GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

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# Effectiveness of financing options in the adoption of climate smart agriculture practices among farmers in delta state, Nigeria

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GSC Advanced Research and Reviews, 2026, 26(02), 133-146

Publication history: Received on 06 January 2026; revised on 16 February 2026; accepted on 19 February 2026

Article DOI: https://doi.org/10.30574/gscarr.2026.26.2.0042

## Abstract

This study was carried out to examine the effectiveness of financing options in the adoption of climate smart agriculture practices among farmers in delta state, Nigeria. Survey questionnaire was administered to 210 respondents in the study area through the use of multistage sampling technique. Descriptive statistics such as, means, percentage and frequency count was used to achieve the objectives and hypotheses were tested using binary logistics regression. The study shows that most respondents were female (71.0%), married (60.5%), aged 30–49 (62.9%), and operated small farms under 3 hectares (80.5%). Education varied, but 27.1% had secondary education. Many relied on personal savings (45.2%) and leased land (49.5%). Contact with extension agents was minimal (76.2% had none), and only 34.8% belonged to cooperatives. Access to CSA financing was highest through youth and women's schemes like N-Power Agro (91.9%) and commercial bank green loans (64.3%), while access to schemes like NIRSAL, Anchor Borrowers' Programme, and CBN Agricultural Credit Guarantee Scheme Fund remained low (<30%). Effectiveness ratings of existing financing schemes were generally below average (mean < 2.5), indicating weak support for CSA adoption, hindered by bureaucratic bottlenecks and poor outreach (Abioye et al., 2021; Oladipo et al., 2022). Severe challenges included high collateral, interest rates, and limited insurance (Food and Agriculture Organization, 2021). Innovative strategies like results-based financing and blended finance showed modest support (≈30%), while digital and insurance-based tools had low acceptance due to trust gaps (Adeagbo et al., 2022). Regression results showed education, farm experience, and credit access positively influenced CSA adoption. Based on the findings of this study it was recommended that Financial institutions such as NIRSAL, Anchor Borrowers' Programme, and CBN Agricultural Credit Guarantee Scheme Fund should lower collateral requirements, reduce interest rates, and extend repayment periods to make credit accessible to smallholders.

**Keywords:** Effectiveness; Climate-smart; Adoption; Financing

## 1. Introduction

Agriculture remains the backbone of Nigeria's economy, contributing significantly to employment and food security. However, the sector faces severe challenges due to climate change, characterized by unpredictable rainfall patterns, extreme temperatures, and increased incidences of drought and flooding, all of which threaten agricultural productivity (Yelwa, 2019). Global agriculture is seriously threatened by climate change, which has an effect on livelihoods, food security, and environmental sustainability. As a result, a comprehensive strategy to handle the intricate interactions between agriculture, climate change, and food security has emerged: Climate-Smart Agriculture (CSA). CSA technologies include a variety of methods designed to lower greenhouse gas emissions, improve resilience to climate impacts, and boost agricultural productivity. Climate-smart agriculture (CSA) has emerged as a viable approach to enhance resilience and sustainability in food production systems by integrating adaptive strategies, efficient resource management, and innovative financial mechanisms (IPCC, 2014). Despite the potential benefits of CSA, a major obstacle for Nigerian farmers is the lack of access to adequate financing, which hinders the adoption of climate-resilient technologies and

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practices (Ahmed, 2020). The impact of climate change on agriculture, has become a critical area of concern in Nigeria due to its profound implications for food security, livelihoods, and economic development. The increasing variability in climate patterns, including rising temperatures, erratic rainfall, and extreme weather events, has disrupted the value chain processes, creating bottlenecks that hinder productivity and sustainability. These manifest at various stages of the farming value chain, including production, processing, distribution, and marketing, ultimately threatening the resilience of the sector. Climate change is a major global concern that is greatly reshaping the environment and continuously altering Earth's ecosystems. Since the nineteenth century, there has been a global increase in average temperature by 0.9°C (Adam, 2019). Projections indicate warming will continue with an average increase of 3–4°C possible over the next century (Food and Agriculture Organization, 2015). As the earth warms generally, average temperatures rise throughout the year, but the increases may be more significant in certain seasons than in others (United States Environmental Protection Agency, 2022). Climate change leads to a distortion of seasonal patterns and consequently, changes in the pattern of rainfall and temperature (Ibekwe *et al.,* 2019) and this generally affects the cultivation of crops, maize inclusive.

