Exploring Citizen Science for Sustainable Agricultural Extension Service Delivery in the Information Age[1]

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Abstract

Addressing challenges faced by the agricultural extension service delivery system and different needs of its relevant stakeholders in the 21st century information age require multi-dimensional innovative approaches and tools. This paper therefore, critically analyzes the relevancy of citizen science in agricultural extension service delivery, and suggests how advantages offered by the citizen science can be explored to sustainable delivery and agricultural extension service in the 21st century information age. A critical analysis method was used to systematically analyze concepts, texts, data, or phenomena to identify assumptions, determine meaning, and establish implications. The analysis observed that, the past growing relevance of citizen science as a technology-enhanced learning and its expanding scope is a good possibility worthy of being used to provide collective and a more comprehensive sustainable agricultural extension service in the 21st century information age. This would involve leveraging digital technologies to enable farmer-driven data collection, building community-based networks, and placing participatory research within formal extension systems to create inclusive, technology-mediated, and sustainable delivery of services.

***Keywords*:** Agricultural extension service, citizen science, information age, technology-enhanced learning, 21st century

Introduction

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Citizen Science is a Technology-enhanced Learning (TEL) that involves learners fully or partially in a scientific investigation, with a focus on generating knowledge, skills, and wisdom from the participants to help them answer the initially set out scientific questions. Barau (2024) claims that "Citizen science is a digital technology-based collaborative, but confined by scope of interest learning process and knowledge generation involving experts and non-experts alike who contribute to the pool of data and its analyses, that could be commonly accessed and shared among global citizens."

Furthermore, the Open University (2024) observed that, technology in the modern world facilitates learners and educators to source extensive information than a single person is able to gather. Therefore, this makes citizen science a key vehicle by which agricultural extension service could be delivered to a large number of farmers (and other interested audience) with minimum or no barriers using an enhanced system of computer technology. Citizen science is an evolving deliberate, collaborative and participatory knowledge generation and dissemination means that engages public from different backgrounds in promoting new ideas and understanding of the world (Haklay et al., 2021). The application of citizen science is predominant in sciences (Fraisl et al., 2020; Kullenberg & Kasperowski, 2016), but transcending beyond it due to its relevance in collaborative science that is advanced in today's information age.

On the other hand, agricultural extension professionals and practitioners in the 21st century are challenged by open access to information, meeting the needs of large number of farmers, and evolving farming population with dynamic composition and learning needs including youth who are largely tech-savvy. Though, agricultural extension is a public good (Anderson & Feder, 2004), and penetration of internet technology is 66. 2 percent globally (Petrosyan, 2024), citizen science presents a vital advanced participatory umbrella for knowledge and skills generation; effective communication between farmers, scientists, students and public for interaction and contribution to agricultural technology development and transfer like never before. Agricultural extension systems now tend to be hampered by restricted coverage, top-down information, and poor responsiveness to local issues, which are solved by citizen science through real-time participatory data collection and localized knowledge production (Anderson & Feder, 2004; Mapiye et al., 2021). However, institutional integration, scalability, and verification of citizen science data have gaps that can be

filled by formal partnerships, cyber infrastructures, and feedback mechanisms to enhance service delivery (Fraisl et al., 2020; Kullenberg & Kasperowski, 2016).

So, citizen science could facilitate data generation for inference in the agricultural sector which hitherto especially in developing countries relies on available scanty or outdated sources (FAO, 2011; Oladuni, 2015). This paper therefore, analyzes the relevancy of citizen science in agricultural extension service delivery, and suggests how advantages offered by the citizen science can be explored to sustainable delivery and agricultural extension service in the 21st century information age. Specifically, it looked at, i) citizen science in the information age; ii) agricultural extension service delivery in the information age; and iii) sustainable delivery of agricultural extension service through citizen science in the information age.

Methods

This paper adopts a critical analysis approach to examine how citizen science can be explored for sustainable delivery of agricultural extension service in today's information age. The analysis is particularly based on secondary sources. Critical analysis involves a wide assessment of an issue in order to develop a deep comprehension and a perspective in relation to an issue or topic under consideration. The method utilizes different related opinions from diverse sources, including books, journals, reports and websites.

