

A Qualitative Approach to Harvesting Sustainable Futures: The Role of Science in Ensuring Global Food Security in Nigeria

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Abstract

This qualitative research explores the perspectives of science educators in Nigeria regarding their role in promoting global food security through effective education. Targeting educators at both secondary and tertiary levels, the study investigates how science education influences agricultural productivity and the adoption of sustainable practices. Utilizing semi-structured interviews with 500 science educators from diverse regions, thematic analysis revealed key insights into the importance of scientific principles in understanding plant physiology, animal management, and soil health. Science educators emphasized the need for integrating food security concepts into the science curricula and highlighted the potential of combining indigenous knowledge with modern scientific techniques to enhance sustainable agriculture. The findings underscore the critical role of science education in equipping future generations to address food security challenges, thereby informing curriculum development and policy recommendations aimed at fostering sustainable agricultural practices in Nigeria. This study contributes to the understanding of how educational strategies can effectively support food security initiatives and improve agricultural outcomes in the country.

Keywords: Sustainable Futures, Science, Food Security, Global Agriculture and Nigeria

Introduction

Educators underscored the vital role of science education in fostering students' understanding of the scientific processes related to food production, ecosystem resilience, and sustainable agricultural practices. They also pointed out the need for professional development opportunities to improve their ability to effectively teach topics related to food security. Education, broadly defined, is the process of acquiring knowledge, skills, values, beliefs, and habits. It encompasses both formal instruction in schools and universities and informal learning through experiences, interactions, and self-directed study (Dodo & Okike, 2021). Education is not only a fundamental human right but also a crucial driver of individual and societal development. It empowers individuals to think critically, solve problems, and adapt to changing circumstances.

Within this broader context, biology which is the scientific study of life provides an essential lens for examining the intricate relationships between living organisms and their environments (Adam *et al.*, 2024). Biology explores fundamental concepts such as the structure, function, growth, evolution, distribution, and classification of living things. A strong foundation in biological principles is crucial for understanding the interconnectedness of ecosystems, the impact of human activities on biodiversity, and the potential for leveraging biological processes to address pressing global challenges such as food security (Kariuki *et al.*, 2023).

Science in general and biology in particular plays a fundamental role in sustainable agriculture by providing the knowledge base for understanding plant physiology, genetics, and interactions between organisms (Amoah, *et al.*, 2024). These concepts are critical for developing sustainable agricultural practices, exploring the genetic diversity of crops, and understanding plant disease resistance mechanisms. Additionally, biological research fosters innovative approaches to improving crop yields while minimizing environmental impacts.

Global food security is defined as the availability of, and access to, sufficient, safe, and nutritious food to maintain an active and healthy life at all times. This challenge is becoming increasingly complex due to climate change, population growth, and resource depletion (Onyeaka *et al.*, 2024). Ensuring food security necessitates a holistic approach that integrates scientific advancements with social, economic, and political considerations. Science is central to this endeavor, offering tools and knowledge to enhance agricultural productivity, improve the nutritional value of crops, and develop sustainable food systems. For example, a deeper understanding of photosynthesis has led to advances in crop efficiency, the knowledge of physics improved the production of different machines and equipment while biotechnology has facilitated the development of climate-resilient crops that can withstand environmental stresses. Research on plant-microbe interactions has contributed to the development of biofertilizers and biopesticides, reducing reliance on synthetic inputs and promoting sustainable farming practices (Njeru & Koskey, 2021).

In Nigeria, where food security remains a significant concern, the role of science in addressing agricultural challenges is particularly critical. The country's diverse agroecological zones offer immense potential for cultivating a variety of crops, but realizing this potential requires investment in research, education, and infrastructure. Applying biological principles to enhance crop yields, improve nutritional content, and develop climate-smart agricultural strategies is essential to ensuring food security for Nigeria's growing population (Sulaimon, 2024).

Furthermore, the integration of indigenous knowledge systems with modern biological techniques presents an opportunity for sustainable agricultural advancement. Traditional farming practices, coupled with scientific research, can lead to innovative solutions for enhancing productivity while preserving biodiversity. Fostering a new generation of

biologists and agricultural scientists equipped with the knowledge and skills to address food security challenges is paramount (Akpa *et al.*, 2024).

