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Citizens Turning Into Scientists: A Calling to Boost the Knowledge of the Public to Address the Environmental Crisis in the Brazilian Semiarid

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ABSTRACT

The Brazilian Semiarid Region is in a vulnerable state due to ongoing anthropogenic pressure. The lack of efficient regulation of regional economic development has resulted in deforestation, desertification, and soil salinization, threatening traditional communities, cultures and biodiversity. Although technological and scientific progress can help to address climate and environmental crises in the region, fragmented knowledge of biodiversity status and trends along with poor infrastructure to monitor environmental quality impede safeguarding ecosystem functions and cultural heritage. In this essay, we suggest a potential solution to fill knowledge gaps through citizen (or community) science. We discuss how public engagement can provide large-scale data, while raising public awareness with regard to conservation considering human and environmental aspects of the Brazilian Semiarid Region. We argue that converting laypeople into scientists through participative monitoring can efficiently increase our knowledge and public scientific literacy to support public policies to avoid biological extinctions and environmental injustice.

1 | Main

The process of desertification has been documented in the Brazilian Semiarid Region for decades (e.g., Dregne 1986; Silva et al. 2023). In fact, the 11 Brazilian States undergoing desertification (Instituto Brasileiro de Geografia e Estatística Semiárido Brasileiro 2022) are under increasing pressure driven by anthropogenic factors, as scientists warn about potential undesirable ecological and socioeconomic consequences (Oyama and Nobre 2004). Unfortunately, negative impacts are becoming a reality for a large part of the region (Nascimento 2023). The exuberant biodiversity and natural resources, which are currently sustaining various cultural and economic activities at a large scale, are in imminent danger, especially under the progressing climate crisis and human-caused land transformation (Barbosa 2024). Approximately 36.45% of the Brazilian Semiarid is considered highly degraded (Araujo et al. 2023), while well-preserved areas occupy 11.1% of the region (Figure 1) and only 8.76% of the Semiarid is legally protected (MMA Ministério do Meio Ambiente 2024). Currently, deforestation and environmental degradation potentially affect around 22.5 million people (Sena et al. 2017) and it is characterized by the loss of plant species and other life forms, a

Summary

The Brazilian Caatinga, the dry forest that covers much of the most arid, northeastern region of Brazil is under serious environmental stress. Deforestation, desertification, and soil degradation threaten not only its ecosystems, but also the local communities, whose livelihoods depend on natural resources. Advancing science and technology help restore damaged lands and address some of the threats caused by climate change, which are especially severe in this region. Nevertheless, we still do not fully understand how biodiversity is distributed and changes across this vast and complex landscape, which makes it hard to know how to tackle the serious environmental challenges ahead. Our study explores how everyday people, such as rural landowners, students, and local residents can take part in environmental monitoring through citizen science, which simply means science done with the contribution of laypersons. Involving communities directly in data collection and conservation efforts can generate a large amount of information at a large scale, raise awareness, and empower people to protect their land and culture. It is not just about gathering facts, but also about building connections between science and society to promote fairer, and especially more effective environmental policies.

- **Practitioner Points**
  ◦ The Brazilian semiarid region is under severe environmental pressure from various anthropogenic factors.
  ◦ Even with advances in science and technology, most vulnerabilities cannot be overcome without people taking responsibility.
  ◦ Citizen science can generate large-scale environmental data, raise awareness, and support more effective conservation policies.

legacy of high human disturbance in the region (Araujo et al. 2023). To avoid massive biodiversity loss, government agencies in charge of the conservation of native remnants and rehabilitation of degraded vegetation need to adopt evidence-based decision-making through integrated research and biodiversity monitoring.