Findings and Discussion

Citizen science in the information age

Public involvement is scientific issue and knowledge generation and transfer is not new; which is a pillar in citizen science. The term 'citizen science' was first coined and used in the 1980s (Hacklay et al. 2012), as the result of the realization that, knowledge cannot be produced by scientists alone (Nascimento et al. 2014), within the confines of a limited space and participation. But, in the 21st century, public volunteers or interested global citizens are opportune in addressing scientific questions and building body of knowledge that can be shared to solve common problems. The citizen science participants usually crowd source (Howe, 2006), network and volunteer (Franzoni & Sauermann, 2014) in scientific research (Haywood, 2014) through a digitally-enhanced scholarship (Hand, 2010) mediated by computer technology (Nov et al. 2011).

Citizen science is an emerging field of science, education, and training that is past gaining ground in research and practice of today's information age. Citizen science is

argued to cover the gap of no or inadequate participation of non-scientists attributed to open science (Morzy, 2014; Wiggins & Crowston, 2011); and clearly allows novices, non-professional scientists, students, and other interested public members to participate in interactive data generation, and knowledge and skills building for common good. Citizen science is a great tool for unraveling queries and engagement of public in scientific endeavors. It is cost-effective compared to many other tools or methods. In this regard, it is believed that it offers the following benefits amongst others:

i. Gives access to large volume of data and information. This was buttressed in an opinion expressed by Hughes (2024) that, holistic view by a wide number of participants in citizen science provides information that would not have been otherwise generated by single or a few individuals.
ii. Builds interest and awareness of the public in science and broadens its appreciation (Nixon, 2024).
iii. Nurtures sense of belonging and engagement. Gibbons (2024) stated that, citizen science makes people of different age and background feel active contributors to science. As such, a sense of 'we feeling' is created in team through citizen science.
iv. Helps build trust between researchers, students, and other participants. Whatever is formed from a collective contribution builds trust due to commonality shared in the process.
v. Increases literacy in scientific issues. The participation of novices, experts and learners alike increases literacy. Moreover, citizen science primarily deals with scientific issues.
vi. It increases efficiency, transparency, and diversity of opinions in scientific research and dissemination. The open nature of citizen science and its voluntary participation increases efficiency and transparency between researchers, learners, and public.

In the 21st century information age, citizen science can be remarkably effective for engaging people in how science works and for increasing their awareness on matters of concern; whether local or global. The room for participation may serve as a motivating factor to several people who would want to take part for different achievable reasons. For example; some might want to make a difference in their community, while others desire to gain new knowledge, skills or feedback, or contribute toward the purpose of the engagement.

Nonetheless, it has been argued by Cooper et al. (2007) and Shyamal (2007) that, citizen science uses dichotomous identities including experts and non-experts or professional and non-professional scientists, which creates inequality in dealings. Yet, no contribution or participant is considered less except defined by the content of their contribution or participation. In fact, participation in any citizen science project ensures protocol to be observed is explicitly spelt out (The Open University, 2024). Likewise, with increasing digital literacy and sweeping computer technology culture citizen science cannot be hindered or weighed down by intangible dichotomies.

Agricultural extension service delivery in the information age

Agricultural extension mainly enables farmers and organizations to access information on new knowledge that would enhance their skills and practices. Different systems of agricultural extension service exist in the world. Regardless of the differences, they commonly operate to aid learning and extension of new knowledge and technologies in a non-formal setup with the purpose of increasing productivity and income of farmers, and ultimately improves living standard of the society.

Conversely, added to the influx of civil society organizations and private practitioners in the delivery of extension service (Agwu et al., 2023), the 21st century information age has integrated the evolving technologies (such as ICTs and social media) and issues like climate change, demographic changes, globalization etc. within agricultural extension. These elements have demanded for expansion and adaptation in innovative and effective service delivery; involving diverse extension organizations and their personnel (Shimali et al., 2021). The elements are a sort of advances that present further challenges of needing extension professionals and agents with better and diverse knowledge and skills more than before. Similarly, the pluralism and new demands of agricultural extension service have now recognized farmers as deliberate information seekers and intentional about learning how to advance their farming and livelihoods rather than conservative producers who require extrinsic motivation to take in new ideas (Garforth, 2010).

On the other hand, technology has enabled both one-way and interactive learning with and between farmers within the agricultural extension system, such as via mobile phone. That has not only reduced digital divide, but also increased efficiency and access to knowledge by and to farmers although hindrances of infrastructure and initial cost of investment pose threat to the use of technology. Undoubtedly, demand would influence

provision of products targeted at various technology users of emerging and multiple learning contexts such as e-Agriculture and e-Extension. Agricultural extension service delivery is evolving in response to the changing needs of the society. It now utilizes knowledge to solve complex and critical problems collaboratively with citizens and their communities.

