



Citizen Science: Can Public Participation in Agricultural Research Contribute to Sustainability

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Agricultural research has a rich history of involving farmers in the research process, often through participatory approaches where small groups near research centers contribute to trial design and innovation development. However, scaling these methods has been challenging due to the need for organization and training. Recently, crowdsourcing, facilitated by communication advancements, has emerged as a promising approach. Citizen science projects, common in fields like ecology and biology, have shown the potential of involving numerous volunteers in research activities, producing peer-reviewed articles and accomplishing tasks beyond traditional methods due to limited resources. In agriculture, similar approaches are being explored, offering opportunities to engage a broader range of stakeholders, including farmers, and leverage local knowledge for more effective solutions to agricultural challenges.

Keywords: Citizen Science, Farming Householders, Participation, Participatory Methodologies, Training

Introduction

Agricultural research has a rich and illustrious history of involving the public. In recent decades, many approaches have been created to address farmers' involvement in trial design, innovation development, and other research domains as agricultural end-users. Increasing the practical impact of research and fostering synergy between local and formal innovation are two essential goals of incorporating farmers in research. In the agricultural sciences, participatory approaches typically involve small groups of farmers who live close to the research centre and are frequently educated by researchers. Scaling these approaches is typically challenging because farmer group organization and training are needed (Moedas, 2018). However, due to the significant variations in socioeconomic needs and environmental circumstances in many places, there is growing interest in approaches that enable participation. Over the past fifteen years, crowdsourcing has been a popular approach to doing participatory research with many contributors because of the development of current communication systems. (Sauermann, and Franzoni, 2015). While "citizen science" can refer to any participatory research, these approaches are more commonly known as "citizen science" and have produced several peer-reviewed articles in ecology and biology. Numerous volunteers participate in individual, essential elements of formal study in citizen science programs. Due to limited funding, these projects have frequently completed tasks that standard research cannot. The quantity of time spent on the crowdsourced research project, the volume of contributions, and, often, the geographic distribution of data submissions all surpass the limitations of conventional research. Beza et al. (2017) studied about farmer's motivations to participate as a citizen scientist. The factors such as contributing, past time,

sharing information, expectation, expert interaction, community interaction and helping were considered.

Concept of Citizen Science

In June 2014, the words "citizen science" and "citizen scientists" were added to the Oxford English Dictionary (OED). "Citizen science" refers to "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions". "Citizen scientist" is defined as follows: (a) "a scientist whose work is characterized by a sense of responsibility to serve the best interests of the wider community (now rare)"; (b) "a member of the general public who engages in scientific work, often in collaboration with or under the direction of professional scientists and scientific institutions; an amateur scientist". The phrase "citizen scientist" was initially used in a ufology article published in New Scientist magazine in October 1979. The European Commission's Digital Science Unit and Societies. EU released a "Green Paper on Citizen Science" in 2013. It defined CS as "the general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with their tools and resources." In addition to raising new issues and helping to establish a new scientific culture, participants give researchers access to experimental data and facilities." Networks of volunteers, teams, or individuals can do citizen science. To accomplish shared objectives, professional scientists and citizen scientists frequently collaborate. Scientific tasks that would be too costly or time-consuming to complete through other means are commonly conducted by scientists thanks to large volunteer networks. Citizen science is "work undertaken by civic educators together with citizen communities to advance science, foster a broad scientific mentality, and encourage democratic engagement, which allows society to deal rationally with complex modern problems," according to the 2016 book *Analyzing the Role of Citizen Science in Modern Research*. The Australian Citizen Science Association defined citizen science as "public participation and collaboration in scientific research to increase scientific knowledge", in a definition that was published in 2016. "Citizen science is defined as scientific endeavors carried out by the general public, frequently in collaboration with or under the guidance of professional scientists and scientific institutions"

Level of Participation

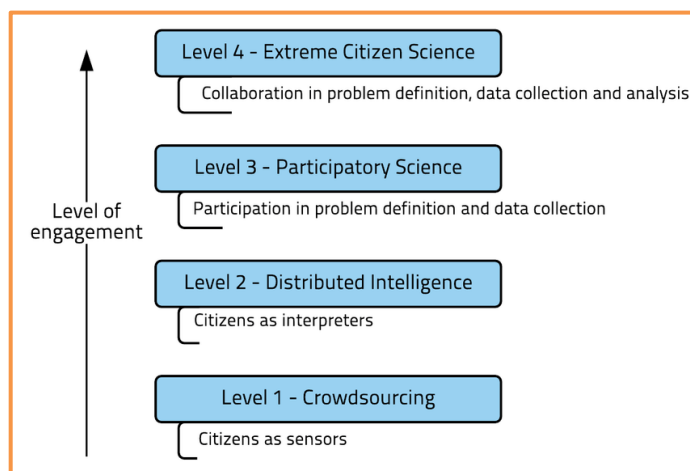
Crowdsourcing, distributed intelligence, participatory science, extreme citizen science.