Nevertheless, it takes more than investment in science and technology to address biodiversity conservation in highly threatened regions. Not only biodiversity monitoring needs to be increased, environmental conditions, such as water quality and soil integrity also need to be improved. While novel technologies, such as palynology, remote sensing through satellite imagery and soil molecular analysis are becoming available and affordable to study land degradation in the Brazilian Semiarid Region (Ledru et al. 2022) and some soil properties are now possible to restore (Araujo et al. 2024), significant knowledge gaps persist in large-scale basic ecological research that require urgent attention. For instance, high-precision maps of natural resources and biodiversity distribution need to be produced along with the description of ecological trends connected to ecosystem functioning. This flux of large-scale ecological data can support land management and cultural activities and is also

aligned with environmental justice, which is currently neglected in the region (Dawson et al. 2023). Real positive transformation can only occur with education and awareness raising, which can be achieved by turning laypersons into volunteer environmental scientists. Individuals without formal scientific education benefit from a democratized approach to science that enhances scientific literacy and enables boarder participation in academic endeavors (Atias et al. 2023; Ottinger 2010). Throughout this process, laypersons may contribute their time and knowledge to large-scale research initiatives.

In this essay, we describe the ecosystem, the climate, and the people of the Brazilian Semiarid Region and discuss the status of biodiversity research in the region. We describe our vision on how engagement of local and visiting citizens (and noncitizens) in knowledge construction could improve the future of this threatened region.

1.1 | The Land, the People, and the Environmental Issues of the Brazilian Semiarid Region

Semiarid areas around the world are naturally characterized by a volume of rainfall that is too low to support vegetative growth all year round (Abdullah et al. 2025). These regions have two defined climatic seasons, the rainy season, which favors vegetative growth and the dry season. In general, the latter is defining the characteristics of the biota and consequently, the economic activities of the resident human population. Typical aridity in these regions makes water one of the most limiting resources for humans, as well as wildlife, dramatically affecting human resilience patterns and the phenotypical features and spatio-temporal distribution of biodiversity (Leite et al. 2018; Silva 2023).

Intermittent water bodies, including rivers and streams that only flow for a short time during the year are a common feature of the Brazilian Semiarid Region. Xeromorphic characteristics enable plants to survive the water deficit. These adaptations include reduced surface in relation to the body volume and leaves that have evolved into thorns, as seen in the Xique-xique cactus (*Pilosocereus gounellei*), the Macambira (*Encholirium spectabile*) and the Mandacaru (*Cereus jamacaru*) (Figure 2). Animal adaptations to high temperatures and low water availability include nocturnality, high physiological tolerance to drought (Leite et al. 2018) and a short reproductive period that coincides with the rainy season (Forti et al. 2022).

