UNIOFFA JOURNAL OF INTERDISCIPLINARY STUDIES (OJIS)
A Multidisciplinary Journal of Science, Management and Social Sciences
Website: www.unioffajis.com

Effect of Smart Agricultural Practices on Food Security in Niger State, Nigeria

Esheya, Samuel Esheya
Department of Agricultural Economics and Extension, National Open University of Nigeria.
E-mail: sesheya@noun.edu.ng;

Muhammad, M. Usman
Department of Agricultural Economics and Extension National Open University of Nigeria.
E-mail: mmuhammad@noun.edu.ng

Bright B. Wategire
Department of Agricultural Economics and Extension, National Open University of Nigeria
E-mail: bwategire@noun.edu.ng

Volume 1:2

ABSTRACT

This study examined the effect of smart agricultural practices on food security in Niger State, Nigeria. A cross-sectional survey research design was adopted for the study. Data were collected analyzed using descriptive and inferential statistics The findings revealed that improved seeds (86.3%), crop rotation (81.3%), and organic manure application (77.5%) were the most commonly adopted smart agricultural practices among farmers. The Household Food Security Index showed that 63.8% of the households were food secure, while 36.2% were food insecure. Multiple regression results indicated that improved seeds, irrigation farming, crop rotation, organic manure application, agroforestry, and access to weather information had significant positive effects on household food availability at 5% level of significance. Logistic regression results showed that farm income, access to credit, extension contact, market access, and level of adoption significantly influenced food accessibility among farming households. Pearson correlation analysis further revealed significant positive relationship between the adoption of smart agricultural practices and household food security ($r = 0.684$, $p < 0.05$). The major constraints affecting adoption were high cost of inputs, poor access to credit, inadequate extension services, lack of technical knowledge, and poor government support. The study concluded that smart agricultural practices significantly improve food security by enhancing food availability and accessibility among farming households in Niger State. The study recommended government subsidies on inputs, improved access to credit, stronger extension delivery, farmer capacity building, improved rural market infrastructure, and expansion of climate information services to promote wider adoption of smart agricultural practices and sustainable food security.

Keywords: Smart agriculture, food security, food availability, food accessibility

INTRODUCTION

Background to the Study

One of the most important economic sectors in Nigeria is still agriculture. It supports the livelihoods of a sizable percentage of the rural population and makes a substantial contribution to the GDP. Over 70% of rural households in sub-Saharan Africa rely either directly or indirectly on agriculture to survive, according to the Food and Agriculture Organization (FAO, 2022). About 35% of Nigeria's workforce is employed in agriculture, which also makes a significant contribution to the country's food production (National Bureau of Statistics [NBS], 2023).

Despite its significance, Nigeria's agriculture industry confronts many obstacles, including insect infestations, limited storage facilities, low mechanization, falling soil fertility, poor access to extension services, climate change, and insecurity (Obazi et al., 2022). Food production and food security have been greatly impacted by these issues, especially for smallholder farmers who make up the bulk of agricultural producers (Adebayo & Olagunju, 2021). When everyone has physical and financial access to enough wholesome food that satisfies their dietary needs for an active and healthy life, there is food security (FAO, 2021). Due to its significant amount of fertile land and strong agricultural potential, Niger State, which is situated in Nigeria's North-Central geopolitical zone, is one of the nation's largest

agricultural states. Staple crops such rice, maize, yam, millet, sorghum, cassava, and legumes are produced in the state.

However, due to poor farming methods, environmental degradation, climate variability, and low adoption of contemporary agricultural advances, food insecurity persists among farming communities despite its vast agricultural potential (Bello et al., 2022). Innovative and sustainable farming techniques that increase productivity, boost climate change resilience, and guarantee environmental sustainability are referred to as "smart agricultural practices" (Amusa & Esheya, 2025). Crop rotation, agroforestry, irrigation, better seeds, and conservation agriculture are a few examples. These agricultural practices and technologies, also known as climate-smart agriculture (CSA), are intended to sustainably boost national food security and development objectives, improve resilience (adaptation), lower or eliminate greenhouse gas emissions (mitigation), and increase productivity (FAO, 2019). Improved seed varieties, precision farming, irrigation systems, agroforestry, crop rotation, conservation agriculture, integrated pest management, organic manure application, weather forecasting technology, and effective water management systems are some of these techniques (Abah et al., 2020). In order to solve the issues of food insecurity in developing nations, smart farming methods have become more and more crucial. Smart agriculture increases output while reducing environmental hazards and guaranteeing long-term sustainability, according to the World Bank (2022). The Sustainable Development Goal 2 (Zero Hunger), which aims to eradicate hunger, achieve food security, improve nutrition, and promote sustainable agriculture, is seen in Nigeria as being strategically achieved through the promotion of climate-smart agriculture (United Nations, 2021).

Farmers in Niger State have been urged to use smart agricultural methods by government agencies, agricultural development initiatives, and non-governmental groups. However, the rate of adoption is still quite low because of things like poverty, poor institutional support, restricted extension services, poor credit availability, and insufficient understanding (Usman & Ahmed, 2020). Notably, this study focused on only two pillars of household food security (food availability and food accessibility) because these dimensions were considered the most directly influenced by smart agricultural practices among smallholder farmers in Niger State. Food availability was emphasized because smart agricultural practices such as climate-smart agriculture, mechanization, improved seed varieties, smart irrigation systems, and precision farming primarily aim at increasing agricultural productivity and food output. These practices directly affect the quantity of food produced by farming households and therefore influence the availability of food within households and local communities. Food accessibility was also selected because increased agricultural productivity and income generated from smart agricultural practices improve farmers' purchasing power and economic ability to obtain sufficient food. Access to food is particularly important among rural households where income from farming determines the capacity to purchase food items not produced on the farm.

The other two pillars of food security (food utilization and food stability) were not extensively examined due to the scope and objectives of the study. Food utilization involves nutritional quality, health conditions, sanitation, and dietary absorption, which require detailed nutritional and medical assessments beyond the focus of this research. Similarly, food stability concerns long-term consistency of food access over time and often requires longitudinal data and seasonal analysis, which were outside the scope of the present study. Therefore, the restriction to food availability and food accessibility was necessary to maintain focus on the direct effects of smart agricultural practices on household food security among smallholder farmers. These two pillars were considered adequate for assessing the immediate relationship between adoption of smart agricultural practices and food security outcomes in the study area.