Agri-food systems continue to receive a disproportionately small amount of climate finance; in 2019–20, the average yearly amount of USD 28.5 billion1, or 4.3% of all global climate finance, was distributed to all agri-food programs. Only 10% of all venture capital investments in agri-food technology during the same period went towards businesses tackling climate-related solutions, or an average annual injection of USD 2.3 billion2. Climate financing for agri-food systems must rise by at least seven times its current level in order to successfully navigate the climate transition. This level is necessary to satisfy the conservative predicted requirements of this transformation, which span hundreds of billions of dollars yearly.

Sub-Saharan Africa receives only 16% of all tracked climate finance provided to agri-food systems, amounting USD 4.4 billion3, while being one of the regions most exposed to the negative effects of climate change on food production. The essential need for a more equal distribution of climate funds to assist climate-smart agricultural practices in Sub-Saharan Africa is highlighted by this glaring mismatch. Financial institutions' strict collateral requirements, high lending rates, and restricted access to formal credit all contribute to the financing gap for CSA in Nigeria (Central Bank of Nigeria, 2021). The bulk of agricultural producers are smallholder farmers, who frequently rely on unofficial lending sources that don't provide enough money for large-scale investments in climate-smart practices like better irrigation systems, drought-resistant crops, and conservation agriculture (Aliero & Ekaette, 2018). Government interventions such as the Anchor Borrowers' Programme have sought to bridge this gap by providing targeted credit schemes, yet challenges persist regarding disbursement inefficiencies and bureaucratic bottlenecks (CBN, 2015).

Private sector involvement and public-private partnerships (PPPs) have been identified as crucial in mobilizing sustainable financing for CSA. Microfinance institutions, impact investors, and agricultural cooperatives are beginning to play a role in providing financial support tailored to the unique needs of climate-smart initiatives (Adams *et al.,* 2019). Moreover, innovative financing mechanisms such as green bonds, climate insurance, and carbon credits offer promising avenues for scaling up investments in CSA (Bose *et al.,* 2015). However, awareness and accessibility of these financial instruments remain low among Nigerian farmers, necessitating stronger policy frameworks and financial literacy programs. Incorporating CSA financing into Nigeria's broader economic policies and development strategies is essential for achieving long-term agricultural sustainability. Strengthening institutional support, improving access to climate finance, and fostering collaborations between the government, private sector, and international development agencies will be key in ensuring that Nigerian farmers can adopt climate-resilient agricultural practices effectively. Without significant improvements in financing mechanisms, the country risks exacerbating food insecurity and economic instability in the face of climate change the need therefore for this study is apt.

### *Objectives of the study*

The broad objective of this study was to examine the Climate Smart Agriculture (CSA) Financing Mechanism among farmers in Delta State, Nigerian.

The specific objectives are:

- Describe socio-economic characteristic of farmers in Delta State.
- Asses existing financing mechanisms for CSA in Delta State,
- Evaluate effectiveness of these mechanisms in supporting the adoption of CSA practices among farmers in Delta State.
- Examine the financing mechanisms for Climate Smart Agriculture in Delta State, and

- Identify challenges facing farmers and other stakeholders for innovative financing mechanisms that can support the adoption of CSA practices in Delta State.

### 1.1. Hypotheses of the study

The following hypotheses were tested in a null form.

- **$H_0$i:** There was no significant relationship between the socio-economic characteristics of farmers and their adoption of Climate-Smart Agriculture (CSA) practices in Delta State.
- **$H_0$ii:** Existing financing mechanisms for CSA in Delta State do not have a significant effect on the adoption of CSA practices among farmers.