The Brazilian Semiarid Region is home to diverse human populations, including Indigenous Peoples, Quilombolas (Afro-Brazilian descendants of escaped slaves residing in quilombo settlements), and traditional local communities. These groups have developed small-scale economic activities adapted to the environmental conditions of the region, largely grounded in sustainable management practices that support biodiversity conservation and preserve cultural heritage, aligning with conservation goals (Dawson et al. 2023; Santos et al. 2019). These traditional activities include agroforestry systems with native species management. One example of such activities is keeping native stingless bees that yield honey and other high-profit food products (de Carvalho et al. 2014;
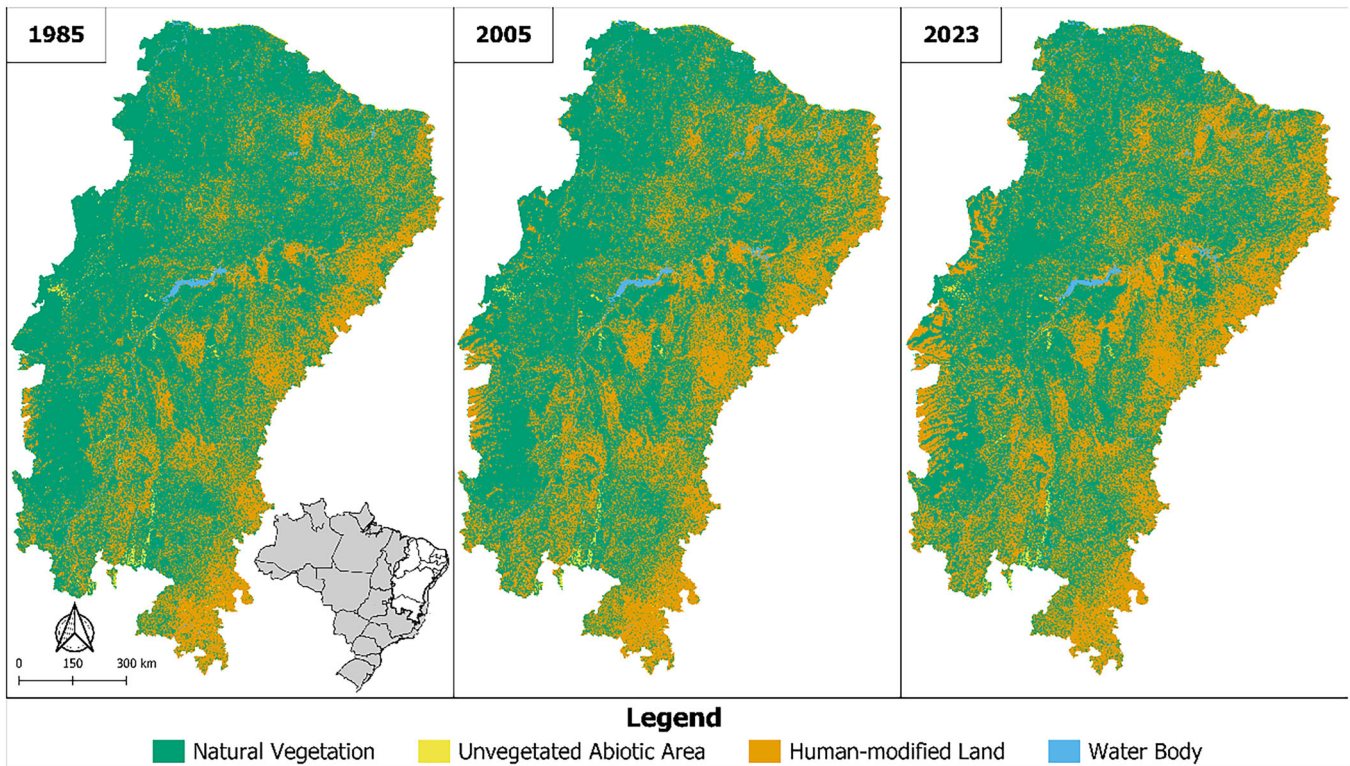
FIGURE 1 | Land degradation in the Brazilian Semiarid region from 1985 to 2023, based on reclassified data from MapBiomas (https://brasil.mapbiomas.org/). Natural vegetation is depicted in green, including forest formations, savanna formations, mangroves, wetlands, grasslands, hypersaline tidal flats, wooded sandbank vegetation and herbaceous sandbank vegetation; unvegetated abiotic areas are shown in yellow, including beaches, dunes and sand spots, other non-vegetated areas and rocky outcrops; human-modified land is in orange, including forest plantations, pastures, sugar cane plantations, urban areas, mining, aquaculture, soybean, and other temporary crops, such as coffee and cotton and a mosaic of uses; and water bodies including rivers, and lakes are depicted in blue. The region has lost a large amount of natural vegetation, while the area of human-modified land has increased.

Maia-Silva et al. 2020). On the other hand, large-scale and unregulated economic development in the region has led to invasions by nonnative species (Pinto et al. 2020), the deforestation of large areas of dry forests and soil salinization (da Silva Dias et al. 2021), jeopardizing soil fertility and water quality (Maia et al. 2025). For instance, aquacultural practices along with dam creation to secure a water supply have contributed to the introduction of nonnative species, such as the Nile Tilapia *Oreochromis niloticus*, which threatens native fish species and alters water properties thereby negatively affecting ecosystem function (Barbosa et al. 2012; Bezerra et al. 2018). In fact, in Brazil stocking nonnative fish species is a historical and common practice supported by governmental initiatives (Pelissoli et al. 2023). This management strategy has resulted in taxonomic homogenization, including the decline of native species, many of them with substantial commercial value (Brito et al. 2020). Besides negative environmental impacts, fish stocking practices affect traditional cultural practices and the way rural citizens in the Semiarid region interact with nature.

