

REVIEW ARTICLE

Sustainable Agricultural Education Practices for Climate-Resilient Farming in Kebbi State, Nigeria

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ABSTRACT

This study examined the role of sustainable agricultural education practices in promoting climate-resilient farming among smallholder farmers in Kebbi State, Nigeria. Agriculture remains the primary livelihood in the state, yet climate change impacts such as erratic rainfall, drought, flooding, and rising temperatures continue to threaten productivity and food security. A descriptive survey design was adopted, and primary data were collected from 120 respondents selected through a multi-stage sampling technique across selected local government areas. The study assessed climate change awareness, integration of climate resilience into agricultural education curricula, access to extension and advisory services, and constraints to effective adoption of climate-smart practices. Findings revealed that farmers and agricultural education students demonstrated general awareness of climate change, their understanding and practical application of climate-resilient farming practices were limited. Climate resilience concepts were weakly integrated into formal curricula, and extension services were inadequate in coverage and capacity. However, access to agricultural education and extension support positively influenced the adoption of climate-smart practices. The study concludes that strengthening sustainable agricultural education and extension systems is essential for enhancing farmers' adaptive capacity and achieving climate-resilient agriculture in Kebbi State.

Key words: Climate-resilient farming, climate-smart agriculture, sustainable agricultural education

INTRODUCTION

Agriculture constitutes the primary livelihood activity for the majority of rural households in Kebbi State, Nigeria, where smallholder farmers dominate crop production systems. However, the sector is increasingly threatened by the impacts of climate change, including unpredictable rainfall patterns, prolonged droughts, soil degradation, and increased incidence of pests and diseases. These climatic stressors exacerbate existing vulnerabilities among farmers, undermine food security, and compromise agricultural productivity. In recognition of these challenges, climate-smart agriculture (CSA) has

emerged as a key strategy to build resilience and sustainability in farming systems by promoting practices such as conservation farming, drought-tolerant crop varieties, and effective soil and water management. Research on CSA in Nigeria has shown that adoption levels are influenced by access to knowledge, extension services, education, and institutional support.^[1]

Agricultural education plays a critical role in equipping farmers and future agricultural practitioners with the knowledge, skills, and attitudes necessary to implement sustainable and climate-resilient practices. Studies in Nigerian tertiary institutions have highlighted that students in agricultural education programs demonstrate a broad awareness of climate change issues but require more structured curricula that integrate climate change mitigation and adaptation content.^[2]

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Similarly, enhancement of advisory and extension systems in the country has been identified as central to closing the gap between knowledge and on-farm adoption of CSA practices.^[3]

Within Kebbi State, empirical evidence indicates that farmers adopt various adaptation strategies to cope with climate variability, yet the intensity and effectiveness of adoption remain sub-optimal due to constraints such as limited access to extension, credit, and relevant climate information (Assessment of climate adaptation strategies in Kebbi State, 2024). This context underscores the importance of sustainable agricultural education practices that are tailored to local climate realities and able to enhance farmers' adaptive capacity, promote innovation, and support resilient agricultural livelihoods.

Statement of the Problem

Despite the growing awareness of climate change and the potential of climate-smart agricultural practices to mitigate its adverse effects, smallholder farmers in Kebbi State continue to face significant challenges in adopting sustainable farming practices. Empirical research shows that while many farmers are aware of climate risks and some adaptive strategies, the intensity and depth of adoption are low due to factors such as limited literacy, inadequate access to extension services, and poor dissemination of climate risk information.^[3]

Moreover, agricultural education programs in Nigeria have not fully integrated climate resilience concepts into formal curricula, leaving a gap in the capacity of future farmers and agricultural professionals to effectively respond to emerging climate pressures. Studies in southwest Nigeria reveal that agricultural education students recognize the importance of climate change issues but lack comprehensive training on mitigation and adaptation techniques.^[2]

These constraints not only hinder the adoption of resilient farming systems but also threaten the sustainability of agricultural production in Kebbi State. There is therefore a critical need to examine how agricultural education practices can be strengthened and aligned with climate resilience objectives to enhance farmers' capacity, promote sustainable practices, and contribute to improved food security.