### 1.2. Theoretical Review

The financing of climate-smart agriculture (CSA) in Nigeria can be examined through the lens of three fundamental economic theories: the Solow-Swan Growth Model, Institutional Economics, and Public Goods Theory. These theories provide insight into how investments in CSA can drive economic growth, the role of financial institutions in supporting farmers, and the need for government intervention in financing sustainable agriculture.

**The Solow-Swan Growth Model and Climate-Smart Agriculture Investment:** The Solow-Swan Growth Model explains long-term economic growth based on capital accumulation, labor, and technological progress (Solow, 1956). It argues that sustained economic growth depends on investments in productive capital and technological advancements. This theory is relevant to climate-smart agriculture in Nigeria, as CSA involves adopting improved farming techniques, such as drought-resistant crops, precision irrigation, and conservation agriculture, which require substantial financial investment (Ahmed, 2020).

The model suggests that increasing capital investment in CSA will lead to higher agricultural productivity, contributing to overall economic growth. However, the Nigerian agricultural sector faces a financing gap, as smallholder farmers lack access to capital needed to adopt climate-smart technologies (CBN, 2021). Government-backed funding programs, such as the Anchor Borrowers' Programme, attempt to address this gap but have been hindered by inefficiencies in credit disbursement and access restrictions (CBN, 2015). If properly financed, CSA can drive agricultural modernization, increase yields, and ensure long-term sustainability, aligning with the model's emphasis on capital accumulation as a driver of growth (Bose et al., 2015).

**Institutional Economics and Access to Finance:** Institutional Economics examines how institutions—formal and informal rules—affect economic behavior and development (North, 1990). This theory is crucial in understanding why Nigerian farmers struggle to secure financing for CSA initiatives. Financial institutions, including commercial banks, impose strict lending requirements, such as high-interest rates and collateral demands, which smallholder farmers cannot meet (Yelwa, 2019). As a result, many farmers rely on informal lending sources, which are often inadequate to fund CSA adoption. Government policies and institutional frameworks must be restructured to facilitate financial access for farmers. Microfinance institutions and cooperative societies, as alternative sources of credit, play an essential role in bridging this gap (Adams, Adaji & Adesope, 2019). Additionally, institutional weaknesses, such as corruption and inefficiencies in agricultural subsidy programs, must be addressed to ensure that CSA financing mechanisms are transparent and effective (IPCC, 2014). Strong institutions can create an enabling environment for climate finance, ensuring that Nigerian farmers have access to credit facilities tailored to their needs. Moreover, public-private partnerships (PPPs) can help mobilize financial resources for CSA by involving banks, impact investors, and agribusiness firms in agricultural financing. A stable institutional framework that supports PPPs will attract investments in sustainable agriculture, reducing dependency on government funding alone (Ahmed, 2020).

**Public Goods Theory and Government Intervention in CSA Financing:** Public Goods Theory highlights the role of government in providing goods and services that the private sector may not efficiently supply (Samuelson, 1954). Climate-smart agriculture financing aligns with this theory because sustainable agricultural practices generate benefits beyond individual farmers. CSA contributes to food security, environmental conservation, and economic resilience, making it a public good that warrants government support (IPCC, 2014).

The market often fails to provide adequate financing for public goods due to externalities for instance, the long-term benefits of CSA, such as reduced carbon emissions and improved soil health, are not immediately profitable for private investors (Bose et al., 2015). This justifies government intervention through subsidies, grants, and low-interest loans to encourage CSA adoption among farmers (CBN, 2021). Programs such as carbon credits and climate insurance can also incentivize farmers to implement sustainable practices by rewarding them for reducing emissions and protecting against climate-related risks. However, government interventions must be well-targeted and efficiently implemented to avoid distortions such as misallocation of resources and corruption. Strengthening monitoring and evaluation mechanisms can ensure that CSA financing reaches the intended beneficiaries and achieves its long-term objectives (Yelwa, 2019). The financing of climate-smart agriculture in Nigeria requires a multi-theoretical approach to address challenges in capital investment, institutional support, and public sector involvement. The Solow-Swan Growth Model underscores the importance of capital investment in increasing agricultural productivity and economic growth. Institutional Economics highlights the role of financial institutions and policies in determining access to credit for smallholder farmers. Public Goods Theory justifies government intervention in CSA financing, as sustainable agriculture generates widespread economic and environmental benefits. By integrating these economic perspectives, Nigeria can develop a robust CSA financing mechanism that enhances food security, reduces vulnerability to climate change, and promotes long-term economic development.

