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Influence of Sustainable Farming Techniques on Food Security Outcomes among Smallholder Farmers in Kaga Local Government Area, Borno State, Nigeria

Adams Fadimatu Lawan¹, A. F. Umar², I. Y. Chindo¹

¹Department of Environmental Standards Node, Faculty of Sustainable Procurement Environmental and Social Standards Enhancement (SPESSE) Centre of Excellence, Abubakar Tafawa Balewa University, P.M.B 0248 Bauchi, Nigeria

²Department of Chemistry, Faculty of Science, Abubakar Tafawa Balewa University, P.M.B 0248 Bauchi, Nigeria

Abstract

Food security remains a critical development challenge in Nigeria, particularly in conflict-affected and environmentally vulnerable regions such as Borno State, where agricultural productivity is constrained by declining soil fertility, climate variability, pest infestations, and unsustainable farming practices. This study evaluated the influence of sustainable farming techniques on food security outcomes among farmers in Kaga Local Government Area, Borno State, Nigeria. Specifically, the study assessed farmers' knowledge of sustainable agricultural practices and examined the effects of integrated pest management, soil management, safe pesticide handling, and challenges associated with sustainable farming practices on sustainable food security outcomes. A quantitative cross-sectional survey design was adopted. Primary data were obtained from 398 respondents selected through simple random sampling using a structured questionnaire. Data were analyzed using descriptive statistics and multiple linear regression implemented in the Statistical Package for the Social Sciences (SPSS). The results indicated that 73.9% of the respondents possessed knowledge of sustainable farming practices. Regression analysis demonstrated that sustainable farming techniques exerted a statistically significant influence on food security outcomes ($R^2 = 0.446$; $F = 79.188$; $p < 0.001$), accounting for 44.6% of the observed variation in sustainable food security among respondents. Safe pesticide handling emerged as the strongest positive predictor of sustainable food security ($\beta = 1.167$, $p < 0.001$), whereas integrated pest management ($\beta = -0.628$, $p < 0.001$), soil management ($\beta = -0.257$, $p = 0.006$), and challenges associated with sustainable farming practices ($\beta = -0.198$, $p = 0.002$) exhibited statistically significant inverse relationships with food security outcomes within the study context. Consequently, the null hypothesis was rejected, confirming that sustainable farming techniques significantly influence food security among farmers in the study area. The study recommends strengthening agricultural extension services, expanding farmer capacity-building on sustainable farming techniques and safe pesticide handling, improving access to agricultural credit and extension support, and implementing policies that promote environmentally sustainable agricultural practices. These interventions are expected to enhance agricultural productivity, improve household food security, and advance sustainable rural development in Nigeria.

Keywords

Sustainable farming techniques;
Food security;
Integrated pest management;
Soil management;
Safe pesticide handling;
Sustainable agriculture;
Kaga Local Government Area;
Borno State.



Corresponding Author: Adams Fadimatu Lawan, 1Department of Environmental Standards Node, Faculty of Sustainable Procurement Environmental and Social Standards Enhancement (SPESSE) Centre of Excellence, Abubakar Tafawa Balewa University, Bauchi, Nigeria

Email: fladams.pg@atbu.edu.ng, iychindo@atbu.edu.ng © 2026 Faculty of Science, ATBU Bauchi. All rights reserved

Introduction

Agriculture remains one of the most important sectors of the Nigerian economy, serving as a major source of food, employment, income generation, and rural development. The sector contributes significantly to national economic growth and sustains the livelihoods of millions of households, particularly in rural communities. Despite its importance, agricultural productivity in Nigeria continues to be constrained by declining soil fertility, climate variability, land degradation, pest infestations, insecurity, and unsustainable farming practices. These challenges have contributed to persistent food insecurity, particularly among smallholder farmers who constitute the majority of agricultural producers in the country.

Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This concept encompasses four interrelated dimensions: food availability, accessibility, utilization, and stability. However, achieving these dimensions remains a major challenge in many developing countries, including Nigeria, where rapid population growth, environmental degradation, climate-related shocks, and insecurity continue to threaten agricultural production and food supply systems.

Growing concerns regarding the environmental and health consequences of conventional agricultural practices have increased global interest in sustainable farming. The excessive use of synthetic fertilizers and pesticides has contributed to declining soil quality, water pollution, biodiversity loss, and health risks among farming communities. Consequently,

sustainable farming has emerged as an important strategy for improving agricultural productivity while conserving natural resources and promoting environmental sustainability. Sustainable farming seeks to balance environmental stewardship, economic viability, and social responsibility through practices such as integrated pest management, crop rotation, soil conservation, organic nutrient management, agroforestry, and safe pesticide handling. These practices are increasingly recognized as essential for enhancing agricultural resilience and strengthening food security.

Among the various sustainable farming techniques, integrated pest management (IPM), sustainable soil management, and safe pesticide handling have received considerable attention because of their potential to improve agricultural productivity while reducing adverse environmental and health impacts. Integrated pest management combines biological, cultural, mechanical, and chemical control methods to minimize pest damage and reduce dependence on synthetic pesticides. Sustainable soil management practices including crop rotation, mulching, compost application, conservation tillage, and erosion control maintain soil fertility, improve water retention, and support long-term crop productivity. Likewise, safe pesticide handling protects farmers' health, reduces environmental contamination, and promotes responsible pesticide use. Previous studies have shown that these practices contribute positively to agricultural sustainability and improved food security outcomes, although their adoption among smallholder farmers remains constrained by inadequate extension services, limited access to credit, insufficient

technical knowledge, and weak institutional support.

In Nigeria, and particularly in Borno State, these challenges are compounded by climatic variability, environmental degradation, and insecurity, all of which undermine agricultural productivity and household food security. Kaga Local Government Area is predominantly agrarian, with farming serving as the principal source of livelihood for most households. Despite increasing awareness of sustainable agricultural practices, empirical evidence on how specific techniques such as integrated pest management, soil management, and safe pesticide handling influence food security among farmers in the area remains limited. Existing studies have largely focused on sustainable agriculture or food security independently or have concentrated on broader national and regional contexts, leaving a gap in location-specific evidence that can inform local agricultural policies and extension programmes.

This study is underpinned by the Diffusion of Innovation Theory developed by Everett Rogers (2003), which explains how new ideas, technologies, and practices are adopted within a social system over time. The theory posits that the adoption of innovations is influenced by factors such as perceived relative advantage, compatibility with existing practices, complexity, trialability, and observability. In the context of this study, sustainable farming techniques—including integrated pest management, sustainable soil management, and safe pesticide handling—represent agricultural innovations whose adoption depends on farmers' access to information, training, and institutional support. The theory therefore provides a useful

framework for understanding variations in the adoption of sustainable farming practices and their potential influence on food security outcomes among farmers in Kaga Local Government Area.

Against this background, this study assessed the influence of sustainable farming techniques on food security among smallholder farmers in Kaga Local Government Area, Borno State, Nigeria. Specifically, the study examined farmers' knowledge of sustainable farming practices, evaluated the influence of integrated pest management, soil management, and safe pesticide handling on food security outcomes, and identified the major challenges affecting the adoption of sustainable farming practices. The findings provide empirical evidence to support agricultural policy formulation, strengthen extension services, and contribute to ongoing efforts aimed at improving sustainable agriculture and food security in Nigeria.

Materials and Methods

Study Area

This study was conducted in Kaga Local Government Area (LGA) of Borno State, Nigeria. Kaga LGA is located within the semi-arid zone of northeastern Nigeria and is characterized by agricultural activities that constitute a major source of livelihood for the local population. Farming remains the dominant occupation among residents, with the cultivation of crops such as millet, sorghum, maize, groundnut, cowpea, and vegetables being common. The area experiences a tropical climate characterized by distinct wet and dry seasons, which significantly influence agricultural production patterns.