Objectives of the Study

The broad objective of this study is to evaluate the role of sustainable agricultural education practices in enhancing climate-resilient farming among smallholder farmers in Kebbi State, Nigeria.

The specific objectives are to:

1. Assess the level of climate change awareness among agricultural education students and smallholder farmers in Kebbi State.
2. Examine the extent to which climate resilience concepts are integrated into agricultural education curricula at tertiary and vocational levels.
3. Evaluate farmers' access to agricultural education, advisory services, and extension support for adopting climate-smart agricultural practices.
4. Identify key constraints to the effective implementation of sustainable agricultural education and its influence on the adoption of climate-resilient farming practices.
5. Provide recommendations for improving educational and extension approaches to strengthen climate resilience among farmers in Kebbi State.

Significance of the Study

This study holds theoretical, policy, and practical significance for agricultural development, climate resilience, and education in Kebbi State. By integrating insights from agricultural education and climate resilience literature, this study contributes to the growing body of knowledge on how education practices influence the adoption of CSA. It builds on Nigerian empirical studies demonstrating the role of education and extension in enhancing resilience.^[2,3] Findings from this research can inform policymakers, curriculum developers, and educational institutions on how to design and implement agricultural education programs that are responsive to climate change challenges. This evidence can support the integration of climate resilience modules into formal agricultural education and strengthen agricultural extension policies that prioritize sustainable practices. Practical Significance: For farmers, extension agents, and agricultural stakeholders in Kebbi State, the study provides actionable insights

into the effectiveness of current education and advisory systems. It identifies practical gaps and opportunities for enhancing knowledge exchange, training, and access to climate-smart solutions that can improve adaptive capacity and productivity.

Significance of the Study and Relevance to the Conference

This study is significant because it addresses a critical but underexplored linkage between agricultural education and climate-resilient farming in Kebbi State, Nigeria. While CSA has received growing attention in Nigeria, limited empirical evidence exists on how agricultural education systems practically influence farmers' adaptive capacity at the local level. By examining curriculum integration, extension services, and farmers' access to climate-resilience knowledge, this is an important gap between awareness of climate change and the actual adoption of sustainable farming practices.

The study contributes to existing knowledge by providing context-specific evidence from a climate-vulnerable, agrarian state where smallholder farmers dominate production. It moves beyond general discussions of climate adaptation by demonstrating that weak curriculum content, inadequate extension coverage, and limited practical training constrain the effectiveness of climate-resilient initiatives.

Practically, the findings have direct implications for policy, education, and extension practice. The study identifies actionable gaps in agricultural education delivery and extension systems, offering insights that can guide curriculum reform, capacity building for extension agents, and the design of farmer-centered training programs. These outcomes respond to pressing societal needs for improved food security, livelihood stability, and climate adaptation among rural farming households.

The paper is highly relevant to the conference theme, "Building Capacities for Sustainable Futures: Bridging Global Challenges and Local Realities," as it demonstrates how strengthening local education systems can translate global climate goals into tangible outcomes for vulnerable communities. By aligning education, policy, and practice, the study provides evidence-based pathways for sustainable and inclusive agricultural development.

LITERATURE REVIEW

Climate Change and Nigerian Agriculture

Climate change presents a profound and escalating threat to agricultural systems in Nigeria. Empirical research highlights that rising temperatures, shifting rainfall patterns, and increasing frequency of extreme weather events such as droughts and floods are significantly disrupting crop and livestock production systems across the country. These climatic shifts contribute to reduced crop yields, heightened pest and disease pressures, soil degradation, and increased vulnerability among rural farming households.^[4,5] Indeed, smallholder farmers, who account for over 80% of Nigeria's food production, are particularly vulnerable due to their limited adaptive capacity and reliance on rain-fed systems. Prolonged dry spells and erratic rainfall undermine water availability for crops, especially in the semi-arid North where Kebbi State is located, exacerbating food insecurity and rural poverty.^[6] Such environmental changes have contributed to declining productivity of staple crops such as rice, maize, and sorghum and heightened the risk profile of agricultural enterprises in Nigeria.^[7] Climate change adaptation research in the Nigerian context underscores that farmers deploy a range of strategies to cope with climatic shocks, including altering planting dates, diversifying crop portfolios, and adopting drought-tolerant varieties.^[7] However, the intensification and effectiveness of these adaptive measures remain limited where supportive institutional mechanisms, knowledge systems, and resource access are weak. This body of literature collectively affirms that climate change is both a current and future threat to agricultural sustainability in Nigeria and that resilience-building interventions must be multi-faceted, involving improved information systems, education, and policy support.