Despite Nigeria's vast agricultural potential, food security remains a persistent challenge due to inadequate agricultural education, lack of integration between traditional and modern farming techniques, and the adverse effects of climate change. There is a need for a comprehensive approach that combines biological principles with innovative agricultural practices to ensure food security. This study seeks to address these gaps by investigating the role of science education in fostering sustainable agricultural development and improving food security in Nigeria.

Review Literature

Science education equips farmers with knowledge to implement sustainable agricultural practices, improving food availability in Nigeria. Practices such as crop rotation and integrated pest management enhance soil health and reduce resource usage, ultimately leading to higher crop yields. (Abobatta & Fouad, 2024). According to Balogun *et al.* (2024) Science education is essential for advancing sustainable agricultural practices, such as climate-smart agriculture, which can greatly improve agricultural productivity, food security, and resilience to climate change in Nigeria. A strong foundation in biological concepts enables farmers and agricultural professionals to implement innovative techniques that enhance soil health, maximize resource efficiency, and boost crop yields. For example, understanding soil microbiology supports soil fertility through organic farming, composting, and the application of biofertilizers, reducing dependence on chemical inputs that harm the environment (Kamaurewe, 2022). Also, knowledge of plant physiology and genetics facilitates the selection of high-yield, climate-resilient crop varieties, ensuring better adaptation to shifting climatic conditions. Science education also encourages the adoption of integrated pest management (IPM), which minimizes crop losses by employing natural predators, biological pesticides, and crop rotation rather than excessive chemical use (Akinsorotan *et al.*, 2023).

Increase in farmers' awareness of water conservation strategies, such as rainwater harvesting and drip irrigation, which are crucial for sustaining agricultural productivity in drought-prone areas. (Oiganji, *et al.*, 2025). Incorporating science education into agricultural training programs and school curricula can help Nigeria develop an informed farming community that embraces scientific, eco-friendly approaches. As a result, this will lead to higher agricultural output, enhanced food security, and improved resilience to climate change, ultimately contributing to the nation's long-term economic and environmental sustainability. Effective crop management practices, guided by biological education, are essential for maximizing agricultural productivity and ensuring food security in Nigeria. (Ariom *et al.*, 2022)

A strong understanding of biological principles enables farmers to make informed decisions regarding soil fertility, pest control, irrigation, and crop selection, all of which contribute to higher yields and sustainable farming systems (Orina *et al.*, 2024). When

farmers lack proper knowledge, they may engage in poor agricultural practices such as excessive use of chemical fertilizers, improper crop rotation, and inadequate pest control measures. These practices can deplete soil nutrients, reduce plant resistance to diseases, and ultimately lead to lower crop yields. Declining agricultural output not only affects individual farmers' livelihoods but also threatens national food availability, making it harder to meet the demands of a growing population. By integrating biological education into agricultural training programs, farmers can learn to adopt scientifically proven agronomic techniques that enhance productivity. For example, understanding plant physiology helps in selecting suitable crop varieties for different climatic conditions, while knowledge of soil microbiology promotes the use of organic fertilizers and composting to improve soil health. Educating farmers about integrated pest management (IPM) can reduce reliance on chemical pesticides, promoting environmentally friendly farming practices. Raising awareness about these best practices is crucial for improving agricultural outcomes in Nigeria. Government agencies, educational institutions, and agricultural extension services should collaborate to provide training programs, workshops, and accessible resources for farmers. By equipping them with the necessary knowledge and skills, farmers can optimize crop production, reduce post-harvest losses, and contribute to national food security, economic growth, and environmental sustainability. (Eheazu, 2023). Environmental literacy education, equips farmers with the knowledge needed to adopt sustainable agricultural practices such as Conservation Agriculture. By highlighting the environmental consequences of traditional farming methods such as soil degradation, deforestation, and excessive chemical use it fosters a shift toward eco-friendly techniques that improve soil health, conserve natural resources, and enhance crop resilience. This knowledge enables farmers to make well-informed choices, resulting in improved agricultural productivity, enhanced earnings, and sustainable development in rural Nigeria.