## 2. Methodology

### 2.1. Study Area and Sampling Procedure and Sampling Size

This study was conducted in Delta State, Nigeria. A multistage sampling technique was adopted for the study in order to ensure that the respondents are adequately and fairly represented across the different agricultural zones. Nine (9) local government areas were purposely selected from the three agricultural zones and from each of the 9 purposively selected LGAs, three (3) communities were randomly selected. This produced: 9 LGAs × 3 communities' = 27 communities. From each of the 27 communities, eight (8) respondents were randomly selected. 27 communities × 8 = 216 respondents. Out of the 216 questionnaires administered, 210 were completed and returned, giving a 97.2% response rate. Thus, Population (N) was 216 and Valid Sample Size Used was 210 (97.2%).

### 2.2. Data Collection and Data Analysis

The study was conducted using primary data which was collected through the administration of well design questionnaire. The well design questionnaire structured for the survey consisted of information on the socio-economic characteristics of respondents, the existing financing mechanisms for CSA in Delta State, the effectiveness of these mechanisms in supporting the adoption of CSA practices among farmers, the financing mechanisms for Climate Smart Agriculture, challenges facing farmers and other stakeholders for innovative financing mechanisms that can support the adoption of CSA practices

Both descriptive and inferential statistic were applied in data analysis, they include frequency, percentage, mean, mode, Likert type scale, and binary logistic regression analysis.

### 2.3. Model Specification

Binary logistic regression model was used to examine the relationship between the socio-economic characteristics of farmers and Climate-Smart Agriculture (CSA) practices. Binary Logistic Regression was used in this study because it predicts the probability of an event occurring when the dependent variable has two categories. It is used to identify significant predictors and examine how independent variables influence the likelihood of an outcome. In this study, it helps determine factors driving adoption of CSA across respondent groups.

It is stated as;

Let $Y_i$ (Climate-Smart Agriculture (CSA) practices) be the dependent variable for household (0 = Adopted, 1 = Not adopted). The logistic model for the probability pi=P(Yi=1) is:

$$\text{Logit}(pi) = \log\left(\frac{pi}{1-pi}\right) = \beta0+\beta1\, x_i + \beta2\, x_i + \beta3\, x_i + \beta4\, x_i + \beta5\, x_i + \beta6\, x_i + \beta7\, x_i + \beta8\, x_i + \varepsilon i \text{ ---1}$$

Equivalently, the predicted probability:

$$\boldsymbol{pi} = \frac{1}{1+e-(\beta 0+\sum k\beta kXki)} \quad \text{-------------------------------------- 2}$$

X1= Gender (male or female)
X2 = Age of farmers (years)

X3 = Marital Status (1=Single, 2=Married, 3 = divorced, 4= widowed)
X4 = Household size (number of persons)
X5 = Years of farm experience (years)
X6 = Level of Education (1= No formal Edu, 2=Primary, 3=secondary, 3= Tertiary Education)
X7 = Contact with extension agent (1 = yes, 2= No)
X8 = Income (amount in naira)
X9 = Access to credit (0=No, 1=Yes)
μ= Error term

## 3. Results and discussion

### 3.1. Socio-Economic Characteristics of Respondents

*3.1.1. Gender of Respondents*

The result shows that 29.0% of the respondents were male, while 71.0% were female. This indicates that female farmers are more involved in Climate-Smart Agriculture (CSA)-related activities in the study area. This finding aligns with Nnadi and Ezudike (2020) noted that women's participation is crucial to the adoption of CSA because they are often more receptive to new agricultural innovations aimed at improving productivity and resilience. According to Adeagbo et al. (2022), gender-inclusive financing mechanisms are essential to enhance women farmers' access to resources and credit, which can accelerate CSA adoption and improve household food security.