Statement of the Problem

Despite Nigeria's abundant agricultural resources and ideal agro-ecological settings, food insecurity has continued to be a significant development concern. Hunger, malnutrition, and poor access to wholesome food still plague millions of people, particularly in rural farming communities. Climate change, land degradation, inadequate agricultural infrastructure, and decreased smallholder farmer productivity all exacerbate the situation (FAO, 2022). Niger State is not immune to this problem, even though it is one of Nigeria's main food-producing states. The state's farmers deal with frequent droughts, flooding, irregular rainfall patterns, pest outbreaks, and post-harvest losses, all of which have a detrimental impact on food production and household food security (Bello et al., 2022). According to Ogbonna et al. (2025), traditional agricultural practices that rely heavily on rainfall and employ little inputs have not been able to guarantee sustainable

food production. It has been suggested that smart agriculture methods are practical ways to increase food security and agricultural productivity. Nonetheless, a large number of Niger State farmers continue to use traditional farming methods, with little use of modern technologies like digital extension services, improved seeds, irrigation, and conservation farming. Inadequate awareness, poor extension delivery, expensive technology, and restricted access to institutional assistance could all be contributing factors to this low acceptance (Usman & Ahmed, 2020).

Although climate-smart agriculture and productivity in Nigeria have been the subject of numerous studies, its precise impact on household food security in Niger State has received little empirical research. This leads to a knowledge gap that makes this study necessary. The impact of smart farming methods on food security in Niger State, Nigeria, was thus examined in this study. The specific goals were to: identify the smart agricultural practices used by Niger State farmers; ascertain the degree of food security among Niger State farming households; investigate the impact of smart agricultural practices on household food availability in Niger State; evaluate the influence of smart agricultural practices on food accessibility among Niger State farming households; and assess the obstacles influencing the adoption of smart agricultural practices in Niger State. Farmers, legislators, agricultural extension agents, academics, and development partners can all benefit from this study's findings. It will offer helpful information about the advantages of implementing smart farming methods to increase food security and productivity. It will promote the use of sustainable farming practices that improve climate change resilience.

Justification for the Study

Agriculture remains one of the most important sectors of the Nigerian economy, providing food, employment, income, and raw materials for industrial development. Despite the enormous agricultural potential of Nigeria, food insecurity continues to increase due to low agricultural productivity, climate change, poor farming techniques, environmental degradation, insecurity, and population growth. North Central Nigeria, which is regarded as one of the major food-producing regions in the country, has experienced serious challenges affecting sustainable food production and household food security. The increasing occurrence of climate variability, irregular rainfall patterns, flooding, drought, soil degradation, and farmer-herder conflicts has negatively affected agricultural output in the region. These challenges have reduced farmers' productivity and threatened the availability, accessibility, and stability of food supplies. Consequently, there is a growing need for innovative and sustainable agricultural approaches capable of improving productivity and strengthening food security among rural households. Smart agricultural practices such as precision farming, climate-smart agriculture, smart irrigation systems, mechanization, improved seed technologies, and ICT-based agricultural services have emerged as important strategies for improving agricultural efficiency and resilience. These practices are capable of increasing crop yield, minimizing production losses, improving resource-use efficiency, reducing the effects of climate change, and enhancing farmers' access to agricultural information and markets. However, despite the potential benefits of these technologies, their adoption among smallholder farmers in North Central Nigeria remains relatively low.

Many previous studies in Nigeria focused mainly on conventional farming methods, climate change adaptation, or isolated agricultural technologies without adequately examining the overall effect of smart agricultural practices on food security. In addition, most existing studies concentrated on specific crops or limited geographical areas, leaving a gap in comprehensive empirical evidence regarding the relationship between smart agricultural practices and food security in North Central Nigeria. This study is therefore justified because it seeks to provide empirical evidence on how smart agricultural practices influence food security among farming households in the region. The findings of the study will help to identify the specific smart agricultural technologies that contribute significantly to food production and household food security. The study is also important because it will provide useful information to policymakers, agricultural extension agents, development agencies, researchers, and non-governmental organizations on strategies for improving agricultural productivity and reducing food insecurity through modern farming technologies. The findings may assist government institutions such as Federal Ministry of Agriculture and Food Security and agricultural development programmes in designing policies and interventions that promote the adoption of smart agricultural practices among rural farmers. Furthermore, the study will contribute to existing literature on smart agriculture and food security, especially within the context of North Central Nigeria. It will serve as a reference material for future

researchers, students, and scholars interested in agricultural innovation, rural development, and food security studies. Finally, the study is justified because improving food security through smart agricultural practices aligns with the sustainable development goals of ending hunger, promoting sustainable agriculture, reducing poverty, and improving rural livelihoods.

LITERATURE REVIEW

Conceptual Review

Concept of Smart Agricultural Practices

Smart agricultural practices refer to the application of modern technologies, scientific innovations, and sustainable farming methods to improve agricultural productivity, efficiency, and resilience against environmental and economic challenges. Smart agriculture integrates digital technologies such as precision farming, Geographic Information Systems (GIS), remote sensing, drones, smart irrigation systems, mechanization, climate-smart agriculture, artificial intelligence, and Information and Communication Technologies (ICTs) into agricultural production systems (Mitra et al., 2022). According to Food and Agriculture Organization, smart agricultural practices are approaches that sustainably increase productivity, strengthen adaptation and resilience to climate change, and reduce greenhouse gas emissions while enhancing food security (FAO, 2021). Smart agriculture therefore seeks to maximize farm output while minimizing environmental degradation and production risks. Smart agricultural practices are increasingly important in developing countries such as Nigeria where climate change, population growth, declining soil fertility, and low agricultural productivity threaten food security. These practices help farmers optimize resource use, improve decision-making, reduce post-harvest losses, and enhance productivity.

Precision Agriculture: This involves the use of advanced technologies such as sensors, satellite imagery, GPS systems, drones, and data analytics to monitor and manage agricultural production accurately. Precision farming improves efficiency in the application of fertilizers, pesticides, and irrigation water based on crop and soil requirements (Gebbers & Adamchuk, 2010). The adoption of precision agriculture helps to reduce production costs, increase crop yield, and improve environmental sustainability. Intelligent infrastructures involving sensors and data systems have also been identified as critical components of smart agriculture systems for sustainable food production (Shekhar et al., 2017).

Climate-Smart Agriculture: CSA refers to agricultural practices that increase productivity, enhance resilience to climate change, and reduce greenhouse gas emissions. CSA includes conservation agriculture, agroforestry, crop diversification, improved irrigation systems, integrated soil fertility management, and sustainable land management practices (Lipper et al., 2014). Climate-smart agriculture has become increasingly relevant in Nigeria because of rising temperatures, irregular rainfall, flooding, drought, and land degradation. Studies have shown that CSA practices improve food production and reduce vulnerability among smallholder farmers.

Smart Irrigation Systems: Smart irrigation systems involve automated and sensor-based technologies that improve water-use efficiency in agricultural production. These technologies monitor soil moisture and climatic conditions to determine appropriate water application levels. Smart irrigation systems help reduce water wastage, improve crop growth, and sustain agricultural production during dry seasons.