Between 1973 and 2019, the extent of native vegetation in the Semiarid Region was drastically reduced, decreasing the resilience of the ecosystem and the availability of resources for local communities (Nogueira 2024). The loss of vegetation cover, mainly due to agricultural expansion and logging, severely affected both biodiversity and traditional human communities

that depend on natural resources for their subsistence (Silva, et al. 2024; Nogueira 2024). The challenges faced by traditional communities go beyond the loss of vegetation cover, as there are also conflicts over land ownership, often caused by the interest of large landowners and the lack of recognition of the territorial rights of communities, which has resulted in loss of access to natural resources and the degradation and loss of traditional ways of life (Santos et al. 2019).

Besides urbanization and conventional agriculture, natural environments in the Brazilian Semiarid Region are also affected by increasing shrimp farming, and the ongoing development of energy infrastructure, particularly wind power and solar photovoltaic plants (Klingler et al. 2024; Soares et al. 2021). Despite being a source of renewable energy, wind farms significantly reduce soil moisture (Wang et al. 2023). Furthermore, wind farms cause habitat fragmentation and displacement of birds and bats, which are vulnerable to collision with the turbines (Rydell et al. 2012). These impacts are aggravated in the Semiarid Region, where biodiversity already faces significant pressures due to habitat degradation and land use change (Silva et al. 2024). The exploitation of natural resources and the lack of adequate environmental management policies, and the enforcement of existing ones also compromise the resilience of coastal ecosystems in the Brazilian Semiarid Region and threaten communities that depend on these ecosystems for fishing and other economic activities.
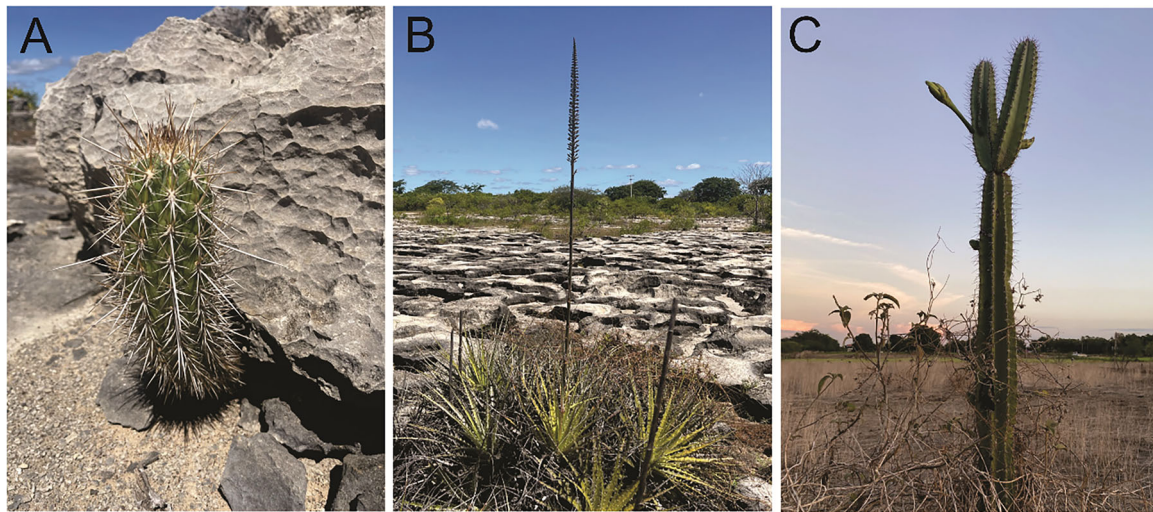
FIGURE 2 | Typical plants of the Brazilian Semiarid Region. (A) Xique-xique cactus *Pilosocereus gounellei*; (B) Macambira *Encholirium spectabile*; and (C) Mandacaru *Cereus jamacaru* (courtesy of Iany Lima - https://www.inaturalist.org/observations/147264301).