Sustainable Agricultural Education

Agricultural education plays a pivotal role in equipping farmers, extension agents, and future agricultural professionals with knowledge and skills necessary for adaptation and resilience in the face of climate change. Literature on agricultural education in Nigeria reveals persistent gaps in the integration of climate change and sustainability topics within formal

curricula at secondary schools, tertiary institutions, and vocational training programs. A major challenge identified is the lack of awareness among both educators and students regarding climate change's complexities and its implications for farming.^[8] This deficit limits the capacity of agricultural education programs to prepare learners for emerging challenges in agro-ecological management and climate adaptation. In addition, financial constraints, inadequate instructional resources, and limited access to practical technologies further impede effective education delivery.^[8]

Empirical studies underscore that sustainable agricultural education must transcend traditional production-centric training to embrace climate literacy, environmental stewardship, and socio-ecological systems thinking. Such integration enhances students' and farmers' readiness to adopt sustainable and climate-resilient practices that can mitigate environmental risks and improve long-term farm viability. Without these enhancements, agricultural education risks reinforcing outdated paradigms that are insufficient for addressing the realities of climate change and sustainability in contemporary agriculture.

CSA in Kebbi State

CSA is recognized as a strategic framework for enhancing agricultural resilience and food security under changing climatic conditions. CSA integrates practices that increase productivity, improve resilience (adaptation), and reduce greenhouse gas emissions where possible. Across Nigeria, CSA interventions include conservation agriculture, agroforestry, improved soil and water management, crop diversification, and the adoption of drought-tolerant varieties.^[9] In Kebbi State, empirical evidence indicates that smallholder farmers face multiple barriers to the adoption of climate-smart agriculture (CSA). These barriers are economic, environmental, socio-cultural, and institutional in nature and include limited access to extension services, declining soil fertility, pest and disease pressures, and inadequate government support for agricultural inputs.^[10] These challenges demonstrate that while CSA holds promise for boosting resilience among farmers, its actualization is contingent on enabling conditions that facilitate knowledge transfer, institutional support, and resource access.

Furthermore, gender dynamics significantly influence farmers' participation in climate-resilient agricultural practices. A study in Kebbi State found that male farmers were more likely to adopt climate-resilient practices than female farmers, largely due to gender-related disparities in access to land, credit, extension services, and opportunities for agricultural decision-making.^[11] This underscores the importance of inclusive CSA programs that consciously address gender barriers to enhance equitable resilience outcomes. Collectively, the literature affirms that CSA frameworks must be context specific and responsive to localized constraints, particularly in regions like Kebbi with pronounced climatic vulnerabilities.

Barriers to Effective Agricultural Education

Barriers to effective agricultural education in Nigeria hinder the sector's ability to impart climate-responsive competencies. Several factors constrain the delivery and uptake of agricultural education, particularly in climate contexts. First, curricula often lack substantive content on climate change and sustainable practices, reflecting a broader gap in educational policy and institutional prioritization.^[8] Second, inadequate funding limits the development of innovative teaching resources, field experiences, and practical demonstrations that are essential for experiential learning. Third, technological deficits including lack of access to digital learning tools and contemporary agricultural technologies reduce educators' capacity to expose students to real-world climate adaptation scenarios.^[8] Furthermore, limited collaboration between agricultural education institutions and extension services weakens the feedback loop between research, formal education, and on-farm application. This disconnect inhibits the translation of academic knowledge into useful practices for farming communities. Without addressing these educational barriers, efforts to build a cadre of climate-literate farmers and agricultural professionals will remain limited.