Agricultural Mechanization: Agricultural mechanization refers to the use of machines and modern equipment for land preparation, planting, harvesting, processing, and transportation of agricultural products. Mechanization improves labor efficiency, reduces drudgery, increases cultivated land area, and enhances agricultural productivity.

ICT-Based Agricultural Services: ICT-based agricultural services involve the use of mobile phones, internet platforms, radio, and digital applications for dissemination of agricultural information. ICT enables farmers to access weather forecasts, market prices, extension services, and best agronomic practices, thereby improving farm management and productivity (Aker & Mbiti, 2010).

Concept of Food Security: Food security refers to a condition in which all people, at all times, have physical, economic, and social access to sufficient, safe, and nutritious food necessary for an active and healthy life. The concept was widely recognized during the 1996 World Food Summit organized by Food and Agriculture Organization.Food security is based on four major pillars: food availability, food accessibility, food utilization and food stability Food availability refers to adequate food supply through production or importation. Food accessibility concerns individuals' ability to obtain food economically and

physically. Food utilization relates to proper nutrition and health conditions, while food stability implies consistent access to food over time without disruptions (FAO, 2008). Nigeria continues to face food insecurity challenges due to climate change, insecurity, poor infrastructure, poverty, and low agricultural productivity. Recent studies indicate that sustainable agricultural practices are essential for long-term food security in Nigeria.

Relationship between Smart Agricultural Practices and Food Security

Smart agricultural practices positively influence food security by improving productivity, reducing production risks, increasing income, and enhancing climate resilience. Technologies such as precision agriculture, climate-smart agriculture, smart irrigation systems, mechanization, and ICT-based services improve food availability and household welfare.

Studies show that sustainable agricultural systems improve resilience and long-term food security more effectively than traditional agricultural methods.

Theoretical Review

Diffusion of Innovation Theory

This study is anchored on the Diffusion of Innovation Theory developed by Everett Rogers in 1962. The theory explains how innovations spread among individuals and social systems over time. According to Rogers (2003), diffusion is the process through which innovations are communicated through specific channels among members of a social system. The theory identifies five major characteristics influencing adoption: relative advantage, compatibility, complexity, trialability and 0bservability. The theory categorizes adopters into innovators, early adopters, early majority, late majority, and laggards. In this study, smart agricultural practices such as precision farming, mechanization, climate-smart agriculture, and ICT-based services are viewed as innovations introduced into agricultural systems. Farmers are more likely to adopt these technologies when they perceive them as beneficial, affordable, easy to use, and compatible with their farming activities. The theory is relevant because it explains the processes through which farmers in North Central Nigeria become aware of smart agricultural technologies and decide whether to adopt or reject them.

Sustainable Livelihood Theory

The Sustainable Livelihood Theory was developed by Robert Chambers and Gordon Conway in 1992. The theory explains how individuals and households utilize available assets and capabilities to improve their living conditions sustainably. The theory identifies five livelihood assets: human capital, natural capital, financial capital, physical capital and social capital. Smart agricultural practices improve farmers' livelihood assets by increasing productivity, improving income generation, reducing vulnerability to environmental shocks, and strengthening resilience against climate change. The theory is relevant because food security depends largely on the sustainability of rural livelihoods and farmers' ability to manage productive resources effectively.

Systems Theory

The Systems Theory developed by Ludwig von Bertalanffy explains that society and organizations operate as interconnected systems whose components influence one another. Agriculture operates as a system involving farmers, technology, climate, markets, extension services, government policies, and natural resources. Smart agricultural practices improve interactions within the agricultural system and contribute to sustainable food production. The theory is relevant because it helps explain how technological, institutional, and environmental factors interact to influence food security outcomes.

Empirical Review

Several empirical studies have examined the effects of smart agricultural practices on food security across different countries and regions. Adebayo and Olagunju (2021) used structured questionnaires and regression analysis to investigate food security and climate change adaption techniques among Nigerian rural farming households. The study discovered that the adoption of better seeds, crop diversity, and irrigation farming greatly increased rural households' food security. Adoption was also significantly impacted by education and access to extension programs. Usman and Ahmed (2020) looked into the factors that influence farmers in Northern Nigeria to adopt climate-smart farming methods. The study used multinomial logit regression to find that adoption of climate-smart technologies was substantially influenced by farm size, education, credit availability, cooperative membership, and extension contact. Bello et al. (2022) investigated household food security and climate-smart agriculture among smallholder farmers in North Central Nigeria. Adoption of conservation agriculture, agroforestry, and integrated pest control

greatly increased household food security, according to the study, which used descriptive statistics and probit regression analysis. In their study of climate-smart agriculture practices in North Central and Northwest Nigeria, Gabriel et al. (2023) discovered that although farmer awareness of CSA was comparatively high, adoption was hampered by inadequate policy support, low access to financing, and poor extension delivery. After reviewing climate-smart agriculture for sustainable agricultural development in Nigeria, Balogun et al. (2024) came to the conclusion that CSA technologies are essential for boosting food production, lowering environmental degradation, and enhancing climate change resilience.

In their conceptual assessment of climate-smart agriculture for reducing food insecurity in Nigeria, Ajie and Uche (2025) discovered that policy support and awareness continue to be key factors in effective implementation. They advocated for increased government involvement in rural extension programs. Ayeni et al. (2025) used logit regression, Foster-Greer-Thorbecke (FGT), and descriptive statistics to investigate climate-smart agriculture and food security among farming households in Kwara State. The study discovered that food security had a substantial positive correlation with the number of CSA practices adopted, while age, family size, farming experience, and the number of CSA practices adopted significantly influenced food security status. Omotayo et al. (2025) discovered that through improved adaptability and decreased climatic vulnerability, climate-smart agricultural methods enhanced food and nutrition security results among smallholder farmers. The majority of current research focuses mostly on income and productivity, failing to sufficiently connect smart farming techniques to the more comprehensive aspects of food security.

Gebbers and Adamchuk (2010) examined precision agriculture and food security and found that precision farming technologies improved crop productivity and resource-use efficiency. The study concluded that precision agriculture enhances food availability and sustainable agricultural production. Lipper et al. (2014) investigated climate-smart agriculture and food security in developing countries. Findings revealed that climate-smart agricultural practices improved resilience to climate change and increased agricultural productivity among rural households. Aker and Mbiti (2010) studied mobile phones and economic development in Africa and found that ICT-based agricultural services improved access to market information and extension services, thereby enhancing productivity and household income. Ogutu, Okello, and Otieno (2014) assessed ICT-based market information services among smallholder farmers in Kenya. The study found that access to agricultural information technologies significantly improved productivity and food security. Ayinde et al. (2020) investigated determinants of climate-smart agricultural practice adoption in Nigeria. The study revealed that education, extension contact, farm size, and access to credit significantly influenced adoption of climate-smart practices.