The implementation of conservation policies that integrate traditional knowledge and promote community participation is essential to face these challenges and ensure sustainability (Soares et al. 2021). The complexity of ecological issues in the Semiarid Region requires public participation to construct specific environmental policies. Water management, the control of greenhouse gas emission and conservation actions aimed at strengthening protected areas as biodiversity refuge are the main ways to combat environmental problems that impact the economy, society and nature in the Semiarid Region. Unfortunately, to act on all these fronts and to avoid the collapse of the ecosystem, precise data are necessary to map and monitor water resources and biodiversity. Furthermore, actions need to be coordinated to control sources of carbon emissions. The National Institute of the Semiarid (INSA—https://www.gov.br/insa/pt-br), a research center linked to the federal government through the Ministry of Science and Technology (MCTI), provides an excellent potential mechanism to centralize research efforts that benefit the management of the Semiarid Region in multiple aspects. Currently, the primary focus of INSA is agriculture—in particular animal production research. However, support for ecological research, especially to biodiversity studies, is still lacking. In fact, we could not identify any lines of research focused on biodiversity conservation conducted by INSA, although there is a recent notice for hiring researchers with some relevance to ecology (https://www.gov.br/insa/pt-br/assuntos/noticias/publicado-edital-de-concurso-para-pesquisador-e-tecnologista-do-insa-mcti). In our opinion, INSA should expand its activities to support ecological research with special focus on biodiversity conservation through public participation. The fight against climate effects and human actions that cause environmental degradation and interfere with economic and social actions in the region is a challenge to be addressed not only by increasing relevant research activities, but also by securing financial investment from federal institutions (Forti 2024). The public should be engaged and actively participating in these endeavors.

1.2 | An Overview of Citizen Science in the Brazilian Semiarid Region

Environmental science has the potential to define our society, especially if it is aligned with public policies. While being a scientist only became a profession in the 19th century, amateur members of the public have long contributed to scientific progress (Miller-Rushing et al. 2012). Discussions among stakeholders on the weight of empirical or experimental evidence can guide political decision. This perspective is aligned with the concept of citizen (or community) science as defined by the Brazilian Network of Citizen Science (https://www.rbcc.ong.br/), stating that citizen science is a partnership for scientific activities between professional scientists and the public. Mutual benefit and applicability are key factors to this concept. Members of the public can contribute to the conception of the project, as well as data collection and/or validation, while professional scientists cover the scientific and technological education of the participants and plan how outcomes will inform politically relevant issues (Haklay 2021). This interpretation is also aligned with the perspective of Alan Irwin, a sociologist who describes citizen science based on the democratization of science and public engagement in decision-making (Irwin 2002). In spite of the multiple benefits citizen science brings, it still faces persistent difficulties that hinder its effectiveness. Data quality and validation also remain major concerns, as contributions from non-experts could lack consistency or rigor (Roche et al. 2020). Additionally, tensions often arise between scientific goals and educational outcomes, especially when projects fail to align participant expectations with research objectives (Ballard 2023). A lack of sustained public interest poses another barrier, as waning engagement can compromise data continuity and undermine the long-term success of initiatives (Hall et al. 2024). Issues of accessibility, inclusivity, and long-term sustainability also challenge the integration of citizen science into formal research and policy frameworks (Queiroz-Souza et al. 2023). These complexities underscore the need for thoughtful project design, robust infrastructure, and collaborative governance to ensure that

citizen science fulfills its transformative potential. Despite these difficulties, the citizen science approach is becoming popular among Brazilian academics, and its value is getting more recognized (Forti 2024). New initiatives relying on public participation are emerging in addition to international platforms, such as the ones focused on recording biodiversity occurrence (e.g., iNaturalist; https://www.inaturalist.org/) and those with the primary focus on environmental data (e.g., EarthEcho; https://www.monitorwater.org/).