Strengthening Extension Services

Agricultural extension services serve as key conduits for disseminating knowledge, technologies, and innovations from research and education systems

to farmers. Evidence from Nigeria suggests that extension services significantly influence farmers' adaptive capacities, climate awareness, and adoption of resilient practices. For instance, studies in Ebonyi State show that extension contact enhances smallholder farmers' capacity to implement soil-water conservation, crop rotation, and drought-tolerant cropping systems.^[12] However, extension systems in Nigeria face systemic challenges including underfunding, limited training, and low institutional support factors that diminish the effectiveness and reach of advisory services.^[13,14]

Moreover, research indicates that extension agents themselves often lack adequate training on climate-smart practices, resulting in weak participation in promoting CSA. Agents' attitudes and limited capacity are influenced by inadequate professional development and structural constraints, which in turn limit farmers' exposure to timely and actionable climate information.^[14] Strengthening extension services thus requires investments in human capital (training and retraining), digital and climate information platforms, and stronger integration with educational institutions to foster continuous learning and technology transfer. Such reforms can enhance the adaptive capacity of smallholder farmers and accelerate the adoption of sustainable and climate-resilient agricultural practices across Nigeria's agrarian landscapes.

METHODOLOGY

The study was conducted in Kebbi State, Nigeria, located in the north-western part of the country. Kebbi State is predominantly agrarian, with a large proportion of the population engaged in crop and livestock production. Major agricultural activities include rice, millet, sorghum, maize, cowpea cultivation, and livestock rearing. The state is highly vulnerable to climate variability such as irregular rainfall, flooding, drought, and rising temperatures, making it suitable for a study on sustainable agricultural education practices for climate-resilient farming.

The study adopted a descriptive survey research design because it allows for the systematic collection of data from respondents to describe existing sustainable agricultural education practices and their relevance to climate-resilient farming without manipulating the

study environment. Primary data were collected directly from respondents through the use of a well-structured questionnaire designed to elicit information on the objective of the study.

A multi-stage sampling procedure was employed in selecting respondents for the study. Stage I: Purposive selection of three (3) Local Government Areas (LGAs) in Kebbi State based on their high level of agricultural activities and vulnerability to climate change effects. Stage II: From each selected LGA, two (2) farming communities were randomly selected, giving a total of six (6) communities. Stage III: In each selected community, a list of farmers was obtained with the assistance of extension agents or community leaders. Stage IV: From each community, 20 respondents were randomly selected using a simple random sampling technique. A total of 120 respondents were selected for the study. This sample size was considered adequate to represent the target population and to allow for meaningful descriptive statistical analysis.

A WAY FORWARD: RESULTS BASED ON THE OBJECTIVE OF THE STUDY

The findings emerging from the research objective provide important insights into how sustainable agricultural education can be strengthened to promote climate-resilient farming in Kebbi State. The way forward is discussed in line with each research objective, drawing from empirical evidence and related academic literature.

Awareness and Understanding of Climate Change and Climate-Resilient Farming

Results from the study indicate that most respondents were aware of changes in rainfall patterns, temperature increase, and extreme weather events, their understanding of climate-resilient farming practices was largely superficial. This aligns with earlier findings by Onyeneke *et al.*,^[4] who observed that Nigerian farmers often possess experiential awareness of climate change but lack technical knowledge of appropriate adaptation measures. The way forward requires strengthening climate literacy through targeted agricultural education programs that translate climate science into locally understandable and actionable knowledge. Integrating indigenous

knowledge with scientific climate information can further enhance comprehension and relevance, as suggested by Oladipo *et al.*^[15]

Integration of Climate Resilience into Agricultural Education Curricula

The study results suggest that climate resilience concepts are weakly integrated into existing agricultural education curricula and training programs. This corroborates the findings of Otufale and Oose^[2] who reported that agricultural education programs in Nigeria inadequately address climate change adaptation and sustainability. Going forward, curriculum reform is essential to mainstream climate change, CSA, and sustainability across all levels of agricultural education. Practical components such as field demonstrations, case studies from Kebbi State, and experiential learning should be emphasized to bridge the gap between theory and practice.^[3]