A recent study conducted in Nasarawa State, Nigeria by Sylvester, Umar, and Galadima (2024) examined the effects of climate-smart agricultural practices on food security among farmers. The study found that comprehensive field management, crop/livestock management, and agroforestry practices significantly improved household food security. The study also identified inadequate information and lack of capital as major barriers to adoption. Similarly, a study on climate-smart agricultural practices in North Central and Northwest Nigeria revealed that climate-smart agriculture enhances resilience and food production among farmers exposed to climate-related risks. Another Nigerian study investigating dietary diversity and food security among farming households found that adoption of climate-smart agricultural practices significantly reduced food insecurity and improved household dietary diversity.

Eneh and Eneh (2025) analyzed agricultural practices and food security in Nigeria using system dynamics modeling. The study concluded that sustainable agricultural practices contribute significantly to long-term food security, while overdependence on traditional or industrial agricultural systems without sustainability considerations may lead to land degradation and food insecurity. Mignouna et al. (2011) examined determinants of improved agricultural technology adoption in sub-Saharan Africa and identified education, household income, extension services, and institutional support as major determinants of technology adoption. Asfaw, Kassie, Simtowe, and Lipper (2012) found that adoption of improved agricultural technologies significantly reduced food insecurity and increased household welfare among rural farmers. Issa, Adebayo, and Yusuf (2021) examined agricultural mechanization and food production in North Central Nigeria and found that mechanized farming increased agricultural productivity and food availability among rural households. Abdullahi, Ibrahim, and Yakubu (2019) investigated smart irrigation systems in Northern

Nigeria and found that improved irrigation technologies enhanced crop productivity and reduced seasonal food shortages. Summarily, the literature reviewed indicates that smart agricultural practices such as climate-smart agriculture, precision farming, mechanization, smart irrigation systems, and ICT-based agricultural services contribute significantly to agricultural productivity and food security. The theoretical review established that the Diffusion of Innovation Theory, Sustainable Livelihood Theory, and Systems Theory provide strong explanations for technology adoption, sustainable livelihoods, and food security outcomes. Empirical studies consistently revealed that adoption of smart agricultural technologies improves crop yield, resilience to climate change, household income, dietary diversity, and food accessibility. However, most existing studies focused on isolated technologies, specific crops, or limited geographical areas. There remains limited comprehensive empirical evidence on the combined effects of smart agricultural practices on food security specifically in North Central Nigeria. Therefore, this study seeks to bridge this gap by examining the overall effect of smart agricultural practices on food security in the region.

RESEARCH METHODOLOGY

This study was carried out in Nigeria's Niger State. The largest state in terms of landmass is Niger State, which is situated in Nigeria's North-Central geopolitical zone. It borders the Republic of Benin, FCT Abuja, Kaduna State, Kebbi State, Kogi State, and Kwara State. The state's lush land, pleasant climate, and access to water bodies like the Niger and Kaduna rivers make it ideal for agricultural development. Rice, maize, yam, millet, sorghum, cassava, groundnuts, and beans are among the main crops grown. Due to its significant contribution to the country's food production, the state is frequently referred to as one of Nigeria's food baskets (Wikipedia, 2026). All smallholder farming households engaged in crop production in particular Niger State agricultural zones made up the study's population. Since they are the main users or prospective adopters of smart agricultural practices, these farmers are directly involved in the production of food crops and are therefore pertinent to the study. Farmers engaged in the cultivation of maize, rice, cassava, yam, millet, and vegetables in particular Local Government Areas (LGAs) comprised the target population. The target population for this study comprised all registered smallholder crop farmers involved in agricultural production activities in Niger State. The study focused on smallholder farmers because they constitute the largest proportion of agricultural producers and are the primary users of smart agricultural practices in the state. According to records obtained from the Niger State Agricultural and Mechanization Development Authority (NAMDA), farmers' cooperative associations, and local agricultural extension offices, the estimated population of registered smallholder crop farmers in Niger State was approximately 32,500 farmers. Therefore, the total population size for the study was 32,500 registered smallholder farmers in Niger State. The sampling frame for the study consisted of the official lists of registered smallholder farmers obtained from: Niger State Agricultural and Mechanization Development Authority, Farmers' cooperative societies, Local Government Agricultural Offices, Agricultural extension service units in the selected LGAs. The lists contained the names, farming locations, and contact information of active smallholder farmers engaged in crop production activities across the selected Local Government Areas. The sampling frame ensured that only identifiable and active farmers who met the study criteria were selected for participation.

The study adopted a multi-stage sampling procedure involving purposive and simple random sampling techniques. Stage One (selection of Agricultural Zones): Niger State is divided into three agricultural zones, namely: Zone I, Zone II and Zone III. For adequate representation, two agricultural zones (Zone I and Zone II) were purposively selected due to their high concentration of farming activities and increasing adoption of smart agricultural practices. Stage Two (selection of Local Government Areas (LGAs): Two LGAs were purposively selected from each agricultural zone, making a total of four LGAs. The selected LGAs were: Mokwa & Bida LGAs from zone I and Katcha & Wushichi LGAs from zone II. The selected LGAs were chosen based on the following criteria: predominance of farming activities, presence of smallholder farmers, adoption of smart agricultural practices (climate-smart agriculture; improved seed varieties; mechanized farming; smart irrigation systems & ICT-based agricultural extension services) and availability of extension services. Stage Three (selection of communities): Two farming communities were randomly selected from each selected LGA, resulting in a total of eight communities. The simple random sampling technique ensured equal opportunity for all farming communities within the selected LGAs to participate in the study. Stage Four (selection of respondents): Twenty respondents were randomly selected from each

farming community using the farmers' register obtained from extension offices and cooperative societies. Therefore, the total sample size for the study was 240 respondents. The sample size for the study was determined using the formula developed by Yamane (1967) for finite population:

n = \frac{N}{1 + N(e)^2} ---------- (1)

Where:

(n) = sample size

(N) = population size

(e) = level of precision (0.05)

Anokye M. Adam in the study titled *"Sample Size Determination in Survey Research"*, the author discussed and applied the Yamane (1967) formula for finite population sample size determination. Sylvester C. L. and colleagues in their study on climate-smart agricultural practices and food security in Nasarawa State, Nigeria, they applied the Yamane (1967) formula in determining respondents for the study. In this study, we adopted several measures to ensure that respondents properly understood and correctly answered the questionnaire items during data collection in Niger State. First, the questionnaire was carefully designed using simple, clear, and unambiguous language that could easily be understood by smallholder farmers. Technical agricultural terms relating to smart agricultural practices were simplified and explained in locally understandable expressions to minimize misunderstanding. Second, the instrument underwent content and face validation through expert review by specialists in Agricultural Extension, Agricultural Economics, and Measurement and Evaluation. Their suggestions helped to improve the clarity, relevance, and comprehensibility of the questionnaire items before field administration. Third, a pilot test (pre-test) of the questionnaire was conducted among a small group of farmers outside the selected study communities but with similar socio-economic characteristics to the target respondents. The pilot study helped identify ambiguous questions, difficult terms, and response challenges. Necessary corrections and modifications were made based on the feedback obtained from the pre-test exercise. Fourth, trained research assistants who understood both English language and the local languages commonly spoken in the study areas were engaged during data collection. The research assistants were trained on the objectives of the study, interview procedures, and ethical considerations to ensure consistency in administration of the questionnaire.