The progress of public participation and the increasing interest of Brazilian scientists in the topic have led to the creation of the Civis platform (https://civis.ibict.br/) and the first Brazilian Citizen Science Conference (https://ebcc.com.br/) held in September 2024. Nevertheless, still only a handful of initiatives cover the Brazilian Semiarid Region. At the time of writing this article, we were able to identify four such initiatives, all created in the last 7 years. (1) The "Seca-Wiki" project (http://www2.cemaden.gov.br/ciencia-cidada/) promotes a system to monitor agricultural drought in Brazil through citizen contributions—this initiative has already issued 272 risk alerts, resulting in 61 registered occurrences based on the public contribution. (2) Guardiões da Chapada (https://civis.ibict.br/project/47) is a project based on participative monitoring to compile data on plant-insect interactions in the Chapada Diamantina in Bahia State, with a high relevance to ecosystem services (Viana et al. 2022). (3) The Suindara platform, which was created by researchers from the Universidade Federal Rural do Semi-Árido (UFERSA) to encourage public participation in data collection on the occurrence and feeding behavior of Barn Owl *Tyto furcata* and Burrowing Owl *Athene cunicularia* in the Semiarid region (https://ccbs.ufersa.edu.br/plataforma-suindara-ciencia-cidada/). Contributions to this project were made by submitting registration forms through the university's website, which received 468 views. (4) The Escutadô Project (https://www.youtube.com/watch?v=JoEopoz5Jq0), an R&D initiative with public participation, which aims to develop an algorithm of artificial intelligence to detect landscape degradation based on soundscape properties. In this last project, members of the public are trained to participate in the audio sampling process, contributing to the development of a regional sound library that has already accumulated more than 16,000 h of recorded soundscapes. Until 2025, 27 rural landholders volunteered to participate in the project by hosting acoustic recording units on their properties, contributing with 63 distinct monitoring points located in three states (Rio Grande do Norte, Ceará, and Paraíba) in northeastern Brazil. As part of its commitment to capacity building and community engagement, Escutadô also organized a scientific meeting tailored to the participants. Even though these initiatives contribute to the democratization of science in the Semiarid Region, they all require more financial and structural support to become popular and reach broader scales. The Escutadô project, for example, is aiming to provide a real-time system to monitor environmental quality and detect degradation trends through voluntary contribution. The collected data could be useful for many environmental institutions, such as ICMBio (https://www.gov.br/icmbio/pt-br) and IDEMA (http://www.idema.rn.gov.br/), as well as stakeholders including local communities and landowners. However, financial support is required to maintain it as a live platform for long-term of data processing and storage.

Although new, dynamic remote-sensing techniques have been successfully employed to monitor changes in vegetation cover and water availability in the region (Silva et al. 2020), a more detailed mechanism is needed to monitor water distribution and ecosystem integrity and to generate more evidence about the occurrence of biodiversity. These actions are essential to detect trends and make timely decisions. A participatory monitoring program focused on fish and other aquatic organisms, developed in collaboration with artisanal fishers across the major basins of the Semiarid Region, could also generate valuable insights for managing invasive species and fostering improved practices to prevent the decline of native species and the loss of ecologically and commercially important biological resources.

The pressing environmental challenges in the Brazilian Semiarid Region underscore the need for greater public engagement and shared responsibility in initiatives aimed at nature management and conservation. However, the reality is that many citizen science programs have had limited success even in areas without such constraints, for example, due to a lack of public interest in participation (Alexandrino et al. 2019; Cunha et al. 2017; Queiroz-Souza et al. 2023). Therefore, more support is needed, not only to increase the number of initiatives with public participation, but also to strengthen existing ones. The regional development of citizen science and participatory monitoring led by research institutions will presumably increase and trigger a more efficient mechanism to achieve better results in the future. Therefore, increased investment in science in the region should focus on schemes involving public participation. Even though poverty, the lack of educational facilities and limited access to technology and internet are formidable social challenges, a future citizen science hub could offer support and host hundreds of initiatives for the Semiarid Region.