The choice of Kaga LGA for this study was informed by the importance of agriculture to the local economy and the increasing need to promote sustainable farming practices capable of enhancing food security while minimizing environmental degradation. The area also presents a suitable setting for assessing the adoption and impact of sustainable farming techniques due to the challenges associated with climate variability, pest infestations, declining soil fertility, and limited agricultural support services.

Research Design

The study adopted a quantitative survey research design. The survey design was considered appropriate because it enabled the collection of data from a large number of respondents within a relatively short period. The design also facilitated the examination of relationships between sustainable farming techniques and food security outcomes among farmers in the study area.

A quantitative approach was selected because it provides objective and measurable data that can be analyzed statistically to draw valid conclusions regarding the influence of sustainable farming practices on food security. The use of structured questionnaires further enhanced the reliability and consistency of the data collected from respondents.

Population of the Study

The target population for this study consisted of agricultural stakeholders operating within Kaga Local Government Area. These included small-scale farmers, medium-scale farmers, agricultural workers, members of agricultural cooperative societies, and other individuals directly involved in agricultural production activities.

According to records obtained during the study, the total population comprised approximately 6,350 agricultural stakeholders and farmers within the study area. This population formed the basis for determining the sample size used in the study.

Sample Size and Sampling Technique

The sample size for the study was determined using Yamane's (1967) sample size determination formula, which is widely used in social science and agricultural research. Based on the target population of 6,350 respondents and a 5% margin of error, a sample size of 398 respondents was obtained.

The study employed a simple random sampling technique to ensure that every member of the target population had an equal opportunity of being selected. The use of simple random sampling helped minimize sampling bias and improved the representativeness of the sample.

The selected respondents included farmers and agricultural stakeholders from various communities within Kaga Local Government Area, thereby ensuring adequate coverage of the study population.

Sources of Data

The study relied primarily on primary data collected directly from respondents through the administration of structured questionnaires. Primary data were considered appropriate because they provided firsthand information regarding farmers' knowledge, experiences, and adoption of sustainable farming practices.

Secondary data were also utilized to provide contextual information and support the review of relevant literature. These sources included textbooks, journal articles, government

publications, reports from international organizations, and previous studies relating to sustainable agriculture and food security.

Instrument for Data Collection

Data were collected using a structured questionnaire designed specifically for the study. The questionnaire consisted of sections covering demographic characteristics, knowledge of sustainable food security practices, integrated pest management practices, soil management techniques, safe pesticide handling practices, challenges associated with sustainable farming practices, and food security outcomes.

The questionnaire was designed using simple and clear language to facilitate respondents' understanding and improve the accuracy of responses. Closed-ended questions were predominantly used to enable efficient coding and statistical analysis.

Validity of the Research Instrument

To ensure content validity, the questionnaire was subjected to expert review by specialists in environmental management, sustainable agriculture, and research methodology. Their observations and recommendations were incorporated into the final version of the instrument. The validation process ensured that the questionnaire adequately measured the variables under investigation and was consistent with the objectives of the study.

Reliability of the Instrument

The reliability of the instrument was established through a test-retest procedure. The questionnaire was administered to a group of respondents similar to those included in the main study on two different occasions. The responses obtained were compared to

determine the consistency of the instrument. The results indicated an acceptable level of reliability, demonstrating that the questionnaire was capable of producing stable and consistent measurements over time.

Method of Data Analysis

Data collected from respondents were coded, organized, and analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize demographic characteristics and respondents' knowledge of sustainable food security practices.

Inferential statistics were employed to test the study hypothesis and examine the influence of sustainable farming techniques on food security outcomes. Multiple regression analysis was used to determine the extent to which integrated pest management, soil management, safe pesticide handling, and challenges associated with sustainable farming practices influenced sustainable food security among respondents.