*3.1.2. Age of Respondents*

The result shows that 5.2% of respondents were less than 20 years, 15.7% were aged 20–29, 28.1% were 30–39, 34.8% were 40–49, 14.8% were 50–59, and 1.4% were 60–69. This indicates that most respondents are within the productive age group (30–49 years), which suggests strong potential for adopting Climate-Smart Agriculture (CSA) practices when supported with appropriate financing mechanisms. According to Ayanlade and Radeny (2020), younger and middle-aged farmers are more likely to embrace CSA due to their openness to innovation and risk-taking. Similarly, Ojo and Baiyegunhi (2021) found that age significantly influences farmers' adoption of climate-resilient technologies in Nigeria

*3.1.3. Marital Status*

The result indicates that 20.0% of the respondents were single, 60.5% were married, 8.1% were widowed, and 11.4% were divorced. The dominance of married respondents suggests a higher likelihood of stable household income, which can influence access to financing for Climate-Smart Agriculture (CSA) adoption. According to Ogunleye and Adeyemi (2020), marital status can affect farmers' financial decision-making and risk-taking behaviour, with married farmers often more willing to invest in long-term agricultural innovations. Similarly, Nwankwo et al. (2021) noted that married farmers tend to have larger household labour and stronger social networks, which can facilitate access to credit for CSA practices in Nigeria.

*3.1.4. Household Size*

The findings show that 32.9% of respondents had household sizes of 1–3 members, 44.8% had 4–6 members, 15.7% had 7–10 members, and 6.7% had above 10 members. The predominance of medium-sized households (4–6) suggests a moderate labour force availability within farming families, which can influence the adoption of Climate-Smart Agriculture (CSA) practices. According to Oladimeji and Abdulsalam (2020), larger households often provide family labour that reduces production costs and supports the uptake of labour-intensive CSA practices. Similarly, Akinyemi et al. (2022) found that household size affects farmers' ability to mobilize internal resources for agricultural financing in Nigeria. This indicates that household size plays a crucial role in determining smallholder farmers' capacity to invest in CSA through improved labour availability and shared financial responsibility.

*3.1.5. Educational Level Attained*

The results show that 10.0% of respondents had no formal education, 11.9% had First School Leaving Certificates, 9.0% had Junior Secondary education, 27.1% attained Senior Secondary education, 16.7% had OND/NCE, 15.7% had HND/B.Sc, and 9.5% had postgraduate education. This indicates that most respondents have at least secondary education, which enhances their capacity to understand and access Climate-Smart Agriculture (CSA) financing opportunities. According to Ogunleye et al. (2021), education improves farmers' ability to process information and adopt innovative agricultural practices. Similarly, Abegunde and Adebayo (2020) noted that educated farmers are more likely to access credit and participate in financing schemes that promote CSA.

*3.1.6. Farming Experience*

The findings indicate that 14.8% of respondents had less than 10 years of farming experience, 39.0% had 11–20 years, 33.8% had 21–30 years, and 12.4% had above 30 years of experience. This shows that the majority of farmers are highly experienced, with over 70% having more than 10 years in farming. Such experience is crucial for understanding and adopting Climate-Smart Agriculture (CSA) practices and financing mechanisms. According to Ali et al. (2021), experienced farmers are more likely to engage in innovative farming practices and seek financial support to improve productivity. Similarly, Ojo and Akinbode (2020) reported that longer farming experience enhances farmers' risk management abilities and willingness to invest in CSA initiatives.

*3.1.7. Contact with Extension Agent*

The result shows that only 1.4% of respondents had weekly contact with extension agents, 3.3% had monthly contact, 8.1% had quarterly contact, 11.0% had yearly contact, while a majority of 76.2% had no contact at all. This indicates poor access to agricultural extension services among farmers, which can hinder their knowledge and adoption of Climate-Smart Agriculture (CSA) practices and related financing mechanisms. According to Bamire et al. (2021), extension services play a crucial role in disseminating information on CSA technologies and linking farmers to financial support schemes. Similarly, Adesina and Mwaura (2020) emphasized that limited contact with extension agents reduces farmers' capacity to access credit and implement climate-resilient practices.