Participants: Who can participate?

Participants and who they are significantly impact the objectives and outcomes of citizen science projects.

What our research team has gathered from the literature and the initial results of the CS Track large-scale survey is the following:

- Well-educated, affluent participants outnumber less affluent participants,
- More men than women participate in many of the programmes that have been analyzed.
- Citizen scientists seem to be white, middle-aged, scientifically literate or generally interested in science or scientific topics.



Levels of Participation in Citizen Science

- Scientists, academics, teachers, science students and people with a passion for the outdoors are among the groups most likely to participate in citizen science.

- In agricultural, biological and environmental science-based programmes, participants are often scientists themselves, science teachers or students, conservation group members, backpackers or hikers or other outdoor enthusiasts – people who care about nature.
- Community and youth citizen science projects are underrepresented in the available data.

Haklay (2013) created the terms "crowdsourcing," "distributed intelligence," "participatory science," and "extreme citizen science" to describe the various levels of participation in the field of citizen science. In this context, citizen science encompasses a range of activities from "citizens as sensors" (crowdsourcing) and "citizens as interpreters" (distributed intelligence) to "participatory science," which involves more participant involvement in problem definition and collection protocols and extreme citizen science, which requires participation in the entire scientific process.

Why should we bring together citizen science, Extension, and food systems now?

Extension has traditionally involved establishing connections between public members in agriculture, primarily farmers and scientific research. The Morrill Act was passed in the US to develop land-grant universities in reaction to the constantly evolving agricultural landscape. Extension services were added to land-grant institutions' missions by the Smith-Lever Act. Extension's goals in the farm setting are to inform farmers and food producers about new observations and issues and to provide them with research and technology. Through collaborations between scientists and the general public, this two-way flow of information provides opportunities for new knowledge to be generated and for citizen science to take place. A farmer may identify a new pest and provide information about it to a scientist or an Extension representative from the university. Next, the scientist connects that observation (a data point) and the larger body of scientific literature, providing the farmer with context for the observation and, ideally, a remedy if necessary. Scientists collaborate with farmers to guide research that is responsive to everyday needs and use them as data collectors. Extension makes possible what many in the citizen science community consider the ideal citizen science.

Citizen science is very new, yet it has increased. Many ideas, information, and insights about how to successfully involve the public in scientific research have grown along with that increase. However, the promise for Extension in the agricultural sciences has yet to be fully realized despite the current surge in interest in and development of citizen science networks and instruments. Similarly, the knowledge and resources produced by citizen scientists have yet to be fully utilized by the agricultural and food scientific domains. This is regrettable because these fields aim to achieve many of the same things (democratize science, engage communities or stakeholders, facilitate bidirectional information sharing, and boost scientific outcomes, to name a few). Therefore, there is still much room for growth in the areas where various industries overlap, both by increasing communication and by forming partnerships that take advantage of each field's infrastructure to expand upon existing areas of overlap. A crucial first question is why now is the right time to combine citizen science, Extension, and food systems. There are at least three main reasons behind this. First, for practical reasons. The amount of money available for Extension is declining, particularly for international Extension through organizations like the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Center for Agriculture and Biosciences International (CABI). The food system is facing more significant issues simultaneously as a result of both the need to feed a growing number of people (possibly a billion more by 2050) and the ever-increasing adverse health effects of people's disconnection from food.

Therefore, new strategies are required to involve the public and stakeholders in the science of food and agriculture, particularly in areas where Extension is cutting back, and there may be a significant loss of infrastructure and experience. The second explanation is the growing internationalization of issues related to agriculture. The spread of diseases and pests in an interconnected society presents an increasing hazard. In response, a globally networked system is required. To realize the potential of citizen science is the third justification. A flaw in most large-scale citizen research projects is the absence of local, in-person networks—

precisely the kind that extension services offer. Therefore, there is a chance to take advantage of Extension's strength, which is its sizeable geographical density of specialists who can distribute knowledge created at a central location (like a university) to assist locals in customizing information for local solutions. We organized a working group to explore strategies to promote more overlap between both professions and the advantages of combining them. We also identified important possibilities at the intersection of Extension and citizen science that entirely use each of their strengths.

