A Citizen Science approach for better knowledge of our Urban Trees

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Resumen– La ciencia ciudadana, también conocida como "participación pública en la investigación científica", se define como actividades científicas en las que científicos no profesionales participan como voluntarios en la recopilación, análisis y difusión de datos dentro de un proyecto científico. Con el advenimiento de la era de la información, los proyectos de ciencia ciudadana, especialmente en conservación ecológica y monitoreo ambiental, están expandiendo rápidamente nuestro conocimiento del mundo que nos rodea y contribuyendo a la gestión y las decisiones políticas. Se puede utilizar un enfoque de ciencia ciudadana para un mejor conocimiento de nuestros árboles urbanos.
Parablas claves– Ciencia ciudadana, Científicos ciudadanos, Árboles urbanos, Guía científico, TreeSnap, aplicación móvil, desafíos, futuro, reconocimiento de árboles, participación pública

Abstract– Citizen science, also known as "public participation in scientific research", is defined as scientific activities in which non-professional scientists participate as volunteers in data collection, analysis and dissemination within a scientific project. With the advent of the information age, citizen science projects, especially in ecological conservation and environmental monitoring, are rapidly expanding our knowledge of the world around us, and contributing to management and policy decisions. A Citizen Science approach can be used for better knowledge of our Urban Trees.
Keywords– Citizen science, Citizen Scientists, Urban trees, Scientist guide, TreeSnap, mobile app, challengs, future, trees recognition, public participation

1 Introduction

1.1 General citizen science

1.1.1 Overview

Citizen science is a scientific research method that involves a large number of science enthusiasts or volunteers to participate in scientific research activities such as data collection, analysis, and application [1]. A complete citizen science project structure, including the public or associations, scientists, government departments, data collection and analysis tools or equipment, data centers and the Internet [2].

The participation of the public and associations is an important feature of citizen science projects that distinguishes traditional scientific research methods. The Audubon Association has nearly 500 chapters distributed in all states of the United States, and the Cornell Ornithological Laboratory has millions of birds. Class observer. Scientists are often the makers and managers of public science projects, and are responsible for the implementation and development direction of the project, as well as the later data analysis and processing. The Cornell Ornithological Laboratory has more than 300 scientific researchers, responsible for the processing and analysis of hundreds of images and videos of birds provided by the public [3]. Government departments mostly appear as policy supporters or executors, and they are not essential components. Measuring tools, sensors, open source electronics, consumer electronics (such as digital cameras and smartphones, etc.) are the main tools for the public to record data in project participation. With the continuous advancement of technology, these tools are rapidly changing, and at the same time this information The application of technology and the design of scientific tasks are the key to the scientific output of the project [4]. The data center is a centralized place for project data storage and external display of results. With the development of cloud computing technology, data in different regions is more likely to be stored centrally. The Internet is an important link between the various parts of public science projects, and the popularization of the mobile Internet has also made the connections between various parts closer and smoother.

For researchers, citizen science offers exciting opportunities to expand the range and scope of data collected and involve a broader and more diverse group of observers and data contributors[5]. By incorporating a large number of interested people working in parallel,

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citizen science has the potential to accelerate the pace and expand the scope of research projects. In today's world of constrained research funding, communicating the value of scientific research to the public is increasingly important, yet avenues for sharing scientific research with general audiences are few and researchers typically have little institutional support for education and outreach activities, despite outreach being a requirement of many grant funding agencies. Citizen science directly connects scientists to the public and shares the importance of their work[6].

1.1.2 History

Citizen science is not a new idea. From early naturalists to long standing species range surveys that rely on contributions from members of the public [1],[7], engaging non-professionals in scientific research has repeatedly demonstrated great value for researchers and participants alike.

Prior to the professionalization of science in the late 19th century, nearly all scientific research was conducted by amateurs – that is, by people who were not paid as scientists[8]. These individuals were largely pursuing research because of an innate interest in particular topics or questions[9]. Many amateurs were recognized experts in their field and conducted research indistinguishable from – and sometimes superior to – that done by most professional scientists of the time. As early as the 17th century and probably earlier, some of these amateur experts had recruited non-experts to contribute natural history observations. For example, in the mid-18th century, a Norwegian bishop created a network of clergymen and asked them to contribute observations and collections of natural objects throughout Norway to aid his research[10]. Such contributions by non-trained scientists have helped to build some of the most valuable collections of animals, plants, rocks, fossils, artifacts, and other specimens worldwide.

Others who have collected information and data about the natural world in the past include farmers, hunters, and amateur naturalists. For instance, wine-growers in France have been recording grape harvest days for more than 640 years[11], while court diarists in Kyoto, Japan, have been recording dates of the traditional cherry blossom festival for 1200 years [12]. In China, both citizens and officials have been tracking outbreaks of locusts for at least 3500 years[13]. In the US, among the oldest continuous organized datasets are phenological records kept by farmers and agricultural organizations that document the timing of important agronomical events, such as sowing, harvests, and pest outbreaks[14].

More recently, during the past 150 years or so, science has become professionalized, while amateurs have often been marginalized. Although amateur scientists still abound – as evidenced by the many naturalist clubs (e.g. bird-, insect-, mushroom-, and plant-focused groups) across the country – the role of amateurs in conducting research has diminished as the number of professional scientists has dramatically increased and the culture of science has changed.

Even so, citizen science has continued and even grown in recent years. The increasing ubiquity of the internet and mobile phones has rapidly expanded the reach and potential of non-professionals collaborating in scientific research or conducting their own research[15]. For example, while ornithological research has a long history of utilizing citizen scientists, newer online community platforms for birders, like eBird from Cornell's Lab of Ornithology, have greatly enhanced the ease with which citizen scientists can contribute data, increasing the amount of data collected, with more than 7.5 million bird observations reported to the eBird website on average each month[16].

