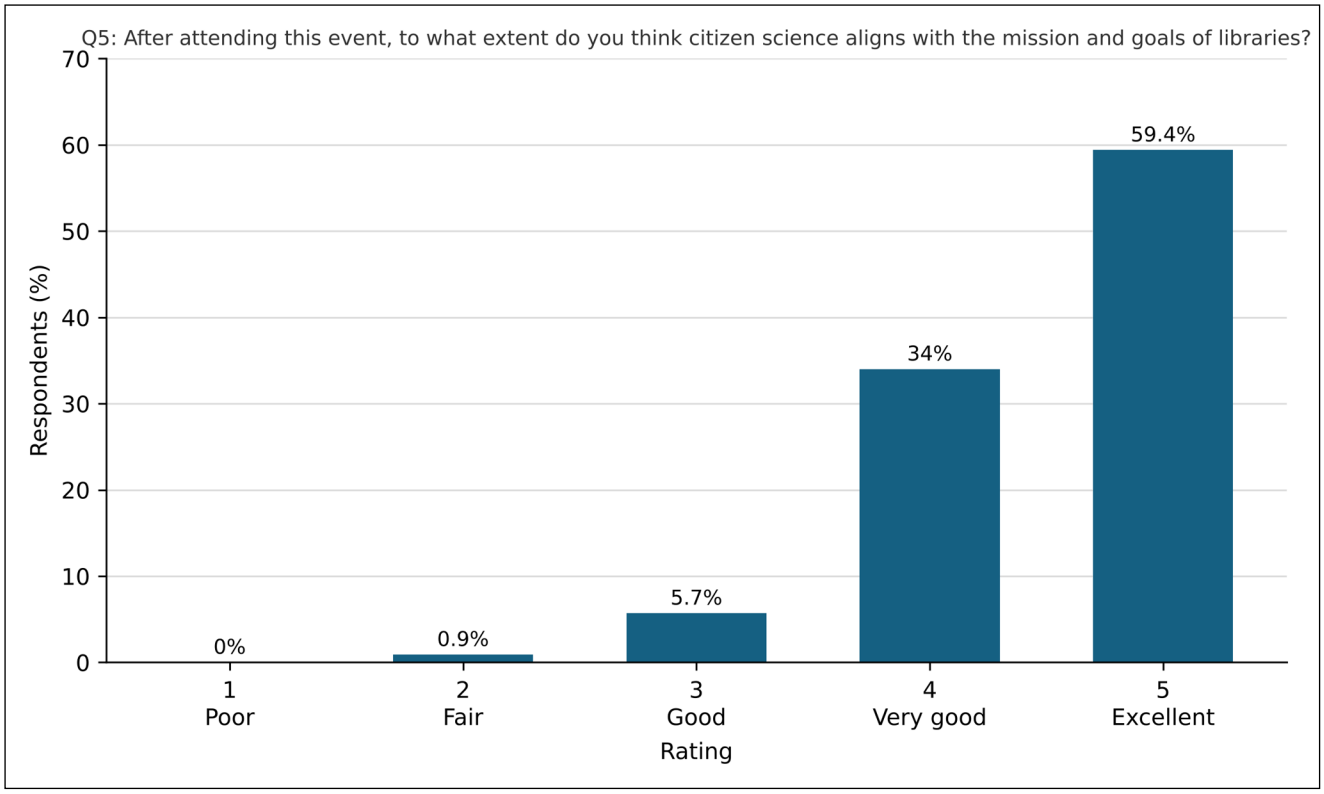

Figure 4 Citizen science alignments.

it highly, with 63.5% selecting 5 (Excellent) and 30.8% selecting 4 (Very good).

A similar pattern was observed regarding perceived alignment with the mission and goals of libraries. Nearly 60% of respondents rated this item 5 (Excellent), while 34.0% rated it 4 (Very good). Only a small proportion selected 3 or 2. These results suggest that participants perceive citizen science as relevant to library practice and broadly compatible with institutional goals.