Role of citizen science in addressing grand challenges in food and agriculture research

Monitoring pests/pathogens

Developing local and regional capabilities to identify and address plant pest issues (insects, diseases, and weeds) is one of agriculture's significant difficulties. Hulbert et al, 2017. expressed Citizen science can augment current efforts to monitor pests and diseases and enhance crop management by promoting a culture of sharing pests and beneficial organism observations. Novel infections and pests are already being documented with the aid of citizen science.

The public's observations of unusual interactions between pests and predators may help identify and develop possible biological control agents. They may also present a chance to spread knowledge about the benefits of using predatory insect communities as an alternative to pesticides. Citizen science is being used in other initiatives to find plants that might be pathogen-resistant. In agricultural environments, both of these activities can be imitated and repeated to increase food security and develop novel pest and pathogen control approaches.

Preserving biodiversity and ecosystem services

The need to protect biodiversity and ecosystem services in agriculture, whether on farms or in nearby environments, is a second significant challenge that citizen scientists may help with. Achieving environmental sustainability is the Sustainable Development Goal (SDG) of the United Nations, and this considerable problem closely relates to it. Biodiversity and related ecosystem services in an agricultural setting are currently the subject of numerous projects. Numerous initiatives support vital studies on pollination and pollinators (Hulbert et al, 2017). Whether the focus is on whole populations or specific species of concern, these programs frequently make the connection between land use and pollination services. initiatives that monitor pollinators, such as the Ohio Bee Atlas and the Great Sunflower Project. (Feoan et al, 2016)

Enhancing food safety, nutrition, and flavour

A third major issue facing agriculture is the need to enhance food safety and nutrition, which is related to the SDG objective of improving customer health and well-being and is addressed by citizen science. For instance, the World Health Organization lists the emergence of antimicrobial-resistant (AMR) infections as one of the biggest dangers to international health, encompassing agriculture and veterinary care (Anonymous, 2014).

Improving food and food security

It will take creative basic and applied research strategies to enhance food security to combat world hunger. Projects involving citizen science help to improve food systems. For instance, several citizen science initiatives collect data on various performances under various environmental circumstances and management strategies to preserve agricultural biodiversity through seed exchanges.

Social justice (e.g. gender, race, ethnicity, and equity)

A history of citizen science focuses on activism and social justice in agriculture, mainly through participatory approaches such as community-based participatory research (CBPR) and participatory action research (PAR). For example, CBPR approaches help document the negative health consequences on neighbours of concentrated animal feeding operations (CAFO) and environmental racism resulting from the placement of CAFOs. Policy changes resulted from these citizen scientific initiatives combined with political action. Additionally, ecological pollutants in home gardens were studied using CBPR.

Education (achieve universal primary education)

A vast network of people who frequently receive credit (volunteer work hours) for their contributions are connected to current citizen science projects in agriculture through outreach programs organized through extension programs like 4-H, Food Corps, Master Gardeners, and Junior Master Gardeners in the United States. Such garden-based learning improves social development and academic results (especially in language arts, math, and science). However, the percentage of citizen scientific initiatives in these programs could be much higher.

Citizen Science and Sustainable Agriculture

When farmers and academics collaborate, applying citizen science in agriculture has an excellent potential to produce sustainable solutions (Mourad et al, 2020). However, the initiatives about citizen science and sustainable agriculture rely on farmers willing to provide their knowledge, time, and labour. Beza et al, 2017. discovered that smallholder farmers and farmers with larger farms had different reasons for participating in citizen science. They contend that although university researchers require large-scale experiments conducted under uniformly controlled conditions to collect readily calibrated data and statistically meaningful conclusions, smallholders do not need to participate in and profit from systematic citizen science programs. Engaging farmers and agricultural communities in more sustainable practices is therefore made possible by citizen science, which is directly beneficial to farmers and tied to farming practice. These subjects include crop productivity, land utilization, irrigation, fertilization, and insect management. (Mourad et al, 2020)

Fertilization

The importance of citizen science projects in measuring land management changes' seasonal and long-term effects was illustrated in France when high school students participated in the Ecoflux program, which funded 18 years of research on nutrients in agricultural catchments.