1.1.3 Types, processes and characteristics of citizen science projects

According to the contribution of public participation in the scientific research process, Bonney et al. [17] classified citizen science projects into three types: contributory, collaborative, and co-created. Shirk et al. [18] added contractual and collegial types, and believed that from contractual, auxiliary, cooperative, co-creation to academic, the degree of public participation has gradually deepened. In contract-type projects, the public invites scientists to carry out specific scientific research and report related reports and results [18]; auxiliary projects are generally designed by professional scientists, and the public mainly participates in data collection and recording [17], [18]; collaborative projects are designed by professional scientists, and the public participates not only in data collection and recording, but also in data analysis, experimental design, and information dissemination processes [17], [18]; co-creation projects are jointly designed by professional scientists and the public, and the public participates in all aspects of the project [17], [18]; while in academic projects, The public can independently conduct research and contribute to a certain scientific field, such as amateur taxonomists discovering new species [18]. In fact, the types of citizen science projects may change to some extent during the implementation process.

1.1.4 Challenges

While citizen science holds great potential for professional scientists and participants alike, there are also inherent challenges such as ensuring that the quality of data collected is sufficiently rigorous for incorporation into research[19]. Without careful consideration, projects that engage non-professional scientists in research run the risk of collecting data that cannot be directly applied to ongoing research or having low public participation. This is especially true in the world of mobile applications. For example, while there are many plant-related mobile apps available, few have a primary goal of contributing to ongoing scientific research. Instead, most serve as identification guides and/or act as repositories of educational information already publicly available. These types of apps are useful, but none focuses on facilitating scientifically meaningful collaborations between non-professional and professional researchers.

Besides, in view of the fact that many data of the citizen science model are derived from the general public. People collect and analyze data (such as species classi cation) with their own cognitive level, time and motivation, which makes the quality of these data suffer from professional science. Criticism of personnel, some professional scienti c personnel believe that the public scienti c data is poorly representative and the noise is large, making it dif cult for scienti c researchers to discover core problems[20].

In some citizen science projects that use miniature sensors, in order to more realistically evaluate the application of these miniature sensors in public science projects, some research institutions in the European Union have determined the sensor's location of pollution sources, rough response to pollution levels, high time resolution, and reliability. In terms of sexuality, an evaluation program different from that of the laboratory has been developed for evaluation, and 25 sets of devices have been deployed in 8 cities in Europe for data collection and analysis. Research believes that this program can be used to judge and compare the application of this type of sensor[21]. Some researchers in the United States have found that the ozone concentration measured by citizen scientists in 4 different cities with the help of low-cost electrochemical sensors has a good correlation with the reference site, but the correlation between the nitrogen dioxide sensor is poor[22] and Similar studies have also shown that the ozone sensor can be used for air pollution measurement under proper calibration and quality control[23]. Although we see that sensors can be used to enhance the quality of data, on the one hand, due to cost and the actual needs of the public, consumer electronics manufacturers lack the pro t driving force to integrate this type of sensor and promote it. On the other hand, such as semiconductor or electrochemical type. The sensor is prone to interference from the external environment (such as temperature and humidity), which makes the sensor need to be calibrated regularly. This type of sensor life is far less than that of professional ecological environment measuring instruments. Therefore, in the face of a wide variety of environmental information, I currently want to use portable sensors. It is still dif cult to rely on the public to collect speci c environmental elements on a large scale.

Although people realize that improving data quality is important, it is dif cult for the public to meet strict scienti c research standards. Therefore, blindly pursuing the quality of public data is also unrealistic. For this reason, the types of data provided by the public and the development of new data for this type of data are unrealistic. The method of analysis and evaluation is more meaningful. In recent years, with the development of deep learning technology, the level of processing of classi cation problems (such as image recognition) by machines has gradually been higher than that of humans, which allows us to see the processing ef ciency of unstructured data, which provides high ef ciency for rich data such as images and texts. Technical means.

1.2 Trees and plants

Trees in the urban environment are living organisms that live with people and provide them with a physical and emotional connection to nature. The city's trees make it possible to interconnect the city's green areas, favouring a green infrastructure around which the city is organised, which contributes to health, comfort and habitability, due to their effects on environmental quality, the beauty of urban landscapes or the creation of areas for socialising and coming into contact with nature in the urban environment[24].

However, industrialization, urbanization, and modern lifestyles have nowadays greatly reduced our direct interactions with nature. As a result, people's knowledge of nature has become restricted[25]. Our growing isolation from the natural world has direct and grave consequences for the conservation of biodiversity and for efforts to live in harmony with nature. It is necessary to develop new ways to raise the awareness of the next generation about the natural world of which they form a part[26].

Speci cally, people know very little about trees. Although trees can be seen everywhere in the city, it is hard for people to recognize its variety by the appearance of the tree, let alone its characteristics.

1.3 Objectives

With this in mind, we started this project to connect citizen scientists to the nature. However, it is dif cult to connect people directly with nature. The urban trees that we see every day may be the rst step.

The main aim of the project is to bring scienti c activities to the general public. In a unique and undemanding way, we want to involve schools as well as public and interest groups in collecting trees data. In return, they will have a better knowledge and be given the opportunities to share the database of urban trees.

In cooperation with other teams, we will design a system capable of recognizing the type of plant based on an image of the leaf and its GPS position. And it would be a plant recognition system that can be integrated into a mobile phone in a later project.

In conclusion, we have three objectives:

1. To have a state of the art on Trees and Citizen Science
2. To have a state of the art about the available tools to increase tree literacy
3. Create a Citizen Science activity for tree literacy

1.4 Structure

This paper presents a citizen science approach for better knowledge of our urban trees. In Section 1, there is a brief introduction of general citizen science, people's knowledge on trees and objectives of the study. In Section 2, the state of the are is presented, including general citizen science and speci c projects on trees. In Section 3, we show the methodology we use in the study. In Section 4, there is a proposal for citizen science project of urban trees. In Section 5, there is a discussion of the study and the contributions. Last but not least, Section 6 presents the conclusion and the study towards the further work.

2 STATE OF THE ART

2.1 General citizen science

Today, the internet and geographic information system-(GIS-) enabled web applications allow participants to collect large volumes of location-based ecological data and submit them electronically to centralized databases.