**Table 1** Socio-Economic Characteristics of Respondents

| **Parameter** | **Frequency** | **Percentage** | **Mean/mode** |
|---|---|---|---|
| Gender | | | |
| Male | 61 | 29.0 | |
| Female | 149 | 71.0 | Female |
| Age | | | |
| Less than 20 Years | 11 | 5.2 | |
| 20-29 | 33 | 15.7 | |
| 30-39 | 59 | 28.1 | 39 |
| 40-49 | 73 | 34.8 | |
| 50-59 | 31 | 14.8 | |
| 60-69 | 3 | 1.4 | |
| Marital Status | | | |
| Single | 42 | 20.0 | |
| Married | 127 | 60.5 | Married |
| Widowed | 17 | 8.1 | |
| Divorce | 24 | 11.4 | |
| Household Size | | | |
| 1-3 | 69 | 32.9 | |
| 4-6 | 94 | 44.8 | 5 |
| 7-10 | 33 | 15.7 | |
| Above 10 | 14 | 6.6 | |
| Highest Educational Level attained | | | |
| No formal Education | 21 | 10.0 | |
| First School living certificate | 25 | 11.9 | |

| | | | |
|---|---|---|---|
| Junior Secondary School | 19 | 9.0 | |
| Senior Secondary School | 57 | 27.1 | Senior Secondary School |
| OND/NCE | 35 | 16.7 | |
| HND/B.Sc | 33 | 15.7 | |
| Post Graduate | 20 | 9.6 | |
| Farming experience | | | |
| Less than 10 years | 31 | 14.8 | |
| 11-20 years | 82 | 39.0 | 10 years |
| 21-30 years | 71 | 33.8 | |
| Above 30 years | 26 | 12.4 | |
| Contact with extension agent | | | |
| Weekly | 3 | 1.4 | |
| Monthly | 7 | 3.3 | |
| Quarterly | 17 | 8.1 | No contact |
| Yearly | 23 | 11.0 | |
| No contact | 160 | 76.2 | |

Source: Field Survey, (2025)

### 3.2. Climate-Smart Agriculture (CSA) Practices Adopted by Respondents

The results indicate varying levels of adoption of Climate-Smart Agriculture (CSA) practices among respondents. Intercropping cereals with legumes recorded the highest adoption rate, suggesting that farmers prefer low-cost, traditional practices that also improve soil fertility and reduce climate risk. This aligns with evidence that intercropping enhances resilience and productivity in smallholder systems. Mulching also showed high adoption, reflecting farmers' awareness of soil moisture conservation under increasing climate variability. The use of drought-tolerant and early-maturing seed varieties was moderately high, indicating responsiveness to changing rainfall patterns. However, drip irrigation recorded the lowest adoption, likely due to high installation costs and limited access to finance, a challenge widely reported in Nigeria (Ahmed, 2020). Overall, the findings highlight the influence of affordability and accessibility on CSA adoption.

**Table 2** Climate-Smart Agriculture (CSA) Practices Adopted by Respondents

| Climate-Smart Agriculture (CSA) practices | Yes n (%) | No n (%) | Rank Order |
|---|---|---|---|
| Drip irrigation/hydroponics | 72 (34.3) | 138 (65.7) | 5th |
| Use of drought-tolerant and early-maturing seed varieties | 148 (70.5) | 62 (29.5) | 3rd |
| Mulching to conserve soil moisture | 165 (78.6) | 45 (21.4) | 2nd |
| Intercropping cereals with legumes (e.g. maize–cowpea) | 182 (86.7) | 28 (13.3) | 1st |
| Application of organic manure and compost | 130 (61.9) | 80 (38.1) | 4th |