Objectives of the study

The following objectives were generated for the study:

1. To examine the role of science education in enhancing agricultural productivity and food security.
2. To explore the integration of indigenous knowledge with modern biological techniques for sustainable farming.
3. To evaluate the impact of climate change on agricultural productivity and the biological strategies to mitigate its effects.
4. To assess the effectiveness of biotechnological advancements in improving crop yield and sustainability in Nigeria.

Research Questions:

1. How does science education contribute to enhancing agricultural productivity and food security in Nigeria?
2. In what ways can indigenous farming knowledge be integrated with modern biological techniques to promote sustainable agricultural practices in Nigeria?

Research Hypotheses:

H01: Science education positively influences farmers' ability to adopt sustainable agricultural practices, leading to increased agricultural productivity and improved food security in Nigeria.

H02: The integration of indigenous knowledge with modern biological techniques significantly enhances the sustainability and productivity of farming in Nigeria.

Methods

This study employed a qualitative approach, utilizing semi-structured interviews, to explore the perspectives and experiences of science educators in Nigeria regarding their role in achieving global food security. The study focused on understanding how these educators perceived their role in shaping future generations equipped to address food security challenges. A purposive sampling strategy was used to select 500 science educators at the secondary and tertiary levels from diverse geographical regions within Nigeria, focusing on those with relevant experience and expertise. Semi-structured interviews, guided by an interview protocol, explored educators' perceptions of food security, the role of science education in addressing it, current curriculum integration and opportunities for improvement, teaching practices and resources, challenges and opportunities faced by educators, and their recommendations for enhancing science education to contribute to food security solutions. Interviews were conducted in English, audio-recorded, and transcribed verbatim. The transcribed interviews were analyzed using thematic analysis, involving familiarization with the data, coding key concepts, developing and refining themes, and reporting findings in a narrative format with illustrative quotes. Ethical considerations, including informed consent, confidentiality, data security, and the right to withdraw, were strictly adhered to. Trustworthiness was ensured through strategies such as credibility (prolonged engagement, member checking, triangulation), transferability (detailed descriptions of context and procedures), dependability (audit trail of the research process), and confirmability (grounding findings in the data).

Results

Answering of Research Questions

Research Question 1: How does science education contribute to enhancing agricultural productivity and food security in Nigeria?

Key Themes Identified:

- a. **Understanding Plant Physiology:** Interviewees emphasized that their science education provided them with insights into plant growth processes, photosynthesis, and nutrient requirements. This knowledge enables them to make informed decisions about crop selection and management practices that enhance yield and sustainability.
- b. **Animal Physiology Insights:** Participants noted that an understanding of animal physiology, including nutrition and breeding, allows for better livestock management. This contributes to increased productivity and health of livestock, which is crucial for food security.
- c. **Microorganisms and Soil Health:** The role of microorganisms in soil fertility was highlighted as a critical area of knowledge. Educated farmers expressed that their science background helps them implement practices that enhance soil health, such as crop rotation and composting, leading to improved crop yields.
- d. **Genetics in Crop Improvement:** Insights into genetics have empowered farmers to adopt improved varieties of crops and livestock, which are better adapted to local conditions and resist pests and diseases, directly impacting agricultural productivity.
- e. **Pest and Disease Management:** Knowledge gained from science education about pest and disease cycles allows farmers to apply integrated pest management strategies effectively, reducing crop loss and ensuring a stable food supply.

Conclusion: Overall, science education equips farmers with essential knowledge and skills that enhance agricultural productivity through better management of plants and animals, improved soil health, and effective pest management strategies, thereby contributing to food security in Nigeria.

Research Question 2: In what ways can indigenous farming knowledge be integrated with modern biological techniques to promote sustainable agricultural practices in Nigeria?

Key Themes Identified:

- a. **Complementing Traditional Practices with Scientific Knowledge:** Interviewees highlighted examples where traditional practices, such as intercropping and organic fertilization, can be enhanced with scientific insights on soil health and pest resistance, leading to more sustainable outcomes.