1.3 | Biodiversity Knowledge in the Brazilian Semiarid Region

The Brazilian Semiarid Region has complex landscapes currently configured by 12 biogeographical districts with properties defined by species endemism and edaphic features (Moro et al. 2024). This region is still considered neglected with regard to biodiversity research (de M. Bento et al. 2021; Forti 2023), and essential knowledge is lacking about the number of species that are potentially disappearing because of climate change and other human impacts. There is a consensual perspective that many species with declining populations are threatened by extinction but are not yet formally described by taxonomists. At the same time, the distribution of many described species is poorly mapped in the region and these spatial gaps hinder efficient conservation planning. Brazil exhibits significant regional disparities in socioeconomic indicators, accompanied by markedly uneven investment in scientific research and development across its regions (McManus and Baeta Neves 2021; Bezerra Marques and Bacelar Araújo 2021). This disparity also affects the way biodiversity research is distributed in the country, with lower effort in the Northeast, where the Semiarid Region is located compared to southern and southeastern parts of the country. In fact, the Caatinga (the Brazilian Semiarid biome) is one of the most

underrepresented biomes, particularly compared to the Atlantic Forest and the Pampa (Forti 2024b, 2024c).

Citizen scientists use national or global platforms to contribute data on species occurrence. These observers are mostly amateur naturalists, students, local people, and tourists, who contribute photos or sound recordings (e.g., iNaturalist https://www.inaturalist.org/ and WikiAves https://www.wikiaves.com.br/index.php) or species lists (eBird https://ebird.org/home). Smartphone apps are often used to upload data to these platforms enabling interaction with contributors (see Forti (2024d) for details on how these initiatives work). Most of the platforms supply data to the Global Biodiversity Information Facility (GBIF https://www.gbif.org/), a repository frequently used for macroecological and biogeographical research and species monitoring. Citizen science has emerged as a powerful tool for ecological and environmental monitoring. On the other hand, it is widely acknowledged that data collected through such initiatives often carry inherent limitations. These include non-systematic or semi-systematic sampling, spatial, temporal and taxonomic biases, and observer-related inconsistencies, all of which can compromise the reliability and generalizability of the findings. Haphazard data collection in large-scale citizen science projects has been reported to lead to gaps and redundancies that hinder robust statistical analysis (Callaghan et al. 2019). Similarly, observer bias arising from differences in detection abilities and recording practices, can distort trend analyses of long-term datasets, particularly in phenological studies (Feldman et al. 2018). Despite these challenges, when addressed through rigorous methodological frameworks and appropriate statistical corrections, citizen science data remain invaluable. Citizen-collected data are especially useful to answer research questions that require extensive geographic coverage or long-term observational data – contexts in which traditional scientific approaches often fall short.

Therefore, involving the public in biodiversity data collection is highly relevant to the targets of the Kunming–Montreal Global Biodiversity Framework (GBF), especially to reversing species decline globally (Danielsen et al. 2024). The contribution of citizen scientists to biodiversity monitoring in Brazil has been increasing in recent years, especially in biomes, such as the Atlantic Forest (Forti 2024a), and for biological groups, such as birds and anurans (Forti and Szabo 2023). We collected data on the iNaturalist using the *rinat* package (Barve and Hart 2022) in the software R version 4.3.0 (R Core Team 2023), and after cleaning for duplicated data using the *distinct* function of the *dplyr* package (Wickham et al. 2022) based on location, date, and species, we found only 153,427 observations collected within the limits of the Brazilian Semiarid Region. The number of observations was almost six times smaller than the contribution from another threatened Brazilian biome, the Atlantic Forest, which is about 23% larger (Forti 2024a).