Sustainable delivery of agricultural extension service through citizen science in the information age

The sustainability of a thing relies on its ability to be managed for the benefit of today and tomorrow. Anything sustainable therefore, sits on a tetrapod stand of technical soundness, economic efficiency, social acceptability, and environmental friendliness. Now, the success of agricultural extension service delivery in achieving sustainability hinge on the approaches and tools it uses to interact with farmers and other interested parties. Thus, the use of innovative approaches and tools is central to its sustainability.

In the past, a range of agricultural extension service delivery approaches were used. But, challenges or even failures have called for trial and adoption of new approaches (Barh & Balakrishnan, 2018). Recently, cyber-extension, SMS (short message service), voice notes, and mobile phone applications have also been used to deliver agricultural extension service. In the same vein, innovation platform (multi stakeholder space for learning and change) concept has received attention in agricultural extension service delivery by contributing to better agricultural innovation and connecting actors in the agricultural value chain to guarantee access to correct knowledge and information as well as advices.

In furtherance of this advances and adaption of various approaches and tools to sustainably deliver agricultural extension service, covid-19 pandemic has accelerated the embrace of digital technologies, allowing decentralized extension model (pluralistic) expands into the spatial scope of centralized extension model (public). So, having severally observed (Naeimi et al., 2017; Mapiye et al., 2021; Gebeyehu and Jira, 2023; Saini et al., 2023) the crucial role played by participatory research and extension, and digital technologies, citizen science presents a more befitting avenue that combines the benefits offered by both the participatory research and extension, and digital technologies, and allows a common space for farmers, researchers, student learners, professionals, and any other interested person(s) to volunteer, interact, discover, develop,

explore, share and access knowledge, information and skills for sustainable agricultural development.

Employing citizen science could sustainably enhance agricultural extension service delivery in the 21st century in the following ways:

i. Co-design and timely transfer of evidence-based agricultural innovations.

ii. Facilitate positive mindset and behavioural changes through exchange of opinion and diverse perspectives.

iii. Provides an opportunity for local and neighbourhood involvement which expands knowledge base.

iv. Participatory design and collection of data by participants for informed decisions and policy making; with farmers and extension professional and agents being the key.

v. Shaping partnerships and consensus between participants and various stakeholders, and the general public.

vi. Creation of awareness and promotion of community-based natural resources management and protection.

vii. Promotion of collective efforts and interventions.

viii. Serve as a tool for participatory monitoring of agricultural interventions and technology implementation/practice.

ix. Engender participation and contribution of the citizenry in agricultural development projects.

x. To successfully scale citizen science, better digital infrastructure, training, and support to overcome poor internet coverage, low digital literacy, and disjointed efforts that reduce participation and data quality are indispensable.

Citizen science builds on the successes of participatory extension methods toward addressing societal challenges. It can sustainably harness and connect agricultural innovations, knowledge, and skills with the society; thereby decreasing the research-extension-farmer gap, and inequality among the farmers and other relevant stakeholders involved in agricultural development.

Conclusions

The current and anticipated change brought by technology-enhanced learning does not leave agricultural extension service untouched. It presents new demands and openings for education, training and advisory services by guaranteeing access to reliable and up-to-date knowledge, skills, and practices. Citizen science could, therefore, offer a new avenue by harmonizing participation, technology development and sharing, dissemination, and huge data accumulation, thereby stimulating collective efforts towards quality extension service delivery for agricultural development. The pace of computer-based learning and technological advancement in agriculture can be jointly explored via citizen science to sustainably build on participatory extension approaches for delivery of agricultural extension service that is compatible with the 21st century information age. It is evident that agricultural extension service needs to work together with communities, citizens, and public through stakeholder collaboration in order to sustainably address diverse growing challenges. And with citizen science that would additionally shorten the gap between research-extension-farmer linkage as well as inequality in terms of access to new knowledge, skills, and practices. Hence, to effectively improve 21st century agricultural extension, policy must involve citizen science, invest in digital infrastructure, and provide digital literacy for farmers and extension agents. This will consolidate community participation, improve research-extension-farmers linkages, and ensure access to existing agricultural information and practices by all.

Declaration

The authors report that there are no conflicts of interest to declare

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