

The Role of Citizen Scientist in the Emerging Scientific World: Supporting CEPA Through Advancements in Wildlife Conservation

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Abstract. Recently, citizen scientists have gained recognition for engaging the public in collaboration with professional scientists in scientific actions. Citizen scientists act as an important force contributing to the Community, Education, and Public Awareness (CEPA) initiatives and promoting sustainable development. Thus, the study's objectives are to conduct a systematic review for citizen scientists in addressing the challenges of working in environmental conservation research and to address the way forward for fellow citizen scientists. We conducted a systematic literature review using the SCOPUS database in September 2023 to review the reliable article on citizen science. The result successfully extracted 118 related articles by applying a few keywords, 'Conservation', 'Education', 'Environment', 'Management', and 'Citizen Scientist' as a primary keyword. Notably, approximately 62% of articles published focused on environmental conservation involving animals and plants. This study also highlights the contributions of citizen scientists in conserving and monitoring biodiversity, including volunteering activities. In conclusion, this review emphasizes citizen scientists' transformative potential in supporting CEPA and offers insights into the crucial role of citizen scientists and their promising pathway toward sustainability.

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1 Introduction

Emerging in the early 1990s, citizen science has rapidly expanded into a diverse field encompassing many topics and taxa [1, 2]. Commonly, it is referred as community science or public participation in scientific research; citizen science represents a collaborative scientific approach who are frequently called citizen scientists, actively participate in research and data collecting even when they have not received official scientific training [3, 4]. Citizen science is already significantly contributing to numerous scientific domains, encompassing conservation, natural resources, and environmental science [5]. Leveraging advancements in information technology over recent decades, citizen scientist has harnessed the potential to involve increasingly larger numbers of volunteers in addressing pressing ecological concerns, particularly in wildlife conservation [6]. Citizen scientists can use online resources to locate projects that interest them and learn the skills and protocols needed to formulate questions, collect data, submit it, and help process and analyse it online [7].

The involvement of citizen scientists in Community, Education, and Public Awareness (CEPA) programmes actively supports community participation and raises public understanding in the context of wildlife conservation. According to Roche et al. [8], this growing field will generate new knowledge and experience through collaboration with scientific research professionals. Hence, citizen scientists serve as direct channels for disseminating information about wildlife and environmental issues to communities and as a bridge between scientific research and the general public [9]. They also play an important role in contributing to data gathering, monitoring, and public education, as well as observing and documenting wildlife behaviour, population dynamics, and habitat characteristics, which is crucial for researchers and conservationists [5, 11]. Thus, the data collection by volunteer-generated datasets can be used to support resource management and conservation initiatives that are needed by many federal and local governments, research institutes, non-governmental organizations (NGOs), and conservation organizations [5]. Combining data has tremendous potential for monitoring the goals, which can close the knowledge gaps and increase overall understanding, especially for large-scale usage [11, 12]. This was proven by Barlow et al., who gathered the data by volunteers at 3,272 locations using standardized methods to generate statistically sound population indices for a significant portion of bat species in Great Britain [13].

Hence, efficient wildlife management at the ecosystem level can be conducted due to the intersections between citizen scientists and sustainability policies [14]. Indirectly, gathering data can lead to cost reductions in overcoming the large scope of operations that requires timely gathering and interpretation of data combined which is a substantial problem for researchers to work alone [15, 16]. The need for rapid outcomes in wildlife management highlights the importance of mobilizing the collaborative potential of citizen scientists to complement the work of professionals, guaranteeing the prompt acquisition of essential ecosystem-level wildlife data [5,17]. This capability stems from the fact that citizen scientists may extend the project's time and geographical scope, often outperforming what professional scientists might do alone [18]. However, citizen scientists' roles in research and society are still underappreciated and have yet to be completely recognized as crucial components in supporting CEPA through wildlife conservation efforts. Here, we review the publications related to citizen scientists in various fields. We also explore the strategies for advancing citizen science in tackling the challenges and charting a path forward for fellow citizen scientists in the context of wildlife conservation. The findings can help empower citizens' true potential to take ownership of their science education and learning.