QUALITATIVE FINDINGS

The findings are presented across five interrelated themes, beginning with participants' initial exposure to citizen science. This first theme highlights how participants described developing awareness and understanding of citizen science as a foundational stage that informs subsequent engagement.

Theme 1: Awareness of citizen science

Participants consistently described the program as a first point of exposure to citizen science and environmental knowledge, highlighting its role in introducing unfamiliar concepts to a broad audience. Many responses reflected a sense of discovery, with participants describing the experience as "an eye opening... especially on citizen science movement" (P47) and noting that a "wide array of information regarding citizen science was shared" (P64). Others emphasized newly acquired knowledge and opportunities for engagement, including "new information on how to become [a] citizen scientist & opportunity to contribute" (P57), as well as simply "got new knowledge from this session" (P49) and appreciation for "the knowledge and the information about citizen science" (P46). These responses suggest that participants experienced the program as an entry point into citizen science, particularly those with little prior exposure.

A key factor supporting this awareness was the clarity and accessibility of content delivery. Participants highlighted facilitators' ability to communicate complex ideas in a simplified and engaging manner, noting that "the speaker was very clear in explaining what we can do as citizen scientists" (P62) and that the session "made it simple for beginners to understand" (P66). Others emphasized the use of relatable explanations, such as "breaking things down step by step" (P75), as well as personalized engagement, where facilitators "remember[ed] our name[s]... and explain[ed] complex concepts in a simple and clear way" (P45). These findings underscore the importance of effective science communication in making citizen science accessible to diverse audiences.

Beyond conceptual understanding, participants also reported increased awareness of environmental issues, particularly biodiversity. This was reflected in statements such as "it makes me more aware on the flora and fauna around me" (P52) and "help[ed] to open my mind to be more responsible toward our earth, nature and environment" (P65). Participants also described greater ecological understanding, noting that they had "learned... about animals in more detail and the different environment they all live in" (P59) and described gaining awareness of "natural environment that are always beside us" (P54). Together, participants described the program as not only introducing citizen science as a concept but also prompting greater awareness of the natural environment, which they associated with clear communication, accessible learning approaches, and contextual relevance.

Theme 2: Perceived confidence in citizen science participation

In addition to increased awareness, participants reported greater confidence and perceived capability to engage in citizen science activities. This confidence was often reflected in participants' expressed belief in their ability to contribute to scientific efforts. For example, one participant noted that the program "gives me potential about being a scientist" (P144), while another highlighted that the experience was "able to develop confidence and self-belief in expressing opinions and sharing ideas" (P319). Similarly, participants expressed personal growth, stating that they felt "very proud... and able to explain what I want smoothly" (P320). These responses suggest that some participants experienced the program as personally empowering, including feeling empowered to express their ideas.

A key driver of this increased confidence was the program's emphasis on hands-on activities and practical engagement with tools. Participants frequently highlighted experiential learning as instrumental in building their understanding and capability. For instance, one participant noted that "the trainer delivered the knowledge clearly... I got to do chemical test on water which is a new experience" (P22), while another emphasized that facilitators "did a lot of hands-on activities... instead of learning theory" (P90).

The introduction of digital tools further reinforced this confidence, particularly in relation to citizen science practices. Participants appreciated being exposed to applications such as iNaturalist, noting that the program "introduced apps like iNaturalist" (P88) and provided "good explanations... on how to use [the] apps and determine water quality" (P62). Importantly, guided facilitation played a critical role, as participants highlighted that "they assisted us... until we are able to do them ourselves and understand" (P136). These findings suggest that participants viewed experiential and supported learning as central to moving

from passive learning toward active contribution, and to their reported competence and confidence in engaging with citizen science activities.

Theme 3: Role of libraries and collaboration

Participants' reflections highlight the role of libraries and program organizers as key enablers of citizen science through education, facilitation, and collaborative engagement**.** The program was widely perceived as an effective learning platform that complements formal education, particularly in fostering awareness and interest in science among younger audiences. For example, one participant noted that the session provided "good information to learn at school" (P57), while others emphasized its value in raising awareness of biodiversity and engaging students, describing it as a "good activity to create awareness among youngsters" (P18) and recognizing how facilitators "play their role to educate people… so citizen[s] can be more aware" (P58).