The ubiquity of smartphones, the potential for digital photo validation of questionable observations, and the development of infrastructure for creating simple online data-entry systems provide added potential for initiating projects quickly, inexpensively, and with stringent criteria to ensure data accuracy. These same web-based tools are democratizing project development, allowing for the creation of data-entry systems for community-based projects that arise out of local, practical issues or needs. Although we cannot currently assess the impact of this democratization for ecological research, such empowerment means that resource management decisions, and the data that drive them, are more likely to be in the hands of the people who will be affected by the outcomes[19].

There is a selection of projects and websites active that provide cyberinfrastructure, tools, and information for project developers and participants:

1. Citizen Science Association (CSA) is a member-driven organization that connects people from a wide range of experiences around one shared purpose: advancing knowledge through research and monitoring done by, for, and with members of the public. It provides support and aggregates resources for project developers, participants, practitioners, educators, researchers, information technology specialists, and evaluators[27].

2. CitSci.org supports the cyberinfrastructure and data management needs of citizen-science projects in a way that allows many users to create their own interface[28].

3. DataONE is a community driven program providing access to data across multiple member repositories, supporting enhanced search and discovery of Earth and environmental data. DataONE promotes best practices in data management through responsive educational resources and materials enabling new science and knowledge creation through universal access to data about life on earth and the environment that sustains it. It offers cyberinfrastructure and management structure to ensure preservation and access to multi-scale, multi-discipline, and multi-national science data, including citizen-science data[29].

4. SciStarter is a globally acclaimed, online citizen science hub where projects, searchable by location, topic, age level, etc, have been registered by individual project leaders or imported through partnerships with federal governments, NGOs, and universities. As a research af liate of NCSU and ASU, and a popular citizen science portal, SciStarter hosts an active community of close to 100,000 registered citizen scientists and millions of additional site visitors. Hundreds of citizen science projects use SciStarter's NSF-supported APIs to help citizen scientists earn credit for their participation in their SciStarter dashboard, across projects and platforms. These features enable SciStarter's partners (libraries, schools, museums, Girl Scouts and more) to catalyze customized citizen science pathways and track and support the progress of their communities through SciStarter. SciStarter also supports researchers in managing projects, including best practices for engaging participant partners[30].

5. A Scientist's Guide for citizen scientists that are focusing on ecology. That is, anyone keeping track of species, communities, interactions, animal behavior, etc. This guide is useful for people who want to be a citizen scientist but do not know how to begin[31].

What's more, according to the degree of public participation, Shirk et al. divided the public participation in science into contract type (the public does not participate, but scientists are invited to lead the project and report the results), contribution type (scienti c researcher-led, the public mainly contributes data), and collaborative (scienti c researcher) Leading, public participation in project design, data analysis, result dissemination), co-creation type (scienti c researcher-led, at least part of the public participates in all aspects of the project) and academic type (completely public-led, and becomes a fellow scienti c researcher)[18].

2.2 Speci c projects on Trees

There is a large quantity of projects over the world which are focus on the protection of nature especially on the trees. Citizen scientists could get involved in any of them:

1. TreeChain Network's 11 billion trees project in the world: TreeChain Network is a global project launched in December 2017 in Australia with the mission of “Make Our Planet Green Again”, to continuously develop and protect the status of the primary forest system in the world. TreeChain Network will implement 4.0 technology, using biochip, blockchain to plant and manage trees. The goal in the next ten years is connect all community resources to plant 11 billion new trees globally. The special feature of the project is the application of blockchain technology to tree planting and community connectivity through the tree map system. As a result, only in the rst year of launch, the project has received the support of the governments of 12 countries around the world, the prestigious NGO for environmental protection.

2. Project to plant 73 million trees to help regenerate forests in the Amazon According to IFL Science, Consevation International will implement a project to plant 73 million trees in the Amazon region by 2023. This is the largest tropical reforestation project in the world. After planting, the new forest cover will cover about 30,000ha of land and will have positive impacts on countless species of forest and climate on Earth.

3. 50 million trees plant project of the Government of Ontario: The Ontario government has pledged to plant 50 million trees by 2025. The 50 million tree program is inspired by global efforts to grow billions of trees around the world each year. Up to the present time, the project has called for about 4,000 homeowners to have planted land. The project aims to improve the quality of land and to restore habitat for wildlife. At the same time, improving the environment and opening up a better future for the next generation.

4. The project planted 9 million trees of Ethiopian Airlines: On 21 March 2018, the United Nations Environment Fund signed a Memorandum of Understanding with Ethiopian Airlines, focusing on sustainability in the aviation business. The goal of the project is to plant 9 million trees under the name of Ethiopian Airlines in different parts of Ethiopia. Each plant will be planted in different parts of Ethiopia.

5. Project to plant 50 million trees by 2023 of the National Forest Foundation: The US National Forest Service is making an ambitious effort to plant 50 million trees in the National Forest by 2023. The goal is to restore tens of thousands of acres of natural disaster- Florida pines to Alaska cedar gardens. At the same time, river basins provide sustainable resources for the lives of the cities of Los Angeles, Atlanta, Seattle and thousands of other communities. And as they grow, they will help combat global climate change and ensure that wildlife has a healthy place to live.

6. Project to plant 50 million trees in one day in India: According to the Telegraph, India has successfully implemented a project to plant 50 million trees along national highways, expressways, railways and forest land within 24 hours in Uttar Pradesh. The project has involved more than 800,000 volunteers including students, legislators, government of cials, housewives and volunteers from a number of non-governmental organizations in India. The plantation project has helped solve many of India's problems in particular and the world in general, such as pollution, deforestation and land use.

7. Project of Tree Roots & Shoots (MTP) of Shanghai: This project started in 2007, aiming to raise awareness about the precious environment of the Earth. The project has helped individuals and organizations understand that each of them can contribute to ghting climate change by planting oxygen-producing plants. The project is still underway in Shanghai and has received active participation from the community.

8. The project planted 847,275 trees one day in Pakistan: In 2013, Pakistan implemented 847,275 planting projects in one day. This project was undertaken by coastal communities, volunteers and staff from the Forestry Department of Pakistan.