2 Methodology

This study entailed a systematic review of scientific articles related to citizen scientists to compile relevant studies. Firstly, indexed published manuscripts related to citizen scientists were searched via the SCOPUS database in September-October 2023. Multiple search strings were employed, with ‘Citizen Scientist’ as the primary keyword, combined with additional keywords, including ‘Conservation’, ‘Education’, ‘Environment’, ‘Management’, and ‘Wildlife’ to enhance precision according to the indexed title, abstract, keywords, and topics.

We applied the inclusion and exclusion criteria to identify the relevant research articles. For the eligibility of articles, thorough inclusion and exclusion criteria were established, defining the types of studies suitable for inclusion within the review. The selection of articles underwent two steps: an initial review of titles and abstracts for relevance and a comprehensive evaluation of full-text articles. Next, the selected articles were classified into five thematic categories, including conservation, education, environmental, management, and wildlife, aligning these categories with the research objectives, which can help address the challenges faced by those engaged in wildlife conservation research. Additionally, this review proposes guidance for fellow citizen scientists within the wildlife conservation community, outlining a way forward for their involvement.

3 Results and Discussion

From a total of 331 articles, we included 118 articles that met the inclusion criteria without repeated articles in different keywords and excluded 213 articles that did not meet the criteria. All the retrieved articles focused on the taxonomic, educational, and public awareness of environmental aspects. Of the 118 articles, 45.7% ($n=54$) were found from the additional keyword “conservation”, followed by environment, management, education and wildlife, excluding the repeated articles. We defined ‘acceptable’ here as any articles focusing on the involvement and contribution of citizen scientists on the environmental aspects. Table 1 summarizes the number of suitable peer-reviewed articles according to the keywords.

Table 1. The number of articles is based on a literature search by the SCOPUS database.

Keywords	Total articles published	Suitable peer-reviewed articles (% already included from the previous research)
“Citizen scientist” AND “conservation”	77	54
“Citizen scientist” AND “wildlife”	19	10 (7%)
“Citizen scientist” AND “education”	67	17 (2%)
“Citizen scientist” AND “environment”	66	20 (6%)
“Citizen scientist” AND “management”	102	17(7%)
Total	331	118

The first publication on citizen scientist was published in 2007, with only two articles. No publications were available in 2008 and 2009, and the third article was published in 2010. Thereafter, the number of publications increased exponentially, before a slight decrease in 2018. (Figure 1). Articles covered various environmental and wildlife topics, including the educational program, public awareness, and conservation management that involved the community and professional agencies.

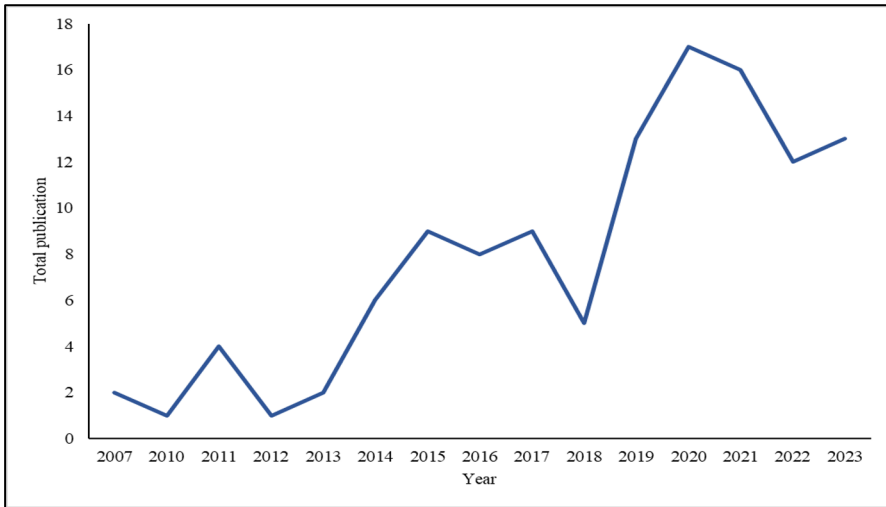


Fig. 1. The trend of publications related to citizen scientists from 2007-2023.