Given the significant spatial gaps in biodiversity data across the Brazilian Semiarid Region, awareness raising about biodiversity conservation is essential and so is enhancing public engagement in biodiversity monitoring. Bioblitz events are well-suited to support both goals. A Bioblitz is a short, intensive survey, where scientists, students, and other members of the community work together to identify and record as many

species as possible within a defined area and timeframe (Meeus et al. 2023). Such events can recruit students from educational institutions along with local residents. Active public participation, particularly when integrated with online platforms for data storage (e.g., https://guardioesdospolinizadores.com.br/), have the potential to address current knowledge gaps (Forti 2023). For instance, documenting rare endemic species, such as the Spix's macaw (*Cyanopsitta spixii*) during the breeding season, can contribute to long-term population monitoring and inform conservation strategies aimed at preserving the rich biodiversity of the Brazilian Semiarid Region. A complementary initiative could involve extending the *Guardiões da Biodiversidade* initiative (Viana et al. 2022) into a broader citizen-science effort focused on monitoring pollinator activity, particularly bees and butterflies, within agricultural landscapes. Such engagement does not only supply biodiversity records, but also provides information about ecosystem services critical to sustainable food production and local livelihoods. Particular attention should be paid to native bee populations (Meliponini), which are crucial for pollination-based bioeconomy strategies and the production of sustainable bee-derived products (Meliponiculture), thereby reinforcing the cultural importance of native bees.

Public participation in mapping native plant flowering and fruiting cycles can provide valuable data on phenological patterns and contribute to understanding ecological responses to climate change. From a botanical perspective, citizen science initiatives aimed at identifying pioneer plant species in degraded areas, using platforms, such as Pl@ntNet (https://plantnet.org/), could inform assessments of natural regeneration and guide habitat restoration and sustainable land-use planning. For example, if citizens consistently record native species recolonizing abandoned farmland, this area could be earmarked for low-cost restoration, while areas dominated by invasive species might require active management and stricter land-use controls. Similarly, a participatory monitoring system involving traditional fishing communities could document native fish species and fishing resources. This approach would not only support sustainable fish stock management, but also generate critical data on seasonal dynamics and hydrological variations, which are increasingly affected by prolonged droughts, while also recognizing the value of traditional ecological knowledge in aquatic ecosystem stewardship. Finally, involving tourists and speleological groups in cave biodiversity assessments may significantly enhance species inventories within highly diverse and vulnerable subterranean habitats. This would promote ecotourism and inform management strategies in conservation units characterized by extensive karst formations. Such efforts would be particularly relevant in the Brazilian Semiarid Region, which harbors numerous cave systems that remain largely unexplored and are increasingly threatened by anthropogenic pressures, including land-use change, pollution, and unregulated visitation.

2 | Conclusion

The Brazilian Semiarid Region faces complex ecological challenges that demand more than incremental advances in environmental science—they require precise, citizen-informed

data collection and targeted, context-specific action. Although scientific institutions have made significant progress in biodiversity research, persistent knowledge gaps continue to hinder conservation actions. In this context, citizen science has been emerging as a powerful, yet underutilized approach to addressing these gaps. Its strength lies in the democratization of scientific inquiry, repositioning local communities not merely as data collectors, but as co-producers of scientific knowledge and critical contributors to evidence-based ecological decision-making. Such collaborative efforts can foster more integrated and resilient ecosystems.

To realize the full potential of citizen science in the Brazilian Semiarid Region, increased investment is essential. Specifically, government research funding agencies should issue targeted calls that support innovative, future-oriented initiatives that use participatory platforms and focus on monitoring endemic species, documenting phenological changes, and restoring degraded landscapes. Moving beyond traditional outreach models, the academic community must adopt a paradigm shift, in which the public is recognized as key actors in biodiversity conservation. This transformation is not optional—it is a strategic imperative for building ecological resilience and shaping informed, effective environmental policy in the Brazilian Semiarid Region.

Author Contributions

Lucas Rodriguez Forti: conceptualization, investigation, writing – original draft, methodology, writing – review and editing, supervision; visualization. **Arthur Igor da Fonseca-Freire:** writing – review and editing, investigation. **Geovan Figueirêdo Sá-Filho:** investigation, writing – review and editing. **Judit K. Szabo:** supervision, writing – review and editing, writing – original draft; visualization, methodology.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are openly available in Zenodo at https://zenodo.org/, reference number 10.5281/zenodo.13905674. Data on the contribution of citizen scientists in the limits of the Semiarid in the iNaturalist platform can be accessed at: https://zenodo.org/records/14628649.

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