9. Australia's 1 billion trees project: In Australia, there is a day called the National Tree Day, which translates as the National Tree Day. This day is held annually by Planet Arktrong last week of July, encouraging the public to plant 1 million native trees each year.

10. The Helena National Reforestation Project: In the spring of 2013, 8,500 pine trees were planted around Helena's ranger station. These seedlings are carefully planted and nursed to ensure optimum survival for newly planted trees. These seedlings are a great gift for the forest and the people here. They help ensure the regeneration of the forest and provide an important source of seed for other forests in the future.

11. Cambridge Urban Tree Monitoring: Collect tree data to determine ecosystem services to maintain, plan, build, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.

2.3 Available tools to increase tree literacy

Citizen science is also increasingly seen as a way to engage the public in science, improve scienti c literacy and interest in science, and inform participants about particular topics, such as urban trees[32].

There are certain tools to increase tree literacy:

1. Leafsnap, an Electronic Field Guide. Leafsnap is a series of electronic eld guides being developed by researchers from Columbia University, the University of Maryland, and the Smithsonian Institution. The free mobile apps use visual recognition software to help identify tree species from photographs of their leaves. They contain beautiful high-resolution images of leaves, owers, fruits, petioles, seeds and bark. The website shows the tree species included in Leafsnap, the collections of its users, and the team of research volunteers working to produce it.

2. Become an observer today in 3 steps (Nature's Notebook). This is a project that encourages people to connect with nature, learn and contribute to scienti c discovery by observing phenology. The website shows every steps that we need to take to become an observer.

3. TreeSnap, a citizen science app connecting tree enthusiasts and forest scientists. It works directly with restoration tree breeders across different tree species killed by invasive pests and pathogens[33].

3 Methodology (Methods and tools)

Successful citizen science projects generally have the following ve important characteristics[34]:

1. Simplicity: the project goals and methods are easy to understand, and the website for uploading data is simple and clear

2. Feedback: Participants know their data usage, and regularly update survey data, etc. , Data can be obtained by participants

3. Communication: Communication strategies are critical to recruiting new participants and gaining their trust, mainly including press releases, network promotion, scienti c publishing, and educational output

4. Plan: Scientists must establish a clear work plan to closely connect participants

5. Continuity: The continuity of the project needs to be maintained, including the normal operation of the basic work framework, and the data can be analyzed and published

In this paper we will follow this rule to study citizen science projects. Besides we will choose the mobile app TreeSnap [33]as a study case to create our own mobile app product for a better knowledge of urban trees. The scientists guide which mentioned above will also be an available tool for using the mobile app.

Designing citizen science projects is a messy business. As Shirk et al. [18] think we should:

- First, clarify the perceived opportunity for citizen science as a strategy. What problem will a citizen science project solve? Can you write a mission statement for the project? Once the opportunity is laid out, examine the goals people in the system will have, with particular attention to the organizers' goals and the participants' goals. The project intiators' goals are likely to include both `sel sh' goals about advancing science, ful lling funders' requirements for outreach, etc., but should also include goals of the organizers for the participants (attitudinal, cognitive, social). Then, when considering participant goals, clarify the audience for the project and their likely motivations to participate (or not).

- Secondly, identify ways to include necessary perspectives on the project. At some point, end users may also be involved in goal setting. Does the project organizing team have the right expertise? Key needs are likely to include expertise in the science domain, expertise in building and supporting the tools needed (typically online tools, but might also include research equipment), and expertise in the goals for the user. If the project initiator identi es increasing positive attitudes towards STEM careers among an underserved population as a key goal, the team will need someone who is an expert in the research on attitudes toward STEM careers in that underserved population.

- Third, once necessary perspectives are identi ed, the project team should start considering the level of engagement of different groups. On the project team side, this may include questions of budgeting and staf ng. On the citizen participant side, consider whether the participants will have input into the project goals, and if so, how much and when; will the participants be doing `contractual' or `collegial' engagement, or something in-between? Perhaps there are different tiers of participants, from the very casual participant to the leader, or from the very novice to the very expert. Or perhaps the participants come from different backgrounds with different engagement models (e.g., schoolchildren vs. adults).

- Fourth, the project designers should consider what conceptual metaphor they prefer for the ways in which the participants will interact with each other and with the project. The list of roles I suggest above may be helpful, or the designer may wish to consider one of the many examples from science education or online communities. These core concepts will help determine a set of activities or tasks the various groups will do, and will further re ne ideas about what tools and logistics are necessary to support those groups. At this point it is worth considering timelines. Knowing that communities take time to build, what might a bootstrapping process look like to get enough participation to get the system up and running? What types of onboarding needs will there be for each kind of participant? What will keep people engaged over time, or will each participant engage for a xed set of activities and then `graduate' out of the project? Are there trajectories for people to advance within the project?

- Finally, the ongoing work of documenting, communicating, and re ning this design must begin. A project might begin by recruiting prospective participants to advise on the project design, or might begin writing up the concept for a funding proposal. The rst website and/or onboarding materials will need to be developed, and channels of communication among the various groups must be set up. Evaluation plans should be established, and mechanisms for adjusting the project in response to the evaluations or other new information should be identi ed. Ideally, a clear connection can be articulated between the opportunity provided by the project, the needs and goals of the various stakeholders, and the roles, practices and tools that form the sociotechnical system. Systems should be put in place to ensure that power structures, biases, and differences in perspective do not unjustly disadvantage either the scienti c or human aims of the project. The literature on community-based participatory research may help in this regard. As the project stakeholders begin communicating more and more, tools are built or assembled, systems or practices are begun, and eventually the project `launches' in a form that supports the desired level of participation.

4 A PROPOSAL FOR CITIZEN SCIENCE PROJECT

4.1 A mobile app

With all in mind, I think it is a good way to create a mobile app to involve citizen scientists participate in recognizing our urban trees and help them get away from diseases and pests. Scientists are working to collect tree's information and understand what allows some individual trees to survive, but they need to nd healthy, resilient trees in the urban to study. Citizen scientists can just tag trees they nd in their community, on their property, or out in the wild using the mobile app. Scientists will use the data the citizen scientists collect to locate trees for research projects like studying genetic diversity of tree species and building better tree breeding programs.