Participants also highlighted the importance of structured guidance and facilitation**,** acknowledging the active role of trainers in supporting their learning process. As reflected in the data, "the trainers were very helpful in guiding… throughout the program" (P217), and "they assisted us… until we are able to do them ourselves and understand" (P136). Others further recognized the facilitators' effort and commitment, noting that "they put so much effort to let us understand what we are going to do next" (P82).

Beyond facilitation, the program was perceived as a space for knowledge sharing and community empowerment**,** where participants were encouraged to actively engage with scientific knowledge and contribute to environmental sustainability. One participant noted that the session "enriched our understanding [and] encouraged active participation… within the community" (P264), while others expressed appreciation for the sharing of knowledge, including "initiatives in citizen science" (P176) and insights on how to contribute to "environmental sustainability and ecological balance" (P319).

Participants also described strong interaction and collaboration during the sessions, which they associated with greater engagement and a more enjoyable learning experience. In particular, they described how facilitators actively involved them in activities, noting that "the presenters try their best to… ensure the students [are] involved" (P97) and that "they make us all involved… which are actually fun" (P198). This collaborative approach was further reflected in shared learning experiences, where "the speaker shows the work together with us" (P175).

Importantly, participants emphasized the program's accessibility and inclusiveness**,** particularly in the way scientific concepts were communicated. One participant noted that the program was "capable to attract interest, and explain complicated things to the layman" (P299), while others appreciated the use of relatable explanations and simplified delivery, such as "breaking things down step by step" (P23). The use of language was also highlighted as a key factor, with participants noting the use of "dual language (English and Malay)" (P227) and appreciating facilitators who "used accessible and familiar language to enhance participants' understanding" (P140). These findings suggest that participants viewed libraries as inclusive learning hubs and facilitators of citizen science, supporting not only knowledge acquisition but also collaborative participation and community engagement.

Theme 4: Opportunities from program implementation

Participants' responses point to opportunities for continued engagement and expansion**,** suggesting potential for the program to develop into a longer-running citizen science initiative. Participants consistently expressed strong enthusiasm to re-engage in similar programs, with many stating that they were "interested in participating… again" (P237) and "would not hesitate to participate" if given another opportunity (P236). Others conveyed a more personal attachment to the program, noting "I want to make this program season 2… because I love this program so much" (P180), while some emphasized its benefits in supporting communication and learning, expressing hope that "they did this program again… [as] it help[s] me to communicate with others and learn new things" (P151). Additional responses further reinforced this enthusiasm, including requests to "please do more program like this in future" (P289) and "more citizen science programs should be organized… it was a very good experience… I would be keen to participate again if similar programs are offered" (P318), reflecting strong stated interest in future participation.

Beyond individual engagement, participants also highlighted the importance of expanding the program to reach wider and more diverse audiences**,** particularly younger students and underserved communities. Concerns about declining interest in STEM were evident, with participants emphasizing that "more citizen science programs [should] be organized especially for primary and secondary students" (P61). Others suggested geographical expansion, proposing that such initiatives be extended to areas with rich biodiversity, such as districts "where a rich diversity of flora and fauna can be found" (P225), as well as underserved communities, including "children from remote interior regions of Sabah" (P319). Participants also recommended diversifying program content and

outreach, including "developing various topics across different branches of knowledge" (P228), "educat[ing] more students about citizen science" (P16), and opening programs to younger participants such as "primary school students… to educate them on the knowledge" (P159). In sum, participants' suggestions point to potential for scaling the program, broadening its inclusivity, and using citizen science initiatives as platforms for STEM engagement.