Where respondents had difficulty understanding English, the questions were translated and interpreted into local languages such as Nupe, Hausa, and Gbagyi to improve comprehension. The use of local language interpretation helped respondents understand the meaning of the questions and provide accurate responses. In addition, the questionnaires were administered through face-to-face interviews rather than self-administration. This approach enabled the researchers and trained assistants to explain unclear questions, probe for clarification where necessary, and ensure that respondents answered all relevant items appropriately. We also ensured that respondents were informed about the purpose of the study and assured of confidentiality and anonymity. This helped reduce fear, suspicion, and response bias, thereby encouraging honest and accurate responses. Furthermore, the questionnaire consisted mainly of structured and close-ended questions with clearly defined response options. This reduced confusion and improved consistency in respondents' answers. These measures collectively enhanced the reliability, validity, and accuracy of the data collected for the study. The secondary data obtained from reports, journal articles, government publications, policy documents, and institutional records were analysed mainly using descriptive and content analytical techniques to complement the primary data collected from the field survey. The secondary sources included information obtained from: National Bureau of Statistics reports; Federal Ministry of Agriculture and Food Security publications; Food and Agriculture Organization reports; agricultural journals; conference proceedings; books; agricultural development programme reports; and previous empirical studies related to smart agriculture and food security. The analysis of the secondary data involved the following procedures: content analysis, descriptive statistical analysis, comparative analysis and trend analysis. These helped to establish the broader agricultural and food security situation in the study area. The secondary data findings were integrated with the primary survey results during discussion and interpretation of findings. The integration helped to strengthen the validity of the study by providing supporting evidence from previous studies and institutional records. Thus, the use of descriptive statistics, content analysis, comparative analysis, and trend analysis ensured systematic and meaningful utilization of the secondary data in achieving the objectives of the study.

Model Specification

Multiple Regression Model

$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\varepsilon$ -------- (2)

Where Y = Household food availability
X_1 = Improved seed adoption
X_2 = Irrigation practice
X_3 = Crop rotation
X_4 = Organic manure usage
X_5 = Agroforestry
X_6 = Weather information access
β_0 = Constant intercept
β_{1-6} = Coefficients
ε = error term

Logistic Regression Model

$P=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\varepsilon$ -------- (3)

Where P = Probability of food accessibility
X_1 = Farm income
X_2 = Credit access
X_3 = Extension contact
X_4 = Market access
X_5 = Adoption level
β_0 = Constant intercept
β_{1-5} = Coefficients
ε = error term

Likert Scale Model

$MS = frac\{sumFX\}\{N\}$ ----------(4)

Decision Rule:

- Mean ≥ 2.50 = Serious Constraint
- Mean < 2.50 = Not Serious Constraint

The construction of the HFSI was based primarily on household food expenditure and calorie adequacy indicators, which reflect the food availability and accessibility dimensions of household food security. The following indicators were used in constructing the Household Food Security Index:

- Quantity of food consumed by the household;
- Household food expenditure;
- Household size adjusted to adult equivalent scale;
- Daily calorie intake per household member;
- Recommended minimum calorie requirement.

The study adopted the minimum recommended daily calorie requirement of 2,260 kilocalories per adult equivalent per day, which has been widely used in food security studies in Nigeria and recommended by international food security assessment frameworks. The computation of the Household Food Security Index involved the following steps:

- Estimation of Household Food Consumption
- Adult Equivalent Adjustment
- Estimation of Daily Per Capita Calorie Intake
- Construction of the Household Food Security Index

The classification thresholds adopted in the study were:

HFSI Value	Food Security Status
HFSI ≥ 1	Food Secure
HFSI < 1	Food Insecure

The threshold of HFSI ≥ 1 indicates that the household meets or exceeds the minimum recommended daily calorie requirement of 2,260 kcal per adult equivalent per day. Such households were therefore classified as food secure because they possessed adequate food consumption capacity. Conversely, households with HFSI < 1 were classified as food insecure because their calorie intake fell below the recommended minimum nutritional requirement. The adoption of this threshold is consistent with established food security literature and previous empirical studies conducted in Nigeria and other developing countries. The approach has been widely used because it provides a simple and objective measure of household food adequacy based on nutritional requirements. The Household Food Security Index was considered appropriate for this study because the HFSI approach aligns with the study objective of examining the effect of smart agricultural practices on household food security among smallholder farmers in Niger State.

The variables included in the logistic regression model: Improved Seeds, Irrigation, Crop Rotation, Organic Manure, Agroforestry, and Weather Information were operationalized as individual components of smart agricultural practices rather than being combined into a single composite index. Each variable was treated as a separate predictor in the regression model to enable the study to assess the specific contribution of each smart agricultural practice to household food security outcomes. The

measurement strategy was based on the understanding that smart agriculture is a multidimensional concept comprising different technological, agronomic, and climate-adaptive practices that may influence food security in different ways. Therefore, aggregating all practices into a composite index could obscure the individual effects and relative importance of specific practices adopted by farmers. Each variable was measured as a binary adoption indicator using respondents' responses during the survey:

Smart Agricultural Practice	Measurement
Improved Seeds	1 = Adopted, 0 = Not Adopted
Irrigation	1 = Practiced, 0 = Not Practiced
Crop Rotation	1 = Practiced, 0 = Not Practiced
Organic Manure	1 = Used, 0 = Not Used
Agroforestry	1 = Practiced, 0 = Not Practiced
Weather Information	1 = Accessed/Used, 0 = Not Accessed

The dependent variable, household food security status, was also measured categorically as food secure or food insecure based on established household food security indicators such as food availability and food accessibility. The decision to model the variables separately is theoretically justified by the Diffusion of Innovation Theory developed by Everett Rogers (2003). The theory explains that adoption of agricultural innovations occurs independently depending on farmers' perceptions of relative advantage, compatibility, complexity, observability, and trialability. Consequently, farmers may adopt some smart agricultural practices while rejecting others based on their perceived benefits, affordability, knowledge level, and environmental suitability. The separate treatment of the variables is also supported by the Sustainable Livelihood Theory proposed by Robert Chambers and Gordon Conway (1992), which recognizes that different livelihood strategies and agricultural practices contribute differently to household welfare and food security

RESULTS AND DISCUSSION

Table 1: Distribution of Respondents by Socio-Economic Characteristics (n = 160)

Variables	Frequency	Percentage (%)
Gender		
Male	104	65.0
Female	56	35.0
Age (Years)		
21–30	18	11.3
31–40	42	26.3
41–50	58	36.2
Above 50	42	26.2
Marital Status		
Single	22	13.8
Married	112	70.0
Widowed/Divorced	26	16.2
Educational Level		
No Formal Education	28	17.5
Primary Education	40	25.0
Secondary Education	58	36.3
Tertiary Education	34	21.2
Farm Size (Ha)		
Less than 2 ha	48	30.0
2–4 ha	72	45.0
Above 4 ha	40	25.0

Source: Field Survey 2026.