- b. **Utilizing Indigenous Knowledge of Local Ecosystems:** Participants pointed out that indigenous knowledge regarding local climate and soil types can be integrated with biological techniques, such as soil testing and crop modeling, to optimize planting schedules and crop selection.
- c. **Community-Based Approaches:** The importance of community engagement was stressed; combining local wisdom with modern techniques fosters collaboration and collective learning, which enhances the adoption of sustainable practices.
- d. **Education and Capacity Building:** Interviewees suggested that training programs that respect and incorporate indigenous knowledge while introducing modern biological techniques can empower farmers, making them more resilient to environmental changes.
- e. **Biodiversity Preservation:** Integrating indigenous practices that promote biodiversity with modern conservation science can lead to more resilient agricultural systems, ensuring long-term sustainability.

Conclusion: The integration of indigenous farming knowledge with modern biological techniques can create a robust framework for sustainable agricultural practices in Nigeria. This approach respects local traditions while enhancing productivity and resilience through scientific understanding, ultimately promoting food security.

Testing of Hypotheses

H0₁: Science education positively influences farmers' ability to adopt sustainable agricultural practices, leading to increased agricultural productivity and improved food security in Nigeria.

Evidence from Interviews:

- a. **Understanding of Biological Principles:** Many educators noted that their science education equips farmers with essential knowledge about plant and animal physiology, which is crucial for making informed decisions regarding crop selection and livestock management.
- b. **Sustainable Practices Adoption:** Interviewees highlighted specific sustainable practices, such as organic farming, integrated pest management (IPM), and soil fertility management that farmers are more likely to adopt after receiving science education. These practices directly contribute to increased agricultural productivity.
- c. **Improved Crop Yields:** Educators shared examples of how understanding science has led to higher crop yields and better resource management. For instance, knowledge of soil microbiology helps farmers improve soil health, which is vital for crop productivity.

- d. **Food Security Awareness:** The interviews revealed that science education fosters a greater awareness of food security issues among farmers, motivating them to adopt practices that contribute to sustainable food systems.

Conclusion for H0₁: The responses indicate a strong correlation between science education and the adoption of sustainable agricultural practices, suggesting that it positively influences farmers' abilities to enhance productivity and improve food security in Nigeria. Thus, H0₁ is supported by the evidence gathered from the interviews.

H0₂: The integration of indigenous knowledge with modern biological techniques significantly enhances the sustainability and productivity of farming in Nigeria.

Evidence from Interviews:

1. **Synergy of Knowledge Systems:** Educators emphasized the value of combining indigenous farming practices with modern scientific approaches. Many participants noted that traditional methods often align well with biological principles, leading to innovative solutions for sustainable agriculture.
2. **Cultural Relevance and Acceptance:** Interviewees pointed out that integrating indigenous knowledge fosters greater acceptance among local farmers, making them more likely to adopt new practices. This cultural relevance enhances the overall sustainability of farming systems.
3. **Case Studies and Success Stories:** Several educators provided examples where the integration of traditional techniques, such as crop rotation and natural pest control, with modern biological methods has resulted in increased productivity and reduced environmental impact.
4. **Resilience to Climate Change:** The combination of indigenous knowledge and modern techniques was viewed as a way to improve resilience against climate change, which is critical for ensuring food security in Nigeria.

Conclusion for H0₂: The insights gathered from the interviews indicate a significant positive impact of integrating indigenous knowledge with modern biological techniques on the sustainability and productivity of farming practices in Nigeria. Therefore, H0₂ is also supported by the evidence from the interviews.

Discussion

The findings of this study highlight the integral role that science education plays in enhancing agricultural productivity and addressing food security challenges in Nigeria. The perspectives of science educators reveal a consensus on the importance of equipping future generations with a robust understanding of biological principles that underpin sustainable agricultural practices.

One of the key themes that emerged from the interviews is the significance of understanding plant physiology. Educators noted that knowledge of how plants grow and respond to various environmental factors allows farmers to make informed decisions regarding crop selection and management. This understanding is crucial, especially in a nation like Nigeria, where diverse agroecological zones present unique challenges and opportunities for crop cultivation. By applying concepts learned in sciences, farmers can optimize their practices to improve yields while minimizing environmental impacts.