The involvement of citizen scientists is higher in the environmental field compared to community programmes. Out of 118 articles, 62% ($n=73$) of articles were classified as environment study involving 59 articles on animals and 14 on plants. Meanwhile, 38% ($n=45$) of articles focused on community programmes, especially volunteering activities, as shown in Figure 2.

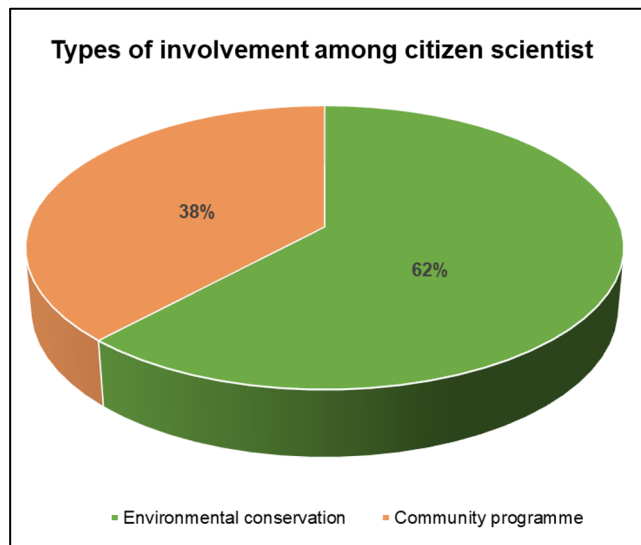


Fig. 2. Percentage of involvement among citizen scientists based on the publications.

The results show that the active involvement of citizen scientists in various scientific projects has positively impacted scientific research. Citizen scientists have become valuable contributors within a broad spectrum of scientific disciplines, making notable and important

contributions beyond the traditional boundaries of professional expertise. In the field, they complement the efforts of professional scientists by expanding the networks for data collection and facilitating data acquisition within remote or challenging environments [19]. The findings by He et al. [20], Pope et al. [21], Stenhouse et al. [22] reported on wildlife monitoring, while Carlson et al. [23], Heigl et al. [24] and Lewandowski and Oberhauser [25] reported on biodiversity surveys contributed by citizen scientists which proving their important roles in scientific endeavours. Positively, citizen scientist participation enables research projects to cover larger geographical areas and secure data over extended periods [26]. Data collection by citizen scientists can serve as a tool to improve the environmental assessment by professional scientist where it can be a part of a university-run and managed electronic database [27]. This data equips researchers to address crucial scientific questions, monitor environmental changes, and advance the understanding of various phenomena [22, 28, 29]. The scale of data collection would often be unattainable without the invaluable contributions of citizen scientists.

Citizen scientists, often driven by a passion and interest for the subject matter, collect and observe data, resulting in extensive datasets that would be logistically or financially challenging for professional scientists alone to generate [22]. The perspectives and enthusiasm of citizen scientists often lead to unexpected discoveries. Their unconventional approaches and fresh viewpoints have resulted in several breakthroughs, including a Cornell University student discovered a single adult *Coccinella novemnotata* amongst a series of specimens collected [30] and *Cryptocoryne esquerionii* (Araceae) was found by a citizen scientist in Zamboanga Peninsula [31]. However, data-quality issues must be addressed, and data collected by the public must be validated whenever possible to ensure that citizen science is widely accepted by scientific community [32]. Additionally, citizen scientists sometimes misidentify species or fail to measure other data accurately [33]. This is due to the expertise required for the accuracy and reliability of high-quality data, especially involving an enormous number of citizen scientists [34]. The lack of training in data collection and fundamental knowledge of the subject is one of the main issues in citizen science. The issue can lead to a lack of volunteer participation, which is crucial in collecting information to manage ecosystems better [35].