Theme 5: Future engagement and perceived behavioral intentions

The findings further indicate that participants anticipated continued engagement with citizen science**,** which they expected to extend into their daily lives, interests, and future actions. Participants highlighted the practical relevance of the program, noting that it was "applicable to everyday life" (P188) and "informative and close to daily life" (P122), while others emphasized that the knowledge gained was "very useful… to practice" (P236). The integration of digital tools also supported continued engagement, with one participant sharing that using apps for biodiversity observation "complement[s] my hobby on bird watching and photography" (P52).

Beyond practical application, participants described a perceived shift in mindset and continued interest in science and nature**.** Several noted that the program "made me more interested in science" (P237), while others reflected on a broader reconceptualization of science, recognizing that it is not limited to laboratory settings but also involves engagement with the natural environment (P328). This shift was further reinforced by a more inclusive understanding of scientific participation, with participants expressing that "all of us can be a scientist" (P182) and that "everyone can be a scientist even young children" (P171). In addition, participants reported developing a deeper appreciation of the environment, as reflected in expressions such as "a deeper appreciation for the environment" (P326).

Participants also indicated intentions to extend their learning into community-based engagement and knowledge sharing**,** suggesting that they would "share… how important it is [what] we learn" (P323) and proposing initiatives such as "creat[ing] clubs and communities… for deep knowledge learning and sharing" (P118). Others highlighted the potential value of collective participation, noting that increased involvement could "attract [people] into science for future research & knowledge" (P117).

At a wider level, participants recognized the potential of citizen science to contribute to societal and generational development**,** with one noting that "citizen scientist is important for the development of [the] country" (P127), while others expressed hope that such initiatives would continue "for the next generation" (P295). Concerns about declining interest in STEM further reinforced the importance of sustaining such programs, particularly for younger audiences (P61). These findings suggest that, immediately after the program, participants expressed intent to stay involved, continued interest in science, and aspirations toward community-driven citizen science practices**.**

SUMMARY OF FINDINGS

Across the quantitative and qualitative data, a consistent pattern emerges. High mean scores (4.26–4.58) reflect strong positive perceptions of citizen science and its alignment with the role of libraries, while the qualitative findings trace a reported progression from initial awareness to increased confidence and interest in participation. Participants viewed libraries as accessible platforms for community-based science, and reported perceived changes in attitudes and intentions for future engagement.

DISCUSSION

The findings suggest that libraries may hold a strategic and underexplored position in advancing citizen science within the Malaysian and broader Asian context. The Borneo Adventure: Citizen Science in Action 2025 program illustrated the potential of libraries as inclusive and trusted platforms for fostering scientific literacy, public participation, and collaborative learning. The consistently high quantitative ratings and positive qualitative feedback suggest that citizen science programs anchored in library settings may broaden participation in science and strengthen community connections to research.

This study aligns with global evidence showing that GLAM institutions, particularly libraries, are evolving from repositories of knowledge into facilitators of co-created learning (Cigarini et al. 2020). Similar to initiatives in Europe and North America, the Malaysian experience suggests that when libraries embed citizen science into their programming, they may broaden how participants perceive science, from expert-led inquiry toward community-driven discovery. Participants' reported awareness and understanding of biodiversity and environmental monitoring are consistent with European initiatives such as LIBER Citizen Science Working Group and Public Libraries 2030, which highlighted libraries' potential to expand inclusivity in scientific participation. The findings also contribute to the growing literature emphasizing the importance of confidence and capacity building among librarians (Tenopir et al. 2015). Participants in the Borneo Adventure program expressed enthusiasm but also indicated the need for more structured training to sustain engagement. This echoes Tautkevičienė and Pranckutė's (2024) argument that

librarians' involvement in citizen science requires not only motivation but also the development of new competencies in facilitation, data management, and outreach. By offering experiential learning through biodiversity tracking and water quality testing, the program provided participants with practical exposure to scientific methods within a familiar learning environment.