Socio-Economic Characteristics of Respondents

The findings indicate that in the research area, agricultural production was dominated by male farmers (65%). This implies that men perform the majority of labor-intensive farming tasks. Strong labor availability for farm activities is shown by the fact that the majority of respondents (36.2%) were in the economically active age range of 41–50 years. The majority of respondents (70%) were married, which could have a favorable impact on household labor supply and farming decision-making. With (36.3%) having completed secondary school, educational attainment was rather moderate, indicating a reasonable capacity for adoption of modern agricultural technologies. Smallholder agricultural systems predominated, as evidenced by the majority operating between two and four hectares of cropland.

Table 2: Smart Agricultural Practices Adopted by Respondents

Smart Agricultural Practice	Frequency	Percentage (%)	Rank
Improved Seed Varieties	138	86.3	1st
Crop Rotation	130	81.3	2nd
Organic Manure Application	124	77.5	3rd
Irrigation Farming	118	73.8	4th
Mixed Cropping	115	71.9	5th
Agroforestry	92	57.5	6th
Minimum Tillage	84	52.5	7th
Weather Information Access	78	48.8	8th

Source: Field Survey 2026.

Smart Agricultural Practices Adopted by Farmers

Farmers understand the value of high-yield and drought-resistant varieties in increasing output, as evidenced by the fact that improved seed varieties scored best (86.3%). Applying organic manure and rotating crops were also common practices, indicating a growing understanding of managing soil fertility. Access to weather information was the least popular (48.8%), suggesting that farming decisions are not well integrated with climate information services. Poor extension service delivery and restricted access to ICT tools could be the cause of this.

Table 3: Household Food Security Status Using HFSI

Food Security Status	Frequency	Percentage (%)
Food Secure (HFSI ≥ 1)	102	36.2
Food Insecure (HFSI < 1)	58	63.8
Total	**160**	**100**

Source: Field Survey 2026.

Level of Food Security Among Farming Households

According to the results, (36.2%) of the households were food insecure and (63.8%) of the families were food secure. This suggests that most respondents have access to enough food. However, a sizable percentage of the respondents continued to face vulnerability and food shortages. The large percentage of adopters who are food secure may be related to increased production brought about by the application of organic manure, improved seeds, and irrigation.

Table 4: Multiple Regression Result on Food Availability

Variables	Coefficient	Std. Error	t-value	p-value
Constant	2.184	0.741	2.95	0.004
Improved Seeds (X_1)	0.428	0.102	4.20	0.000*
Irrigation (X_2)	0.316	0.095	3.33	0.001*
Crop Rotation (X_3)	0.274	0.087	3.15	0.002*
Organic Manure (X_4)	0.251	0.091	2.76	0.007*
Agroforestry (X_5)	0.193	0.080	2.41	0.017*
Weather Information (X_6)	0.165	0.072	2.29	0.024*

Model Summary

R^2	Adjusted R^2	F-value	Prob (F-stat)
0.712	0.698	38.42	0.000

*Significant at 5% level

Source: Field Survey 2026.

Effect of Smart Agricultural Practices on Household Food Availability

All smart agriculture methods had a significant and favorable impact on household food availability, according to the regression result. The greatest contribution to food availability was made by improved seeds, which had the highest coefficient (0.428). The independent variables in the model accounted for 71.2% of the variation in family food availability, according to the R^2 value of 0.712. Overall model fitness was shown by the F-statistic, which was significant at 5%. This demonstrates that implementing smart agriculture practices greatly increases household food output and availability.

Table 5: Logistic Regression Result on Food Accessibility

Variables	Coefficient	Std. Error	Wald	p-value
Constant	1.762	0.623	8.01	0.005
Farm Income	0.384	0.118	10.58	0.001*
Credit Access	0.295	0.107	7.60	0.006*
Extension Contact	0.278	0.101	7.58	0.006*
Market Access	0.332	0.110	9.11	0.003*

Variables	Coefficient	Std. Error	Wald	p-value
Adoption Level	0.441	0.126	12.25	0.000*

Source: Field Survey 2026.

Influence of Smart Agricultural Practices on Food Accessibility

The findings show that food accessibility among farming households was strongly influenced by farm income, loan availability, market access, extension contact, and adoption level. The adoption level showed the highest coefficient (0.441), indicating that households using smart agriculture methods more frequently had better access to food due to steady production and higher incomes. This suggests that intelligent farming methods enhance not only food production but also food access and purchasing power.

Table 6: Mean Ranking of Constraints

Constraint	Mean Score	Decision	Rank
High Cost of Inputs	3.62	Serious	1st
Poor Access to Credit	3.48	Serious	2nd
Inadequate Extension Services	3.41	Serious	3rd
Lack of Technical Knowledge	3.29	Serious	4th
Poor Government Support	3.16	Serious	5th
Climate Uncertainty	3.08	Serious	6th
Insecurity	2.94	Serious	7th
Poor Market Access	2.76	Serious	8th

Source: Field Survey 2026.

Constraints Affecting Adoption of Smart Agricultural Practices

The biggest barrier to adoption was found to be the high cost of agricultural inputs. This suggests that many farmers are unable to afford better seeds, irrigation systems, and other essential technology. Inadequate extension services and poor financing availability also scored highly, indicating institutional and financial obstacles to adoption. This emphasizes the necessity of more robust farmer assistance programs and government involvement.

Discussion of Findings

The findings of this study revealed that smart agricultural practices such as improved seeds, irrigation, crop rotation, organic manure, agroforestry, and access to weather information positively influenced household food security among smallholder farmers in Niger State. These findings are largely consistent with several previous empirical studies conducted in Nigeria and other developing countries. The positive effect of improved seed adoption on household food security agrees with the findings of Asfaw, Kassie, Simtowe, and Lipper (2012), who reported that adoption of improved agricultural technologies significantly increased crop productivity and reduced food insecurity among rural households in sub-Saharan Africa. Similarly, the result aligns with Ayinde et al. (2020), who found that climate-smart agricultural practices improved agricultural productivity and food security among Nigerian farmers.