The students' weekly samples revealed a significant drop in nutritional content throughout the recording period. As an additional illustration, a fascinating citizen science study conducted on Welsh livestock farms as part of the PROSOIL project confirmed that local knowledge of the national dates on which daffodils bloom indicates when to apply nitrogen fertilizer for the first time. Sixty-seven farmers participated in the initiative, using a peer-to-peer learning methodology to cultivate a few bulbs of the same daffodils and record the soil temperature when the flowers bloomed.

Pest control

Under the two-year Mosquito Stopper's citizen science initiative, a success story, citizen scientists could reliably gather data that tracked trends seen in a comparable researcher-generated database with little to no instruction or training. In another study, host resistance in pest-infested woodlands was identified through citizen science. It was shown that incorporating people (citizen scientists) in these initiatives can effectively complement management strategies and offer a low-cost way to maximize search efforts across regions. Additionally, locals assisted with the initial reporting and tracking of forest diseases. Finally, farmers may not see the dangers of relying too much on herbicides regarding weed control. As a result, outreach initiatives targeted at audiences are required to sway farmers' choices about weed control.

Land Use and Irrigation

In October 2018, NASA incorporated locals into their research through the GLOBE Observer citizen science program. People took pictures of the land cover with their cellphones, and crucial information might be obtained by comparing the observations with satellite data. Olteanu-Raimond et al. have launched campaigns as part of the Land Sense project to create an experimental framework for incorporating citizen science into a land change detection process. This effort aims to meet climate targets and develop policies that will lessen soil sealing caused by increased urbanization.

Crops and Yield

Reddy and Ankaiah, (2008) suggested a framework for an economical agricultural information dissemination system (AgrIDS) that would maximize crop output in India by providing farmers with the knowledge and guidance required to cultivate a crop and choose a site based on market demand. However, "land potential," or the capacity for resilience and productivity, is crucial for sustainable agricultural output. A Land Potential Knowledge System (LandPKS) was created by Herrick et al, 2016. to give specific users point-based assessments of land potential based on the combination of cloud-based knowledge and information with straightforward, geotagged user inputs.

Benefits of Citizen Science Projects

This approach closes the gap between scientists and non-scientists. This platform allows individuals who read scientific articles and innovations outside of work, which many do, to express and advance their interests.

- The development of information and communication technology (ICT) has made it simpler to link scientists and citizen scientists.
- Filling in the research gaps leads to a more sophisticated and targeted understanding of the problems, which increases the effectiveness and targeting of problem-solving initiatives.
- In addition, the involvement of citizen scientists guarantees increased responsibility, openness, and accessibility of research and innovation, resulting in thoughtful consideration of societal demands.
- In addition to lowering research costs, using citizen scientists gives academics access to unexplored and otherwise unreachable areas and a bigger pool of resources.
- The augmentation of non-scientist participants' awareness regarding research, data gathering, biodiversity, and their surroundings is a consequence of citizen science.
- Finally, the engagement of local groups also brings about humanitarian, social, and economic progress in the lives of those affected by adverse impacts on their surrounding environment, as seen in the post-independence Indian ventures with Project Tiger and Project Elephant for the species' conversation.

Drawbacks

Despite being a rapidly expanding data collection and analysis sector, citizen science has many drawbacks that the scientific and social communities must address through institutional reforms or regulatory changes. Among the disadvantages are:

- Reliability of data quality: Data obtained may have errors and contradictions due to the input of data by citizens who are only sometimes skilled in scientific research and data collection.
- Some types of research may need to be revised for public participation. Although general observation and involvement in research are becoming more popular, not all research projects can be made public due to a lack of knowledge about citizen science initiatives or restrictions on the research material.
- Offering incentives for the study project: Although many participants participate in these initiatives due to their passion for the topic, co-authorship and recognition issues may make them less likely to join.
- Data ownership, privacy, and accessibility: To develop an open-source, accessible knowledge dissemination system, participants should be made aware of these provisions before the institution stores and shares their data. This is true even though many projects are open-sourced.

Conclusion

In the social and scientific spheres, community involvement is becoming more and more prevalent. It is critical to go forward and put important policies into place. The country's creative and scientific community may combine modern technology with the traditional

knowledge of local communities through citizen science projects. By making the most of this intervention's potential, a foundation for effectively implementing scientific advances in local communities is created, turning them into agents of sustainability and self-sufficiency.

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