4.2 Trees to study

There are so many types of trees that we cannot fully understand them all at once. Therefore, we chose TOP10 trees of UAB's database as the research objects in the initial development stage of the mobile app (UAB has contributed to this study with a prototype of database for GPS annotated trees. The database is not clean and only used for testing tasks shared with us):

1. Liquidambar styraci ua
2. Melia azederach
3. Populus nigra
4. Pinus pinea
5. Spartium junceum
6. Olea europea
7. Cupressus arizonica
8. Platanus acerifolia
9. Cupressus sempervirens
10. Pinus halepensis

4.3 How does the mobile app work

4.3.1 Architecture

A common organisation scheme in interactive software is based on distinguishing between a front end (which users can see and interact with) and a back end (which only administrator accounts can access); see Fig. 1 This structure is also often used in citizen science toolkits and platforms. Generally speaking, the platform contains the core functionalities, but additional features can also be integrated. The system provides all the user functionality; users interact with it via a front end user interface. This front end can be accessed via a web browser (web app) or an app on a smartphone (mobile app) [35].

Data contributions are stored in the platform's database. A database usually contains entries labelled by their ID, date, and category. An application programming interface (API) provides data access via de ned parameters so data can be exchanged internally between the application server and the front end or externally with other servers. The API is also used to integrate external data in a citizen science toolkit, for example, sensors, which are prompted on a regular basis by the system.

Especially for more sensitive data, such as users' account information and personal data, safeguard mechanisms must be employed. Furthermore, all sensitive data traf c should be encrypted to protect the data from being accessed and misused.

While, for some citizen science apps, a constant Internet connection is required, others, such as eld monitoring apps, also need to work of ine. In that case, all critical content and functionalities must be included in the app itself, and data contributions must be saved locally to be uploaded later. As our app is map based, an of ine map download feature can also be required.

Fig. 1: An app/server system with a common online infrastructure [35]

4.3.2 Function

Based on the experience of using TreeSnap [33] mentioned in the previous article, I came up with the general functions of the mobile app.

The mobile app is freely available on both iOS and Android. After downloading the app and creating an account, a user is presented with a list of tree species with active research partnerships. This list is automatically ltered by the app to present native species of interest in their current location. Tapping on each tree species will allow the user to not only submit data, but get more information about the trees, pests or pathogens, and the scienti c partners. The user answers the questions posed by the research partners, takes relevant photos, and the app collects the GPS coordinates. The entire user experience is designed to take less than one minute to record a given tree, with questions using as little technical terminology as possible. Figures and diagrams are present to guide users in collecting data. The app does not require an internet connection to function, meaning users can access this documentation and create observations while in the deep woods. The data are saved locally on their phone and when the user is back in wi or cellular service, they can upload them to the web-server by pressing a button.

In addition to the mobile app, we also have a website that provides an online interface to explore observations via a map, with options to lter and search. For security, users can always opt to be anonymous and GPS coordinates for individual trees are shifted up to 5 miles. To facilitate transfer of these data to the scienti c partners, a password-protected scientist portal is included with numerous custom tools for discovering, sorting, curating, and downloading the data. Scientists can set up lters and alerts based on the questions associated with each record to only show certain trees meeting certain criteria (i.e., tree health, height, or location). They can create teams (referred to as groups in the app) to easily share observations and can contact users within the website to ask follow-up questions or get permission to visit the tree's location.

4.4 Features of the mobile app

The mobile app follows a range of best practices proposed to improve how citizen science is conducted[36]. For example:

- Accessibility: The app is freely available on the majority of mobile platforms.
- Consistent Protocol: The App submission form ensures a common-structured and partner-speci ed set of questions are answered by each participant for each focal tree species. The plain language, pop-up help diagrams, and background information guide less experienced users and help create a positive learning experience.
- Real Research: The policy requires that partners will actively use data collected in the App for meaningful research that generates new knowledge of trees with real-world outcomes.
- Data Security: Personal user data are not shared with anyone, including scientists. Exact location of observed trees are also protected and limited to scienti c partners to minimize risk of timber theft and vandalism.

4.5 TreeLearnUAB

TreeLearnUAB (see Fig. 2) is a citizen science project in which participants can collect the characteristics of various trees during the hiking route and update them to the database of a mobile app as a citizen scientist, aiming to help participants have a better knowledge of the trees in UAB and have more tree-related data for the further study. This project could be an example of citizen science project.

5 DISCUSSION

5.1 The challenge of general citizen science

Although citizen science has shown obvious advantages in the elds of ecology research, ecological protection, and environmental education, the development of public science projects also faces many challenges, such as data quality and management issues, funding support, and long-term monitoring.

Data quality and management issues are issues that large-scale data surveys will face, and many public science projects are no exception. In public science projects, the professional knowledge, practical experience, and training of participants may affect the quality of data [37],[38]. Fitzpatrick et al. [39] investigated a low-density distribution of pests and found that compared with professionals, there is still some gap in the quality of data obtained by public participants. Gardier et al. [40] compared the data quality of three public science projects related to ladybugs and found that validated public science was the most effective data collection method. Compared with professionals, volunteers participating in public science are more likely to mistakenly identify rare species [38]. These problems also exist in other plant and animal monitoring [37], and are inevitable [41]. The analysis of Crall et al. [42] showed that volunteers' performance in species identi cation is not affected by age, experience, education and scienti c literacy, but is related to volunteers' practical experience. At the same time, the monitoring samples of most public science projects have great sampling deviations [37]. Most volunteers choose to participate in public science projects in areas near their living quarters, resulting in most public science projects. The data comes from areas with concentrated populations. These potential data quality problems will also lead to many limitations in data management and analysis. Therefore, some scholars have begun to develop mathematical models to overcome the shortcomings of these data [43].