This study also found that irrigation practices significantly improved food security by enhancing dry-season farming and reducing vulnerability to rainfall variability. This finding corroborates the work of Abdullahi, Ibrahim, and Yakubu (2019), who reported that smart irrigation technologies increased

crop productivity and reduced seasonal food shortages among farming households in Northern Nigeria. Likewise, Lipper et al. (2014) emphasized that climate-smart agricultural practices such as irrigation strengthen resilience to climate change and improve food availability. The positive influence of crop rotation and organic manure on food security observed in this study is consistent with the findings of Mignouna et al. (2011), who noted that sustainable soil management practices improve agricultural productivity and long-term food sustainability. The result also supports the Sustainable Livelihood Theory developed by Robert Chambers and Gordon Conway, which emphasizes the importance of sustainable resource management in improving rural livelihoods and food security. Furthermore, the finding that access to weather information significantly influenced food security agrees with Aker and Mbiti (2010), who established that ICT-based agricultural information services improve farmers' production decisions, market access, and productivity. Similarly, Ogutu, Okello, and Otieno (2014) found that access to agricultural information technologies enhanced farm productivity and household welfare among smallholder farmers in Kenya.

This study's findings on agroforestry are also in agreement with recent studies on climate-smart agriculture in Nigeria. For instance, Sylvester, Umar, and Galadima (2024) reported that agroforestry and integrated farm management practices positively influenced household food security among farmers in Nasarawa State. Agroforestry contributes to soil conservation, environmental sustainability, income diversification, and resilience against climate-related risks. However, some findings of this study differ slightly from previous studies. While earlier studies such as Ojo and Adebayo (2012) identified poverty and infrastructural deficiencies as the dominant causes of food insecurity, the present study found that adoption of smart agricultural practices could significantly moderate these challenges by improving productivity and household income. This suggests that technology adoption may serve as an effective pathway for improving food security even in resource-constrained rural settings. In addition, unlike some previous studies that focused on single agricultural technologies or isolated interventions, this study adopted a broader and more integrated approach by examining multiple smart agricultural practices simultaneously within one regression framework. This allowed the study to identify the relative contribution of different smart agricultural practices to household food security.

CONCLUSION

Finding out how smart agricultural techniques affect household food availability, food accessibility, and overall food security among farming households in the research area was the main goal. The results of this study lead to the conclusion that intelligent farming methods significantly improve food security in Niger State, Nigeria. Adopting techniques like better seed types, irrigated farming, crop rotation, applying organic manure, agroforestry, and having access to weather data significantly increases the amount of food available and accessible in households. These methods boost farm income, boost agricultural output, lessen susceptibility to climate-related shocks, and raise farming households' resilience. The study also finds that farmers who use more intelligent farming techniques are more likely to be food secure than those who only use conventional farming techniques. However, high production costs, difficult access to institutional credit, poor extension services, and a lack of government backing continue to limit the adoption of these approaches. The full advantages of smart farming methods might not materialize unless these obstacles are removed. In order to achieve sustainable food security in Niger State and throughout Nigeria, it is imperative that agricultural policy be strengthened, financing be made more accessible, rural extension services be improved, and farmer education be supported.

RECOMMENDATIONS

Accordingly, the following recommendations were made:

1. Federal Ministry of Agriculture and Food Security and the Niger State Agricultural and Mechanization Development Authority should strengthen policies and intervention programmes that promote the adoption of smart agricultural practices such as improved seeds, irrigation technologies, crop rotation, agroforestry, and organic manure among smallholder farmers.

2. Agricultural extension agencies should intensify farmer education and training programmes on the effective use of smart agricultural technologies to improve productivity and household food security in rural communities.

3. Government and financial institutions should provide accessible and affordable agricultural credit facilities to smallholder farmers to enable them adopt modern agricultural technologies and climate-smart farming practices.

4. Investment in rural irrigation infrastructure and water management systems should be increased to support all-season farming and reduce dependence on rainfall among farming households.

5. Agricultural research institutes and extension organizations should improve dissemination of weather and climate information through ICT platforms, radio programmes, and mobile phone services to help farmers make informed production decisions.

ACKNOWLEDGEMENT

We would like to thank NOUN Management and TETFUND for approving and supporting our research application under the 2017–2025 TETFUND Institution Based Research (IBR) Intervention. These institutions' dedication to academic achievement, innovation, and knowledge advancement is reflected in this kind act. The grant's approval has given us the tools and inspiration we need to continue our research project with more commitment and assurance. It has strengthened our ability to make significant contributions to our field of study and reaffirmed our dedication to maintaining the high standards of research associated with these sister institutions. We sincerely appreciate the faith and confidence placed in us, and we promise to continue being dedicated to making sure that the goals of this study are accomplished in a way that would benefit Nigeria as a whole and the university community in particular. We would like to express our gratitude once more for this chance and the ongoing support provided to NOUN researchers.

REFERENCES

Abah, D., Hembafan, V. D., & Esheya, S.E. (2020). Effects of deforestation on rural household income in Vandeikya Local Government Area of Benue State, Nigeria. Production Agriculture Technology Journal, 16 (2), 33-45.

Abdullahi, A., Ibrahim, H., & Yakubu, M. (2019). Effect of smart irrigation systems on agricultural productivity in Northern Nigeria. *Journal of Agricultural Extension and Rural Development, 11*(4), 45-53.

Adebayo, O. O., & Olagunju, K. O. (2021). Climate change adaptation strategies and food security among rural farming households in Nigeria. *Journal of Agricultural Extension, 25*(2), 45-58.

Ajie, E. N., & Uche, C. (2025). Climate smart agriculture in food insecurity mitigation in Nigeria: A conceptual evaluation. *Asian Journal of Agricultural Extension, Economics & Sociology, 43*(1), 63-71.

Aker, J. C. (2011). Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics, 42*(6), 631-647.

Aker, J. C., & Mbiti, I. M. (2010). Mobile phones and economic development in Africa. *Journal of Economic Perspectives, 24*(3), 207-232.

Amaza, P. S., Umeh, J. C., Helsen, J., & Adejobi, A. O. (2009). Determinants and measurements of food insecurity in Nigeria: Some empirical policy guide. *International Journal of Food Security, 1*(2), 45-56.

Amusa, T. A., & Esheya, S. E. (2025). Climate smart-agricultural practices among arable crop farmers in Abia state: Heckman Double Stage Selection Approach. *Farm Management Association of Nigeria (FAMAN) Journal,* 25 (2B), 99-110.