Another key contribution of this study lies in its exploration of collaboration as a foundational pillar of sustainable citizen science. The partnerships between academic, public, and community libraries, alongside NGOs and governmental agencies, illustrate the potential for multi-sectoral cooperation in participatory research. These collaborative frameworks reflect the networked model proposed by Hecker et al. (2018), where citizen science sustainability depends on distributed leadership, institutional alignment, and mutual reinforcement between professional and community actors. The Malaysian model, characterized by its inclusion of the Librarian Association of Malaysia (PPM), Sekitar Kita, and American Corners, provides an example of how cross-institutional alliances can operationalize citizen science in regions where institutional structures are still emerging. Equally significant is the theme of sustainability and future engagement. Participants' expressed desire for continuity underscores the need for long-term institutional commitment to citizen-science initiatives within libraries. This finding is consistent with Haklay's (2018) notion that for citizen science to achieve social transformation, it must be integrated into stable community infrastructures. Libraries, as enduring civic institutions, are well positioned to provide this continuity. Aligning citizen science initiatives with broader educational and environmental objectives may support ongoing participation, iterative learning, and policy relevance.

The implications of these findings extend beyond Malaysia. They contribute to a global call for diversification in citizen science research, amplifying voices from the Global South, where institutional and cultural contexts differ significantly from the Western-centric models that dominate the literature (Kullenberg and Kasperowski 2016). The Borneo Adventure case illustrates how contextual adaptation through localized partnerships, culturally relevant outreach, and integration into existing library frameworks may support accessible and potentially sustainable citizen science in developing regions. Ultimately, this study suggests that libraries are increasingly positioned as potential agents of social change within the participatory science ecosystem. Their ability to convene diverse stakeholders, provide open access to information, and maintain continuity between scientific institutions and communities uniquely situates them to advance open science and lifelong learning. The Malaysian experience thus broadens the conceptualization of GLAM-based citizen science, offering a practical example of how libraries may contribute to scientific literacy, environmental stewardship, and the UN SDGs.

CONCLUSION AND RECOMMENDATIONS

This study provides evidence that participants viewed libraries as important facilitators of citizen science and community engagement. The Borneo Adventure: Citizen Science in Action 2025 program provides a strong example within the Malaysian context, showing how citizen science can be embedded within library ecosystems. The quantitative and qualitative findings indicate that participants reported increased awareness of citizen science and confidence in participating in scientific activities, as well as a clearer recognition of the role of libraries in supporting scientific literacy and participation. These findings highlight the evolving role of libraries as inclusive platforms for participatory science, extending beyond traditional information services toward facilitating collaboration, knowledge co-creation, and community engagement. The findings further suggest the potential of library-led initiatives to support environmental awareness, public participation, and continued engagement with science, aligning with broader movements in open and participatory science. As data were collected immediately after each session, these findings reflect participants' perceptions, experiences, self-reported changes, and intentions; they do not establish causal effects, sustained behavioral change, or longer-term institutional or community outcomes. Future studies could combine pre- and post-program measures with follow-up data collection. To build on these findings and explore longer-term outcomes, several recommendations are proposed. First, there is a need for capacity building among librarians, particularly in citizen science methodologies, data management, and facilitation skills, to support effective program delivery. Second, the development of structured frameworks and practical toolkits can guide implementation while allowing flexibility for local adaptation. Third, strengthening multi-sectoral collaborations among libraries, academic institutions, NGOs, and governmental agencies is essential to enhance scalability and long-term sustainability.

From a policy perspective, embedding citizen science within national library and education strategies may support institutionalization and help secure sustained funding and recognition. In addition, the integration of digital platforms and open-data systems can enhance accessibility, visibility, and alignment with global initiatives

such as the SDGs, particularly SDG 4 (Quality Education), SDG 13 (Climate Action), and SDG 15 (Life on Land).

Overall, this study contributes to the growing discourse on GLAM-based participatory science by providing empirical evidence from a Global South context. It suggests that libraries have strong potential to support inclusive scientific engagement and participatory approaches to science. As citizen science continues to expand, libraries are well-positioned to play a leading role in advancing a more inclusive and sustainable scientific ecosystem.