Although tens of thousands of volunteers collect data for free, maintaining a well-run public science project also requires certain funds for project management, volunteer training, event promotion, data management, platform construction, etc.; but these The cost is much lower than that of research projects involving only scientists [40]. Take the Cornell Ornithology Laboratory as an example. The public science projects they manage cost nearly 1 million dollars per year [17]. These funds mainly come from the National Natural Science Foundation of the United States. Therefore, the development of public science projects requires the support of the state and the government in many ways to ensure its long-term and healthy development.

In the elds of ecology and environmental science, long-term monitoring data plays an extremely important role in understanding natural phenomena and exploring natural laws. Such data is very lacking in both traditional science and public science. The successful development of long-term monitoring projects requires good project design and long-term collaboration in many aspects, as well as high-level public participation. Therefore, ensuring the sustainability of the project through various channels, including government support and social fundraising, will be a major challenge for public science projects.

5.2 The discussion of the mobile app

Through the process of creating the mobile app, it could be found that there is a great need for and interest in better technology to facilitate scienti c data collection by both citizen scientists and professional scientists. Professional researchers want to engage citizen scientists in their work but lack the infrastructure to do so effectively[17]. At the same time, many of the same scientists want better tools to facilitate their own data collection, curation, and long-term management [44]. While such tools do exist, our experience searching for open source software solutions for this project revealed that they are seldom free, easily accessible, up-to-date, or custom-tailored to individual research needs. While the app was created as a citizen science app, the most active users are highly engaged non-specialist participants or professional researchers, underscoring the demand among scientists for more user friendly mobile apps for data collection. Collaboration among citizen scientists, scientist partners resulted in an advanced suite of data curation and management abilities that would likely not have been the focus of private sector app developers.

At the same time, given the somewhat specialized user base for the app (for example, users must be able to identify speci c tree species) this experience has demonstrated that it is essential for the scientists leading projects to actively include the public in their work to develop meaningful tools for engaging citizen scientists. It is not enough for scientists to have a project on the mobile app or some other citizen science platform; scientists must also put effort into personal relationships with the citizen participants. This more invested relationship with the public drives continued citizen interest in a project, by incorporating this specialized public in the totality of the research process, from planning, data collection, and analysis to sharing of results.

5.3 Contributions

5.3.1 General citizen science

With the rapid development of citizen science projects, multiple citizen science project platforms have emerged. These platforms provide basic information about public science projects, methods and techniques for conducting public science projects (Mentioned in Section 2). Based on the analysis of the output of these projects, we believe that public science has the following three main contributions.

(1) Contribution to ecological research. Landscape ecology and macro ecology The development of macroecology can help us understand the distribution patterns of large-scale species and their internal mechanisms more deeply. Through satellite images and other remote sensing technologies, a large amount of large-scale data can be obtained, but the corresponding ground survey data is extremely lacking, which limits the development of related research. A citizen science project with a large data collection team can ll this gap and become an important data source. For example, combining published data with public scienti c data, or using public scienti c data alone, can give a list of species in a certain area and describe its biodiversity [45]. Stegen et al. [46] used the data provided by the North American Reproductive Bird Survey to analyze the species turnover of bird communities on space and time scales and their environmental driving factors. Because many public science projects have a long duration and a large area, their observation records are also ideal data for studying the biological effects of global climate change. For example, based on the analysis of the monitoring data of 254 bird species based on the Christmas Bird Survey that began in 1900, from 1975 to 2004, the northern boundary of their distribution area, the center of the distribution area, and the center of abundance migrated 1.48 northward each year on average. , 0.45 and 1.03 km [47]; Based on the large number of different bird population data collected by several research projects managed by the Cornell Ornithology Laboratory [17], the researchers analyzed Spatial and temporal changes in bird populations There are a lot of scienti c issues such as regularity, the relationship between reproductive success rate and environmental changes, the mode of transmission of infectious diseases among animal populations, the impact of acid rain on the dynamics of bird populations, and the latitude pattern of seasonal changes in bird nest eggs. Similarly, public scienti c data can also reveal the evolutionary adaptability of a species in the context of climate change. For example, Cepaea nemoralis, a snail distributed in Europe that is very sensitive to outside temperature, from 1950 to 2009, due to the impact of climate change, the proportions of certain colors and band types of the shells of different regional populations have undergone signi cant changes[1]. In addition, public scienti c data can also be used to study the migration routes and phenology of species. The main autumn migration route.

(2) Contribution to ecological protection. Public science projects can study ecological and environmental issues such as biodiversity conservation, invasive species management, and environmental pollution through collaboration between scientists, citizens, and farmers [48]. Public science has unique advantages in biodiversity monitoring and is an effective way to monitor rare and invasive species. For example, The Lost Ladybug Project discovered Coccinella novemnotata, which is considered extinct [49]. In Chicago, USA, more than 650 volunteers monitored 990 populations of 233 rare and endangered plants[50]. Gallo and Waitt (2011) used the data collected by The Invaders of Texas Public Science Project to monitor changes in the distribution area and range of invasive plants. Similarly, public science can also provide useful data for the implementation of biodiversity. As long as it is used properly, the data collected by volunteers can be used for routine environmental management.

(3) Contribution to environmental education. Public science helps to improve the public's scienti c literacy and environmental protection awareness [51]. On the one hand, the systematic observation of participating projects can improve the public's understanding of the ecosystem. For example, public science projects can enrich volunteers' knowledge of bird biology and ecology[52], improve volunteers' ability to identify invasive species, understand the adverse effects of invasive species on the environment [51], and increase the knowledge of science and the feeling of natural beauty [51]. On the other hand, public science projects can also increase volunteers' willingness to participate in public affairs, and even enter middle school classrooms as part of formal education. However, in some cases, volunteers' attitudes towards the environment and understanding of scienti c processes [52][51] or behaviors towards invasive species [51] are not Signi cant changes, so when designing the project, the potential con icts between scienti c goals, educational goals, and motivation for participation should be considered.