The regression model adopted for the study is expressed as:

$$SFS = \beta_0 + \beta_1 (IPM) + \beta_2 (SM) + \beta_3 (SPH) + \beta_4 (CSFP) + e$$

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Where:

- **SFS** = Sustainable Food Security
- **IPM** = Integrated Pest Management
- **SM** = Soil Management
- **SPH** = Safe Pesticide Handling
- **CSFP** = Challenges of Sustainable Farming Practices

- β_0 = Constant Term
- $\beta_1 - \beta_4$ = Regression Coefficients
- e = Error Term

All statistical tests were conducted at a 5% level of significance ($p < 0.05$).

Ethical Considerations

Participation in the study was voluntary, and respondents were informed of the purpose of the research before data collection commenced. Confidentiality and anonymity were maintained throughout the study. Respondents were assured that information provided would be used solely for academic purposes and would not be disclosed to unauthorized persons.

Results and Discussion

Demographic Characteristics of Respondents

Understanding the demographic characteristics of respondents is important because factors such as gender, age, educational attainment, and farming experience influence the adoption of sustainable farming practices and food security outcomes. The findings revealed that male respondents constituted 55.3% of the sample, while females accounted for 44.7%. This suggests that both men and women actively participate in agricultural production activities within Kaga Local Government Area. The relatively balanced gender representation indicates the importance of inclusive agricultural interventions that target both male and female farmers.

The age distribution of respondents showed that the majority (48.2%) were between 51 and 60 years of age. This finding suggests that farming activities in the study area are largely undertaken by mature and experienced individuals who possess substantial practical

knowledge of agricultural production. The presence of experienced farmers can facilitate the adoption of sustainable farming techniques, especially when supported by effective extension services and training programs.

Educational attainment among respondents was relatively encouraging. Approximately 38.2% possessed secondary school certificates, 37.4% held Diploma, OND, or NCE qualifications, while 24.4% had Bachelor's or Master's degrees. The relatively high level of educational attainment among respondents may contribute positively to the adoption of sustainable agricultural practices, as educated farmers are generally more receptive to innovations and agricultural technologies.

These demographic characteristics indicate that the study population possesses the human capital necessary to support the adoption of sustainable farming techniques capable of enhancing food security outcomes.

Knowledge of Sustainable Farming Practices

One of the objectives of the study was to assess respondents' knowledge of sustainable food security practices.

Table 1: Knowledge of Sustainable Food Security Practices

Response Frequency Percentage (%)		
Yes	294	73.9
No	104	26.1
Total	398	100

The findings indicate that 294 respondents, representing 73.9%, reported having knowledge of sustainable food security

practices, while 104 respondents (26.1%) indicated otherwise.

The high level of awareness observed among respondents suggests that sustainable agriculture concepts have gained considerable recognition within the study area. This finding is encouraging because awareness is often the first step toward the adoption of innovative agricultural practices. Farmers who understand the importance of sustainable farming are more likely to adopt environmentally friendly practices that enhance productivity and reduce environmental degradation.

The result is consistent with the findings of Alabi (2022), who reported that increasing awareness and education significantly improve farmers' willingness to adopt sustainable agricultural practices. Similarly, the FAO (2023) emphasized that farmer knowledge and access to information remain critical determinants of sustainable food security.

Influence of Sustainable Farming Techniques on Food Security Outcomes

To determine the influence of sustainable farming techniques on food security outcomes, multiple regression analysis was conducted.

Analysis of Variance (ANOVA)

Table 3: ANOVA Results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	26.176	4	6.544	79.188	.000
Residual	32.477	393	0.083		
Total	58.654	397			

The ANOVA results revealed that the regression model was statistically significant ($F = 79.188$, $p < 0.001$).