DATA ACCESSIBILITY STATEMENT

The data generated and analyzed in this study include aggregated survey results and open-ended participant responses. Aggregated findings may be made available from the corresponding author upon reasonable request. However, individual-level survey responses and open-ended responses are not publicly available due to confidentiality, privacy considerations, and the possibility of identifying participants through contextual information. Data are therefore reported and shared only in aggregated form to protect participant anonymity.

ETHICS AND CONSENT

This study involved human participants and received ethical approval from the Universiti Malaya Research Ethics Committee (UMREC), approval reference number UM.TNC2/UMREC_3363. All participants were informed about the purpose of the study, the voluntary nature of their participation, their right to withdraw, and the confidentiality of their responses. Informed consent was obtained from all participants before data collection. All responses were anonymized before analysis, and no personally identifiable information is reported in the manuscript.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Nurfarawahidah Badruesham led the conceptualization of the study, program design, and overall coordination of the research. She was involved in data collection, analysis, and manuscript preparation. Mohd Faizal Hamzah contributed to program implementation and was involved in data collection and the development of data collection materials. All co-authors contributed to the implementation of the program, supported data collection, and contributed to the development and review of the manuscript. All authors reviewed and approved the final version of the manuscript.

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REFERENCES

Ambole, A., Anditi, C., and **Oni, T.** (2025) Potential of citizen science to advance urban planetary health research in low- and middle-income countries: a scoping review. *PLOS Global Public Health*, 5(5), e0003958. DOI: https://doi.org/10.1371/journal.pgph.0003958

Bonney, R., Phillips, T.B., Ballard, H.L., and **Enck, J.W.** (2016) Can citizen science enhance public understanding of science? *Public Understanding of Science*, 25(1), pp.2–16. DOI: https://doi.org/10.1177/0963662515607406

Bowser, A., Wiggins, A. and **Stevenson, R.D.** (2013) *Data policies for public participation in scientific research: a primer*. Albuquerque, NM: DataONE.

Braun, V. and **Clarke, V.** (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), pp.77–101. DOI: https://doi.org/10.1191/1478088706qp063oa

Bridgeman, M. (2023) Public libraries can be open science laboratories for citizen science projects. *Evidence Based Library and Information Practice*, 18(2), pp.150–152. DOI: https://doi.org/10.18438/eblip30385

Cigarini, A., Bonhoure, I., Vicens, J., and **Perelló, J.** (2020) Public libraries embrace citizen science: strengths and challenges. *Library & Information Science Research*, 42(5), 101090. DOI: https://doi.org/10.1016/j.lisr.2020.101090

Cox, T., Cavalier, D., Ash, D., Giles, E., and **Nickerson, C.** (2026) Embedding citizen science in libraries: a SciStarter and Arizona State University case study of adoption, scaling, and sustaining participation. *Citizen Science: Theory and Practice*, 11(1), 9. DOI: https://doi.org/10.5334/cstp.939

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., Moorthy, I., et al. (2020) Mapping citizen science contributions to the UN sustainable development goals. *Sustainability Science*, 15(6), pp.1735–1751. DOI: https://doi.org/10.1007/s11625-020-00833-7

Fraisl, D., Hager, G., Bedessem, B., Gold, M., Hsing, P.Y., Danielsen, F., Hitchcock, C.B., et al. (2022) Citizen science in environmental and ecological sciences. *Nature Reviews Methods Primers*, 2(1), pp.1–20. DOI: https://doi.org/10.1038/s43586-022-00144-4

Haklay, M. (2013) 'Citizen science and volunteered geographic information: overview and typology of participation', in Sui, D., Elwood, S. and Goodchild, M. (eds.) *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*. Dordrecht: Springer, pp. 105–122. DOI: https://doi.org/10.1007/978-94-007-4587-2_7

Haklay, M. (2018) 'Participatory citizen science', in Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J. and Bonn, A. (eds.) *Citizen Science: Innovation in Open Science, Society and Policy*. London: UCL Press, pp. 52–62. DOI: https://doi.org/10.14324/111.9781787352339

Haklay, M., Fraisl, D., Greshake Tzovaras, B., Hecker, S., Gold, M., Hager, G., Ceccaroni, L., et al. (2021) Contours of citizen science: a vignette study. *Royal Society Open Science*, 8(8), 202108. DOI: https://doi.org/10.1098/rsos.202108

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., and **Bonn, A.** (eds.) (2018) *Citizen Science: Innovation in Open Science, Society and Policy*. London: UCL Press.