5.3.2 Mobile App

The mobile app meets a speci c research need: to connect citizen scientists to urban trees' recognition, restoration tree breeders seeking new tree breeding material and forest pest/pathogen sightings. It involves citizen scientists participate in recognizing our urban trees and help them get away from diseases and pests.

6 CONCLUSION

Through those mentioned above on citizen science, I think I have found some reasons for people to participate in citizen science projects. I hope that this will allow more citizens to participate in citizen science projects.

6.1 Goals of project initiators

There are typical goals of citizen science project initiators or organizers who are professional educators or scientists. These goals fall into two rough categories: scienti c goals, and educational or outreach goals. Within the category of scienti c goals, project initiators may have a wide range of preferred outcomes, from the very narrow (assistance in collecting or analyzing a type of data for a well scoped study led by professionals) to the very large (increasing the speed and robustness with which a scienti c eld progresses, making new discoveries, or making science more responsive to the needs of society). The scienti c goals might be more applied (for instance, ensuring local communities have scienti c data on local environmental systems to feed into planning or conservation processes), or more driven by pure scienti c questions (such as a sky survey looking for evidence of particular astrophysical phenomena). These goals are as diverse as the goals of science generally, and initiators who work primarily as scientists are usually well-equipped to think of these types of goals. On the other hand, professionals initiating citizen science projects may hold a variety of educational or outreach goals, and scientists may be less familiar with how these goals map on to the research literature on how people collaborate and learn. We examine the theoretical stances that may be useful in a later section, but for now we can list some of the major education and outreach goals that might be connected to a citizen science project.

6.1.1 Attitudinal

• Improving attitudes about science,the particular domainsof science or the application area of science

• Improving attitudes towards orenthusiasm for participation in science or STEM; developing an identity as a scientist or competent in science

• Changing dispositions or `habitsofmind'[51]to use scienti c ways of thinking

6.1.2 Cognitive

• Improving participant knowledge about the scienti c domain or skills associated with the science domain

• Improving participant knowledge of the epistemology or methods of a particular science domain (e.g., how concepts are tested and proven in chemistry or climate science)

• Increasing basic familiarity with the ndings or methods of science for general science literacy

6.1.3 Social

• Development or shifts of knowledge building communities, communities of practice , communities of interest, or other new communities

• Helping people with an interest in a STEM topic locate and befriend others who might help them pursue that interest • Increasing equity and democracy in science, either by inclusion of previously missing groups, or by changing social norms, practices, and implicit biases to be more egalitarian, meritocratic, or democratic.

6.1.4 Summary

These goals can take on many forms in different projects, and most projects will necessarily address some of the education and outreach goals as primary and others as either instrumental or secondary goals. Two things are critical to recognize though. First, no project achieves all of these goals equally, and thus the initiators of citizen science activities need to know where their priorities lie. Second, these goals are not pursued in a vacuum. Due to the collaborative nature of citizen science (at minimum between the citizen scientist and the project), the goals of participants must also be taken into account.

6.2 Goals of citizen scientists

There are many reasons non-scientists participate in citizen science projects. In some cases, there is an institutional or organizational mandate that requires it. Probably the biggest category of such goals would be the involvement of schoolchildren in citizen science as required by their teachers. Some citizen science is paid, either by outsourcing scienti c tasks as piecework through platforms like Amazon's Mechanical Turk, or more directly by hiring non-scientists to work on scienti c data collection. By far the majority of participation in citizen science, however, is voluntary.

Voluntary participation in citizen science follows two kids of goals: altruistic (for instance, helping the eld), or egotistic (such as learning a valuable skill). Curtis in her dissertation [53] studied participants in three online citizen science projects, and found motivations varied from starting to work on a project to sustaining their work on that project. Motivations in the beginning included reasons such as contributing to research outcomes or worthy causes, intellectual challenge and interest in science, or the chance to make a discovery. Sustained participation was linked to reasons such as competition, community, interaction with others, or developing new skills, in addition to the altruistic sense of making a contribution.

Any initiator of a citizen science project should expect that participants will bring their own goals to any voluntary citizen science opportunity, and that not all participants will share the goals of the initiator. Furthermore, these goals are likely to change over time, and some participants will deepen their relationship to the project while others may remain static or drift away. The `reader-to-leader' framework describes a dynamic equilibrium in online communities in which some, but not all, participants progress from reader, to contributor, to collaborator, to leader. Any vibrant community will have some leaders, but most communities will have a predominant membership of people who are less engaged. This process has been alternately described in the communities of practice literature as a process of enculturation through `legitimate peripheral participation' in which learning represents individuals gradually moving from more peripheral roles to ones in which they are central to the practices of expertise. One expectation is that communities emergently develop norms, values, and practices, and thus the goals the initiators of the citizen science project have will shape, but not determine, what expert practice and identity looks like in the project.

A nal model of participant goals is when a participant merely consents, but then doesn't actually have to do anything active to be part of the citizen science project. For example, a user might agree to contribute log le data on an app they already use for research purposes, or might allow their computer's processing power to be used when the computer would otherwise be idling. Here the goals might be as shallow as being inattentive enough to miss unchecking a check box on a terms-and-conditions clickthrough (so the goal is simply to get past a dialog box). Yet even in a project in which passively providing computational power seems to prohibit deep engagement, citizen scientists may have strong goals that allow them to participate much more fully. For instance, in the Folding@home project in which participants download and install a program to provide computation to chemistry research, some participants have gone so far as to design and build custom computational hardware con gurations in order to excel at contributing [53]. Thus, the `no goals' version of participation is likely to be rarer than some might think.

6.3 Roles of participants in citizen science

Within the context of the variety of goals participants and initiators have for citizen science projects, it is helpful to examine typical roles for participants in citizen science. De ning and designing roles for participants is a key aspect of designing collaborative learning systems. There are many ways to describe roles; in a 2009 report, citizen science roles were divided into contributory, collaborative, or co-created projects, based on the level of input and leadership exercised by the public as opposed to the scientists. [17] Hetland, Mørch, and Ponti[54] provide a slightly different classi cation, in which users are targetted for dissemination of science, for dialogue with science, or participation in science. In this section, I use a more granular list of types of roles to examine several paradigms of citizen science.