Addressing the various challenges citizen scientists encounter is paramount to effectively supporting their significant role in wildlife conservation and CEPA efforts. Key actions include establishing robust training and education programs, often facilitated through community-based monitoring (CBM) methods [36]. Hence, a training workshop can be done to ensure the continuity of citizen scientist involvement, similar to the suggestion by Crall et al. [37]. Citizen scientists, also referred to as first-tier screeners, play a crucial role in ensuring the success of conservation activities by collecting data. This has been demonstrated by studies, highlighting citizen scientists' effectiveness as a first-tier screening strategy [38-40]. Besides, citizen scientists have been recognized in several studies to engage stakeholders and the general public in the planning and managing local ecosystems [36, 41]. Programs such as species management, ecosystem service management, climate change, impact assessment, invasive species control, and pollution detection and enforcement profoundly impact managing environmental issues [5]. These programs aim to enhance the skills and knowledge of citizen scientists while promoting collaboration and networking between citizen scientists, professional researchers, and organizations [32, 42]. The collaboration and community engagement fostered by citizen scientists has built bridges between the scientific community and the broader public, promoting scientific literacy and active engagement [43]. Their work goes beyond scientific investigation and extends into advocacy where citizen scientists motivated by their commitment to a cause, passionately champion policy changes and awareness campaigns [44]. Ensuring citizen science projects are accessible and welcoming to individuals from various backgrounds including underserved communities, can lead to

more comprehensive data collection and a broader range of perspectives [45]. Initiatives that actively engage and recruit citizen scientists from diverse demographics contribute to a richer understanding of ecosystems, foster greater community involvement, and help address environmental justice concerns [46].

The way forward in encouraging citizen scientist involvement and inspiring others to join this dynamic journey towards a more sustainable and resilient future is marked by several key factors. Firstly, technology integration proves to be indispensable. Adopting cutting-edge tools and platforms, ranging from mobile apps to data visualization, will streamline participation and empower citizen scientists to contribute more efficiently and effectively [47]. New technologies and skills related with mobile applications, online computer and even gaming will appeal and attract to a diverse and broader set of citizen-science participants [47]. Secondly, education and outreach programs wield significant influence in igniting a passion for citizen science, especially for the youth. For instance, it was stated that most of youth-focused community programs are oriented towards research, management, and education in the field of conservation [48]. These initiatives mostly provide a dual contribution. First, they provide valuable scientific data that informs conservation research and enhances the management of sites, species, and land. Second, these programs have a transformative impact on the participating youth, fostering their comprehension and dedication to environmental responsibility, whether on an individual or collective scale, and this influence can manifest both immediately and in the long term. By emphasizing the importance of these initiatives, we can not only attract new enthusiasts but also retain their interest as they develop a deeper understanding of the positive impact they can have. Thirdly, the provision of recognition and rewards becomes essential in maintaining ongoing engagement [49, 50]. These incentives and acknowledgments serve as convincing motivators, reinforcing the sense of purpose among citizen scientists, which will indirectly help foster long-term community-level involvement. Furthermore, citizen scientists can play a critical role in promoting education by bridging knowledge gaps and advocating for sustainable practices. In essence, the way forward involves citizens as scientists becoming an integral part of our collective effort to better understand and care for our world, especially in conservation of our natural resources.

4 Conclusion

This review highlights the significant contributions of citizen scientist in the environmental field. The study shows citizen scientists' enormous potential in providing conservation information via CEPA. Long term engagement with citizen scientist is required in order to conduct effective research that can get through their experiences and knowledge. Future research is required to enhance our understanding approaches in selection citizen scientist to bridge environmental, economic and sustainability policies.

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