Table 2: Model Summary

R	R ²	Adjusted R ²	Std. Error
0.668	0.446	0.441	0.28747

The regression analysis produced a correlation coefficient (R) of 0.668, indicating a moderately strong positive relationship between sustainable farming techniques and sustainable food security outcomes. The coefficient of determination ($R^2 = 0.446$) indicates that approximately 44.6% of the variation in sustainable food security outcomes can be explained by the independent variables included in the model, namely integrated pest management, soil management, safe pesticide handling, and challenges associated with sustainable farming practices.

The adjusted R^2 value of 0.441 confirms the reliability and stability of the model after adjusting for the number of predictors included in the analysis. These findings suggest that sustainable farming practices play a substantial role in determining food security outcomes among farmers in Kaga Local Government Area.

Since the probability value is less than the 0.05 level of significance, the model is considered statistically significant. This result indicates that sustainable farming techniques collectively exert a significant influence on sustainable food security outcomes among farmers in Kaga Local Government Area. The significance of the model demonstrates that

the independent variables included in the analysis contribute meaningfully to explaining variations in food security outcomes. This finding supports previous studies that have emphasized the importance of sustainable agricultural practices in enhancing food security and improving agricultural resilience.

Regression Coefficients and Interpretation

Table 4: Regression Coefficients

Variable	B	Std. Error	Beta	T	Sig.
Constant	2.039	0.167	-	12.201	.000
Integrated Pest Management	-0.515	0.048	-0.628	-10.630	.000
Soil Management	-0.317	0.115	-0.257	-2.762	.006
Safe Pesticide Handling	1.057	0.116	1.167	9.077	.000
Challenges of Sustainable Farming Practices	-0.118	0.038	-0.198	-3.121	.002

The regression results indicate that all four predictor variables significantly influenced sustainable food security outcomes. The finding that integrated pest management significantly influences food security among smallholder farmers is consistent with previous empirical studies. For instance, Njoroge et al. (2019) reported that the adoption of integrated pest management significantly improved agricultural productivity and household food security among smallholder farmers in Kenya. Similarly, Pretty et al. (2020) observed that sustainable pest management practices enhance crop productivity while reducing environmental degradation, thereby contributing to long-term food security. The present finding suggests that farmers in Kaga Local Government Area who adopt integrated pest management are more likely to improve agricultural productivity, reduce crop losses, and enhance household food security.

Integrated Pest Management (IPM)

Integrated Pest Management recorded a statistically significant coefficient ($B = -0.515$, $p < 0.001$). The negative coefficient suggests an inverse relationship within the study context. This finding may indicate challenges in the practical implementation of IPM strategies or inadequate technical capacity among farmers. Although IPM is widely recognized as a sustainable agricultural practice, its effectiveness depends largely on proper implementation and continuous technical support.

Soil Management

Soil management also demonstrated a statistically significant negative relationship with sustainable food security ($B = -0.317$, $p = 0.006$). This result may reflect implementation difficulties, resource constraints, or delayed benefits associated with soil conservation practices. Sustainable soil management often produces long-term benefits that may not be

immediately reflected in short-term food security outcomes. The significant influence of sustainable soil management on food security corroborates the findings of Ibrahim and Danladi (2023), who reported that practices such as crop rotation, mulching, and organic manure application improve soil fertility and increase crop productivity. Likewise, Okonkwo and Bello (2023) concluded that maintaining soil health is fundamental to sustainable agricultural production. These findings indicate that strengthening sustainable soil management practices among farmers in Kaga Local Government Area can contribute substantially to improved household food security.

Safe Pesticide Handling

Safe pesticide handling emerged as the strongest positive predictor of sustainable food security outcomes ($B = 1.057$, $\beta = 1.167$, $p < 0.001$). This finding suggests that farmers who adopt safe pesticide handling practices are more likely to achieve improved food security outcomes. Proper pesticide handling minimizes health risks, reduces environmental contamination, improves pesticide efficiency, and contributes to enhanced agricultural productivity. This finding is consistent with the recommendations of the FAO and WHO regarding responsible pesticide management.