Asfaw, S., Kassie, M., Simtowe, F., & Lipper, L. (2012). Poverty reduction effects of agricultural technology adoption: Evidence from rural Tanzania. *Journal of Development Studies, 48*(9), 1288-1305.

Ayeni, M. D., Adio, M. O., Elizabeth, O. I., & Owolabi, A. (2025). Climate-smart agriculture and food security: An empirical analysis of farming households in Kwara State, Nigeria. *NIPES Journal of Science and Technology Research, 7*(1), 795-801.

Ayinde, O. E., Adewumi, M. O., Ojehomon, V. E. T., & Daramola, F. S. (2020). Determinants of adoption of climate-smart agricultural practices among farmers in Nigeria. *African Journal of Agricultural Research, 15*(4), 512-520.

Babatunde, R. O., Omotesho, O. A., & Sholotan, O. S. (2007). Socio-economic characteristics and food

security status of farming households in Kwara State, North-Central Nigeria. *Pakistan Journal of Nutrition, 6*(1), 49-58.

Balogun, O. S., Nwahia, O., & Nwebor, E. (2024). Climate-smart agriculture for sustainable agricultural development in Nigeria: An empirical review. *Journal of Applied Sciences and Environmental Management, 28*(6), 1853-1858.

Bello, M. A., Ibrahim, H. Y., & Abdullahi, U. S. (2022). Climate-smart agriculture and household food security among smallholder farmers in North Central Nigeria. *Nigerian Journal of Agricultural Economics, 12*(1), 77-91.

Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: Practical concepts for the 21st century*. Brighton: Institute of Development Studies, IDS.

Eneh, C. A., & Eneh, O. C. (2025). A system dynamics analysis of agricultural practices and food security in Nigeria. *Journal of Health, Population and Nutrition, 44*(285), 1-9.

Esheya, S.E. (2018). Assessment of agro-chemicals utilization among rural farmers in Ebonyi state, Nigeria. *AKSU Journal of Agricultural Economics, Extension and Rural Development,* 1(1), 11-14.

Esheya, S.E. & Awolumate, S. (2025). Environmental and socioeconomic impacts of mineral exploitation on fisheries in Imo State, Nigeria. *African Journal of Agricultural Science and Food Research, 18 (1), 214-225.*

Food and Agriculture Organization (FAO). (2008). *An introduction to the basic concepts of food security*. Rome: FAO.

Food and Agriculture Organization. (2019). *Climate-smart agriculture sourcebook*. Rome: FAO.

Food and Agriculture Organization. (2021a). *The state of food security and nutrition in the world 2021*. Rome: FAO.

Food and Agriculture Organization (FAO). (2021b). *Climate-smart agriculture sourcebook*. Rome: FAO.

Food and Agriculture Organization. (2022). *The state of food and agriculture 2022*. Rome: FAO.

Gabriel, I., Olajuwon, F., Klauser, D., Michael, B., & Renn, M. (2023). State of climate-smart agriculture practices in the North Central and Northwest zones Nigeria. *CABI Agriculture and Bioscience, 4*(33), 1-15.

Gebbers, R., & Adamchuk, V. I. (2010). Precision agriculture and food security. *Science, 327*(5967), 828-831.

Issa, F. O., Adebayo, E. F., & Yusuf, S. A. (2021). Agricultural mechanization and food production in North Central Nigeria. *Journal of Agricultural Science and Technology, 13*(2), 88-99.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Delhi: New Age International Publishers.

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., & Torquebiau, E. F. (2014). Climate-smart agriculture for food security. *Nature Climate Change, 4*(12), 1068-1072.

Mignouna, B., Manyong, V. M., Rusike, J., Mutabazi, K., & Senkondo, M. (2011). Determinants of adopting improved agricultural technologies in developing countries. *Journal of Agricultural and Applied Economics, 3*(1), 1-8.

Mitra, A., Vangipuram, S. L. T., Bapatla, A. K., Bathalapalli, V. K. V. V., Mohanty, S. P., Kougianos, E., & Ray, C. (2022). Everything you wanted to know about smart agriculture. *Internet of Things and Cyber-Physical Systems Review*, 1-25.

National Bureau of Statistics. (2023). *Nigerian gross domestic product report*. Abuja: NBS.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Obazi, S.A., Iheanyichukwu, M.O., Okoronkwo, D.J., Obasi, K., & Esheya, S.E. (2022). Adoption level on organic farming practices by fluted pumpkin vegetable farmers in Enugu State, Nigeria. *International Journal of Agricultural Science, Research and Technology in Extension and Education Systems*, 12(4), 179-188.

Ogbonna, S.I., Esheya, S.E. & Nwandu, P.I. (2025). Environmental effects of poultry production in Abia state, Nigeria. *NOUN Journal of Agricultural Research and Development*, 1 (2), 24-31.

Ogutu, S. O., Okello, J. J., & Otieno, D. J. (2014). Impact of information and communication technology-based market information

services on smallholder farm input use and productivity in Kenya. *World Development, 64*, 311-321.

Ojo, M. A., & Adebayo, P. F. (2012). Food security status of rural households in Nigeria. *International Journal of Food and Agricultural Economics, 1*(2), 45-58.

Omonona, B. T., & Agoi, G. A. (2007). An analysis of food security situation among Nigerian urban households: Evidence from Lagos State, Nigeria. *Journal of Central European Agriculture, 8*(3), 397-406.

Omotayo, A. O., Olagunju, K. O., Ogunniyi, A. I., & Hounnou, F. E. (2025). Climate-smart agricultural practices and food-nutrition security outcomes: Insight from rural smallholder farmers. *Agriculture & Food Security, 14*(28), 1-18.

Rogers, E. M. (1962). *Diffusion of innovations*. New York: Free Press.

Sylvester, C. L., Umar, H. S., & Galadima, O. E. (2024). Effects of climate-smart agricultural practices on food security situation of farmers in Nasarawa State, Nigeria. *UNIZIK Journal of Agricultural Economics and Extension, 1*(1), 1-10.

United Nations. (2021). *Sustainable development goals report 2021*. New York: United Nations.

Usman, A., & Ahmed, S. (2020). Determinants of adoption of climate-smart agricultural practices among farmers in Northern Nigeria. *African Journal of Rural Development, 5*(3), 112-126.

World Bank. (2021). *Climate-smart agriculture overview*. Washington, D.C.: World Bank.

World Bank. (2022). *Climate-smart agriculture in Africa: Opportunities and challenges*. Washington, DC: World Bank.

Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). New York: Harper and Row.

Zhang, N., Wang, M., & Wang, N. (2002). Precision agriculture: A worldwide overview. *Computers and Electronics in Agriculture, 36*(2–3), 113-132.