Kaarsted, T., Blake, O., Nielsen, K., Alving, B., Rasmussen, L., Overgaard, A.K., and **Hansen, S.** (2023) How European research libraries can support citizen-enhanced open science. *Open Information Science*, 7(1), pp.202–217. DOI: https://doi.org/10.1515/opis-2022-0146

Kullenberg, C. and **Kasperowski, D.** (2016) What is citizen science? A scientometric meta-analysis. *PLOS ONE*, 11(1), e0147152. DOI: https://doi.org/10.1371/journal.pone.0147152

Lewenstein, B.V. (2022) Is citizen science a remedy for inequality? *The ANNALS of the American Academy of Political and Social Science*, 700(1), pp.42–55. DOI: https://doi.org/10.1177/00027162221092697

Lotfian, M., Ingensand, J., and **Brovelli, M.A.** (2021) The partnership of citizen science and machine learning: benefits, risks, and future challenges for engagement, data collection, and data quality. *Sustainability*, 13(14), 8087. DOI: https://doi.org/10.3390/su13148087

Mumelas, D. and **Martek, A.** (2024) Benefits of citizen science for libraries. *Publications*, 12(1), 8. DOI: https://doi.org/10.3390/publications12010008

Nurfarawahidah, B., Kaur, K., and **Aspura, M.K.Y.I.** (2023) Exploring citizen science participation and challenges in academic libraries: a comprehensive qualitative study. *Pakistan Journal of Information Management and Libraries*, 24, pp.45–62. DOI: https://doi.org/10.47657/7566

Pierroux, P., Hetland, P., and **Esborg, L.** (eds.) (2020) *A History of Participation in Museums and Archives: Traversing Citizen Science and Citizen Humanities*. London: Routledge. https://doi.org/10.4324/9780429197536

Pimentel, F.A.S. and **Gomes, L.I.E.** (2024) Data on librarians' perceptions of participation in a citizen science project in a network of public libraries. *Canadian Journal of Information and Library Science*, 47(2), pp.1–9. DOI: https://doi.org/10.5206/cjils-rcsib.v47i2.17705

Ridge, M. (ed.) (2014) *Crowdsourcing Our Cultural Heritage*. Farnham: Ashgate Publishing.

Tautkevičienė, G., and **Pranckutė, A.** (2024) Competences of librarians in performing different roles in citizen science projects. *University Library at a New Stage of Social Communications Development. Conference Proceedings*, 9, pp.226–236. DOI: https://doi.org/10.15802/unilib/2024_316954

Tenopir, C., Allard, S., Sinha, P., Pollock, D., Newman, J., Dalton, E., Frame, M. et al. (2015) Research data services in academic libraries: data intensive roles for the future? *Journal of eScience Librarianship*, 4(2), e1085. DOI: https://doi.org/10.7191/jeslib.2015.1085

Todowede, O., Lewandowski, F., Kotera, Y., Ashmore, A., Rennick-Egglestone, S., Boyd, D., Moran, S., et al. (2023) Best practice guidelines for citizen science in mental health research: systematic review and evidence synthesis. *Frontiers in Psychiatry*, 14, 1175311. DOI: https://doi.org/10.3389/fpsyt.2023.1175311

Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R. et al. (eds.) (2021) *The*

Science of Citizen Science. Cham: Springer. DOI: https://doi.org/10.1007/978-3-030-58278-4

Wehn, U., Gharesifard, M., Ceccaroni, L., Joyce, H., Ajates, R., Woods, S., Bilbao, et al. (2021) Impact assessment of citizen science: state of the art and guiding principles for a consolidated approach. *Sustainability Science*, 16(5), pp.1683–1699. DOI: https://doi.org/10.1007/s11625-021-00959-2

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