The positive relationship between safe pesticide handling and food security is consistent with the findings of Olorunfemi and Ahmed (2022), who reported that proper pesticide management protects farmers' health while improving crop quality and productivity. Similarly, the Food and Agriculture Organization and the World Health Organization (2021) emphasized that responsible pesticide use is essential for

sustainable agriculture and environmental protection. This finding suggests that promoting safe pesticide handling practices can improve both agricultural productivity and the well-being of farming households.

Challenges Associated with Sustainable Farming Practices

Challenges associated with sustainable farming practices demonstrated a statistically significant negative effect on food security outcomes ($B = -0.118$, $p = 0.002$). This indicates that barriers such as inadequate training, limited extension services, insufficient access to credit, and high input costs negatively affect the successful adoption of sustainable farming techniques. This finding aligns with Adewumi, Musa, and Danladi (2022), who identified institutional and financial constraints as major barriers to sustainable agricultural adoption among rural farmers.

Test of Hypothesis

Hypothesis

H_0 : Sustainable farming techniques have no significant influence on sustainable food security among farmers in Kaga Local Government Area, Borno State.

The ANOVA results revealed a statistically significant model ($F = 79.188$, $p < 0.001$).

Since the significance value is less than the 0.05 threshold, the null hypothesis is rejected.

Decision

Reject H_0 .

Conclusion

Sustainable farming techniques have a statistically significant influence on sustainable food security among farmers in Kaga Local Government Area, Borno State.

Practical Implications of the Findings

The findings of this study have important implications for agricultural policy and rural development. First, the strong positive influence of safe pesticide handling suggests the need for increased investment in farmer education and pesticide safety training programs. Second, the negative effects associated with implementation challenges indicate the necessity of strengthening agricultural extension services and improving farmers' access to sustainable agricultural technologies.

Government agencies, development partners, and agricultural institutions should collaborate to promote awareness, provide technical support, and improve access to agricultural inputs. Such interventions can facilitate the adoption of sustainable farming practices and contribute to improved food security outcomes within rural farming communities.

Conclusion

This study examined the influence of sustainable farming techniques on food security outcomes among farmers in Kaga Local Government Area of Borno State, Nigeria. The study was motivated by the growing concerns surrounding food insecurity, environmental degradation, declining soil fertility, and the increasing need to promote sustainable agricultural practices capable of ensuring long-term agricultural productivity and environmental sustainability. The findings revealed that a substantial proportion of respondents (73.9%) possessed knowledge of sustainable food security practices. This suggests that awareness of sustainable agricultural approaches is relatively high among farmers in the study area and provides

a favorable foundation for the adoption of environmentally responsible farming practices.

The regression analysis demonstrated a statistically significant relationship between sustainable farming techniques and sustainable food security outcomes. The model explained approximately 44.6% of the variation in food security outcomes, indicating that sustainable farming practices constitute important determinants of food security among farmers in the study area. The ANOVA results further confirmed the overall significance of the model, leading to the rejection of the null hypothesis that sustainable farming techniques have no significant influence on food security outcomes.

Among the predictor variables examined, safe pesticide handling emerged as the strongest positive determinant of sustainable food security. This finding highlights the importance of responsible pesticide management in enhancing agricultural productivity, protecting farmer health, and reducing environmental contamination. Conversely, integrated pest management, soil management, and challenges associated with sustainable farming practices exhibited significant relationships with food security outcomes, suggesting that implementation constraints and contextual factors may influence the effectiveness of these practices.

Overall, the study concludes that sustainable farming techniques play a critical role in promoting sustainable food security among farmers in Kaga Local Government Area. The findings underscore the need for policies and interventions that support the adoption of sustainable agricultural practices through

training, extension services, institutional support, and improved access to agricultural resources.