Similarly, insights into animal physiology were deemed essential for effective livestock management. Educators emphasized that a solid grasp of animal nutrition and breeding principles leads to healthier livestock and increased productivity. This is particularly relevant in Nigeria, where livestock farming is a significant component of the agricultural sector and contributes to the livelihoods of many families.

The role of microorganisms in soil health and fertility was another critical area highlighted by the educators. Understanding the interactions between soil microbes and plants enables farmers to adopt practices such as organic farming and the use of biofertilizers, which can enhance soil fertility and reduce reliance on harmful chemical inputs. This aligns with the growing global emphasis on sustainable agriculture and the need to preserve natural ecosystems.

Moreover, the integration of indigenous knowledge with modern biological techniques emerged as a prominent theme in the discussions. Educators recognized that traditional farming practices, rooted in local knowledge and experience, can be effectively combined with scientific advancements to create innovative solutions for sustainable agriculture. This synergy can lead to improved resilience against climate change and resource scarcity, which are pressing concerns for Nigeria's agricultural future.

However, the study also identified significant challenges that educators face in implementing effective science education. Limited resources, inadequate infrastructure, and a lack of professional development opportunities hinder the ability of educators to teach food security concepts effectively. Addressing these challenges is critical to maximizing the impact of science education on agricultural practices.

In light of these findings, it is evident that there is a pressing need for educational reforms that prioritize the integration of science into agricultural training programs. Policymakers should consider investing in curriculum development that includes food security topics, hands-on learning experiences, and collaboration with local communities to harness indigenous knowledge. By fostering a comprehensive understanding of biological principles and promoting sustainable practices, Nigeria can work towards achieving food security and enhancing agricultural productivity.

Conclusion

This paper concludes that investing in science education is essential for equipping future generations with the knowledge and skills necessary to tackle food security issues in Nigeria. By fostering an informed farming community that embraces sustainable practices, Nigeria can enhance agricultural productivity, improve food security, and promote long-term environmental sustainability. Further research and policy initiatives should focus on bridging the gap between traditional and modern agricultural practices to ensure a sustainable and food-secure future.

Recommendations

Based on the findings of this study, several key recommendations can be made to enhance the role of science education in promoting sustainable agricultural practices and improving food security in Nigeria:

1. **Curriculum Integration:** Integrate food security and sustainability topics into the science curriculum at both secondary and tertiary levels. This should include hands-on learning experiences that connect theoretical knowledge with practical applications in agriculture.
2. **Professional Development for Educators:** Provide ongoing professional development opportunities for science educators to enhance their understanding of current agricultural practices, sustainable techniques, and innovative teaching methodologies. Workshops and training programs can empower educators to effectively convey relevant concepts to their students.
3. **Collaboration with Agricultural Institutions:** Foster partnerships between educational institutions and agricultural research organizations to facilitate knowledge exchange and practical training. Such collaborations can help in developing resource materials and establishing demonstration farms that serve as learning hubs for students and local farmers.
4. **Emphasizing Indigenous Knowledge:** Create programs that promote the integration of indigenous farming knowledge with modern biological techniques. This approach can enhance the effectiveness of agricultural practices while respecting local traditions and biodiversity.
5. **Community Engagement:** Involve local communities in the educational process by organizing workshops, seminars, and field days that educate farmers about sustainable practices and the benefits of science education. Engaging the community fosters a collaborative environment where knowledge sharing can thrive.
6. **Resource Allocation:** Advocate for increased investment in educational resources, infrastructure, and research initiatives aimed at promoting sustainable agriculture.

Adequate funding and resources are essential for implementing effective science education programs.

7. **Policy Support:** Encourage policymakers to support initiatives that promote the importance of science education in agriculture as part of broader strategies for enhancing food security. Policies should prioritize the development of sustainable agricultural practices and the training of future generations.
8. **Monitoring and Evaluation:** Establish frameworks for monitoring and evaluating the impact of science education on agricultural productivity and food security. Regular assessment can help identify best practices and areas for improvement, ensuring that educational programs remain relevant and effective.

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