- Participant as data gatherer

  Bonney [17] identify one of the most common paradigms of participation; that of the participant as data gatherer. Their examples, drawn from the eld of ornithology, build on pre-digital projects such as the Annual Christmas Bird Count from the early 20th century, to current work in which amateur birders are enlisted to help collect data. Some of their projects involve minimal expertise in participants, while others demand development of speci c skills to acquire usable scienti c data[37].

- Participant as data analyst

  Another participation structure enlists members of the public to help in speci c aspects of data analysis. For example, the galaxy zoo project was able to categorize the morphology of nearly a million galaxies in the Sloan sky survey dataset with online volunteers. While visual classi cation is not particularly dif cult, the sheer number of galaxies to classify led the scientists to consider involving volunteers.

- Participant as question poser

  Some projects, following more from Irwin's conception of citizen science, engage participants primarily in question asking rather than collecting data to answer questions raised by others. For example, the WeatherBlur project [55]allows shermen, children, teachers, and other members of the public to explore local climate change through question asking and answering. The project explicitly uses a “non-hierarchical online learning community” framework to emphasize that control over the directions of the inquiry are driven by interested participants, without a hierarchy of professional expertise to limit who may ask questions.

- Participant as stakeholder/partner

  Many citizen science projects involve participation of the public either as drivers of, or apprentices to, scienti c goals. But some citizen science projects involve partnerships between the science community and non-scientists whose goals either instrumentally involve science or overlap with those of scientists.

- Participant as competitor or gamer

  In some scienti c areas, gami cation can allow people to participate in scienti c work as recreation or competition. One of the most famous examples is the foldit game in which players compete to nd the lowest energy con guration of a folded protein. Foldit as a project has grown to encompass a wide variety of engagement models, and not just competitive gaming. In another project, Phylo, participants align gene sequences in a casual game–unlike foldit, the game is designed to excise the task from its scienti c context.

- Participant as amateur or apprentice scientist

  Another mode of citizen science is to support participants to act as amateur scientists, with a goal of helping people develop scienti c skills and practices through participation in the overall activities of science, but not necessarily to develop scienti c contributions of great value to the larger scienti c community.

- Participants as cultural guides

  Some projects engage participants not only as researchers or drivers of inquiry, but also re exively as participants in a culture that is relevant to the science. One example is described in which heritage learners in a language school conducted projects to study language and cultural heritage. The research model was one of action research, in which the learners were simultaneously studying and participating in the cultures and practices being examined. While some might argue that this is just a different example of the `participant as amateur scientist' paradigm, one important difference is that the participants have a critical role in not only conducting the research, but also interpeting it, and in bringing meaning-making (both personal and collective) to the work. As crisply pointed out by Medin, Lee, and Bang, "If participation in cultural practices is central to our development as humans, then these practices will in uence how we learn and practice science." They argue for the importance of engaging diverse participants in science not only out of some sense of fairness or equity, but also because the diversity of cultural perspectives engaged in science improves the science itself. When conducting citizen science in a way that explicitly involves nontraditional groups as experts in their own culturally in ected perspectives, it allows a diversity of epistemologies, interpretations, and questions to be surfaced, thereby improving the quality of the research. Work by Bang and Medin illustrates how European-American and Native American learners interpret the relationship between self and nature differently, and how incorporating these differences can enhance ecological science work by students. Especially when dealing with scienti c topics that have historically been used to colonize peoples, incorporating non-professional scientists in the work not only as consultants but also as participants in a more open form of research may help the scienti c endeavor. Decolonizing science is a larger project than citizen science alone can tackle, but citizen science may be one important tool to help ensure science is not biased towards one cultural group or gender and to increase the robustness of the ndings.

- Participants as passive resource providers

  As mentioned in the goals section, some projects deemed citizen science actually only involve non-scientists in passively providing some resource.

These roles help illustrate a variety of conceptual models for how citizens can engage in science. The list is intended to be generative, rather than exhaustive. Many projects involve participants in multiple roles, so Such examples can help inspire those who intend to design citizen science initiatives to consider multiple possible types of interaction.

6.4 Further work

The popularization of the Internet and smart mobile terminals provides huge opportunities for the development of citizen science. The application of the Internet enables scienti c activities such as biodiversity surveys and monitoring with massive human resources investment. Through the information support platform, experts and public participants can break through geographical barriers to form a close collaborative network, various instant messaging tools and forums, etc. The rise of new media has also provided unprecedented convenience for the development of citizen science (such as event promotion, volunteer recruitment, volunteer training, etc.). Researchers can also use databases and information processing technology to greatly improve the ef ciency of data processing, sorting, accumulation, mining and analysis, and improve data quality and output.

In order to effectively promote the development of citizen science, based on the experience and lessons of existing development, we propose the following suggestions:

- Extensive publicity: Through traditional news media, scienti c conferences, and online platforms, actively publicize the public's scienti c operation mode to attract wider public interest.
- Powerful organization: Gradually establish a cooperation mechanism among scientists, government and non-governmental organizations, and the public, and encourage scientists to give more consideration to public participation in project design.
- Development of platforms and technologies: Informatization-oriented, building a network platform as the basis for data exchange, using adaptive observation technology as a means of data collection, reducing the dif culty of citizen participation and improving work ef ciency, and ultimately on the basis of data integration On, comprehensive analysis of accumulated data.
- Looking for the export of public scienti c achievements: In order to realize the sustainability of public science, the observation results must be used for government management, scienti c research, popular science education and production practice.
- Strengthen international cooperation: cooperate with internationally active public science projects in ecological protection and environmental monitoring, and gradually play a leading and leading role in the emerging public science eld.
- Multi-channel funding support: It is hoped that government and non-government fund institutions can provide certain funding for the development of public science, such as supporting the development of speci c public science projects or supporting the analysis of existing public science data.

I sincerely hope that through this article, everyone can have a deeper understanding of public science, and at the same time, when citizen scientists join the project on urban tree research, signi cant research results will be obtained.

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