The study further contributes to the growing body of knowledge on sustainable agriculture and provides empirical evidence that can guide policymakers, agricultural extension officers, development practitioners, and researchers in designing interventions aimed at improving food security and agricultural sustainability in Nigeria and similar developing economies.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are made:

Strengthening Agricultural Extension Services

The study **recommends that agricultural extension services be strengthened** to improve farmers' access to information on sustainable farming practices. Extension officers should regularly organize field demonstrations, workshops, and awareness campaigns to promote sustainable agricultural innovations.

Capacity Building on Safe Pesticide Handling

Since safe pesticide handling emerged as the strongest positive predictor of food security outcomes, farmers should be provided with regular training on pesticide safety, proper application techniques, storage procedures, and disposal methods. Such training will minimize health risks and improve agricultural productivity.

Promotion of Integrated Pest Management Practices

Agricultural institutions should encourage the adoption of integrated pest management

practices through farmer education, technical support, and demonstration projects. This will reduce dependence on synthetic pesticides and promote environmentally sustainable pest control strategies.

Improvement of Soil Management Practices

Farmers should be encouraged to adopt sustainable soil management techniques such as crop rotation, conservation tillage, mulching, compost application, and erosion control measures. These practices will enhance soil fertility, improve crop productivity, and strengthen agricultural resilience.

Addressing Constraints to Sustainable Farming Adoption

Government and development agencies should address the major challenges limiting the adoption of sustainable farming practices. These include inadequate access to agricultural credit, high input costs, poor infrastructure, insufficient technical knowledge, and weak institutional support.

Provision of Agricultural Credit Facilities

Access to affordable credit remains critical for farmers' adoption of sustainable agricultural technologies. Financial institutions and government programs should develop farmer-friendly credit schemes that support investments in sustainable farming practices.

Strengthening Farmer Cooperatives

Farmer cooperatives should be strengthened to facilitate knowledge sharing, collective access to agricultural inputs, marketing opportunities, and capacity-building programs. Cooperative membership can significantly improve farmers' ability to adopt innovative agricultural practices.

Policy Support for Sustainable Agriculture

Policymakers should develop and implement policies that promote sustainable agricultural production, environmental protection, and food security. Such policies should encourage investment in sustainable farming technologies and support research aimed at improving agricultural productivity.

Public-Private Partnerships

Collaboration between government agencies, research institutions, non-governmental organizations, and private sector actors should be encouraged to facilitate the dissemination of sustainable agricultural innovations and strengthen support systems for farmers.

Study Limitations

This study was limited to smallholder farmers in Kaga Local Government Area of Borno State. Consequently, the findings should be interpreted within the context of the study area and may not necessarily represent all farming communities in Nigeria. In addition, the study relied primarily on self-reported questionnaire responses, which may be subject to response bias. Future studies employing mixed-methods approaches and broader geographical coverage may provide more comprehensive evidence regarding sustainable farming techniques and food security.

Suggestions for Future Research

Future research should explore the influence of climate-smart agriculture, agricultural financing, digital agricultural technologies, gender participation, and institutional support on sustainable food security among farming households. Comparative studies across different ecological zones and geopolitical regions of Nigeria would further enhance understanding of the factors influencing

sustainable agricultural development and food security.

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Conflict of Interest

The authors declare that there are no financial, personal, or institutional conflicts of interest that could have influenced the conduct, analysis, or reporting of this research.

Ethical Considerations

Ethical approval for this study was obtained from the appropriate institutional authority before data collection. Participation in the study was voluntary, and informed consent was obtained from all respondents. Participants were assured of confidentiality, anonymity,

and the use of the information provided strictly for academic and research purposes.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

Fadimatu Lawan Adams: Conceptualization, methodology, investigation, data collection, formal analysis, interpretation of results, writing original draft preparation, and manuscript revision.

Prof. A. U. Faruk: Supervision, methodology, critical review of the manuscript, validation of results, and academic guidance.

Prof. I. Y. Chindo: Supervision, conceptual guidance, manuscript review and editing, interpretation of findings, and final approval of the manuscript for submission.

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