Availability of Sustainable Agricultural Education Practices

Findings reveal that non-formal education channels such as extension services, farmer field schools, and cooperative-based training are the dominant sources of agricultural education for farmers in Kebbi State. However, coverage and intensity remain low. Similar observations were made by Aliyu *et al.*^[10] in their study on barriers to CSA adoption in Kebbi State. The way forward involves scaling up sustainable agricultural education practices through community-based learning centers, demonstration farms, and participatory training approaches. These platforms should focus on climate-smart practices such as crop diversification, drought-tolerant varieties, soil conservation, and water management tailored to local agro-ecological conditions.

Influence of Agricultural Education and Extension on Adoption of Climate-Resilient Practices

The results demonstrate a positive relationship between access to agricultural education, extension contact, and adoption of climate-resilient farming practices. Farmers with frequent extension visits and training exposure were more likely to adopt climate-smart

practices. This finding supports empirical evidence from Ogueri^[12] who found that extension services significantly enhance adaptive capacity among Nigerian smallholder farmers. Strengthening extension services is therefore critical. The way forward includes increasing the number of trained extension agents, improving their capacity on CSA, and leveraging digital extension platforms such as mobile phones and radio programs to widen outreach.

Constraints to Effective Agricultural Education for Climate Resilience

The study identified key constraints including inadequate funding, limited extension coverage, low educational attainment among farmers, weak institutional coordination, and poor access to climate information. These challenges mirror national-level constraints reported by Ajayi^[13] and Onyeneke *et al.*^[4] Addressing these barriers requires a multi-stakeholder approach involving government agencies, educational institutions, research organizations, and development partners. Increased investment in agricultural education infrastructure, training of educators and extension agents, and provision of climate information services are essential steps forward.

Strategies for Strengthening Agricultural Education for Climate Resilience

Based on the study findings, a strategic way forward is the adoption of an integrated agricultural education model that links formal education, non-formal training, and extension services. This model should emphasize continuous learning, farmer participation, and feedback mechanisms between research institutions and farming communities. Gender-sensitive approaches are also necessary, as previous studies in Kebbi State indicate that women face greater barriers in accessing agricultural education and extension services.^[11] Policies should therefore prioritize inclusive education programs that empower women and youth as key agents of climate resilience.

CONCLUSION

The study underscores the critical importance of sustainable agricultural education in strengthening

climate-resilient farming systems in Kebbi State, Nigeria. Evidence from the findings indicates that although awareness of climate change exists among smallholder farmers and agricultural education stakeholders, the depth of knowledge and practical application of climate-resilient practices remains inadequate. This gap is largely attributable to weak integration of climate resilience concepts into agricultural education curricula, limited access to effective extension services, and institutional and infrastructural constraints.

The results further demonstrate that agricultural education and extension services play a significant role in influencing farmers' adoption of climate-smart agricultural practices. Farmers with regular access to training, advisory services, and extension contact were more likely to adopt practices such as crop diversification, soil and water conservation, and use of improved crop varieties. However, challenges such as insufficient funding, low extension coverage, poor access to climate information, and weak coordination among stakeholders continue to hinder the effectiveness of education-driven climate resilience efforts.

Overall, the study concludes that enhancing climate-resilient farming in Kebbi State requires a holistic and integrated agricultural education approach that links formal education, non-formal training, and extension services. Strengthening these systems will not only improve farmers' adaptive capacity but also contribute to sustainable agricultural productivity and food security in the face of increasing climate variability.

Recommendations

1. Curriculum integration: Climate change, CSA, and sustainability concepts should be fully integrated into agricultural education curricula at all levels, with emphasis on practical and locally relevant training.
2. Strengthening extension services: Government and development partners should invest in expanding and capacitating agricultural extension services through training, recruitment of extension agents, and use of digital advisory platforms.
3. Multi-stakeholder collaboration: Stronger collaboration among educational institutions, research bodies, extension agencies, and

community organizations should be promoted to enhance knowledge sharing and inclusive climate-resilient agricultural development.

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