### 3.3. The Existing Financing Mechanisms for Climate Smart Agriculture

The findings reveal varied levels of access to financing mechanisms for Climate Smart Agriculture (CSA). The highest reported access was through Youth and Women in Agriculture Programmes such as N-Power Agro (91.9%), followed by commercial bank loans like Access Bank Green Finance (64.3%). Moderate access was reported for NIRSAL (27.6%), Anchor Borrowers' Programme (23.3%), and CBN Agricultural Credit Guarantee Scheme Fund (21.0%), while lower access was found for Green Alternative (17.6%), National Agricultural Development Fund (16.2%), agri-fintech platforms like FarmCrowdy and ThriveAgric (17.1%), and impact investment funds such as Sahel Capital (11.0%). Very low access was reported for the Ecological Fund (10.5%), private insurance schemes (10.0%), and development partner grants (8.6%).

This shows that most farmers depend on government social programmes and commercial loans, while uptake of institutional and innovative finance mechanisms remains weak. Limited access to formal agricultural credit often constrains farmers' ability to adopt CSA technologies (Makate et al., 2019). Studies highlight that access to tailored credit and insurance can significantly enhance CSA adoption and resilience to climate risks. However, farmers face barriers such as high collateral demands, bureaucratic bottlenecks, and low awareness of available schemes (Ali et al., 2020). Expanding access to blended financing models and risk-sharing platforms is therefore critical to scale CSA among smallholders.

**Table 3** Ranking of Financing Options for CSA in Delta State

| Financing mechanisms for Climate Smart Agriculture | Yes | % | No | % | Rank order |
|---|---|---|---|---|---|
| Anchor Borrowers' Programme (ABP) | 49 | 23.3 | 161 | 76.7 | 4th |
| NIRSAL (Nigeria Incentive-Based Risk Sharing System for Agricultural Lending) | 58 | 27.6 | 152 | 72.4 | 3rd |
| Green Alternative (Agriculture Promotion Policy) | 37 | 17.6 | 173 | 82.4 | 6th |
| CBN Agricultural Credit Guarantee Scheme Fund (ACGSF) | 44 | 21.0 | 166 | 79.0 | 5th |
| National Agricultural Development Fund (NAFAD) | 34 | 16.2 | 176 | 83.8 | 8th |
| Ecological Fund | 22 | 10.5 | 188 | 89.5 | 10th |
| Youth and Women in Agriculture Programmes (e.g., N-Power Agro) | 193 | 91.9 | 17 | 8.1 | 1st |
| Agri-Fintech Platforms (e.g., FarmCrowdy, ThriveAgric) | 36 | 17.1 | 174 | 82.9 | 7th |
| Commercial Bank Loans (e.g., Access Bank Green Finance) | 135 | 64.3 | 75 | 35.7 | 2nd |
| Impact Investment Funds (e.g., Sahel Capital) | 23 | 11.0 | 187 | 89.0 | 9th |
| Development Partner Grants and Loans | 18 | 8.6 | 192 | 91.4 | 12th |
| Private Insurance Schemes (Index-based Insurance) | 21 | 10.0 | 189 | 90.0 | 11th |

Source: Field Survey, (2025)

### 3.4. Effectiveness of Financing Sources in the adoption of CSA practices among farmers

The analysis shows that most financing mechanisms recorded mean values below the effectiveness threshold (mean = 2.5), indicating limited support for the adoption of Climate Smart Agriculture (CSA) among smallholder farmers. For instance, Anchor Borrowers' Programme had a low mean (mean = 2.2), similar to NIRSAL (mean = 2.12), Green Alternative (mean = 2.11), and CBN Agricultural Credit Guarantee Scheme Fund (mean = 1.92). This suggests these schemes are not effectively driving CSA uptake, aligning with findings that bureaucratic procedures and limited outreach hinder smallholder access (Abioye et al., 2021). Likewise, National Agricultural Development Fund (mean = 1.97), Ecological Fund (mean = 1.78), and Agri-Fintech platforms (mean = 1.93) also demonstrated low effectiveness, reflecting challenges of inadequate funding and risk perception (Oladipo et al., 2022).

Conversely, two mechanisms showed high effectiveness: Youth and Women in Agriculture Programmes (mean = 3.08) and commercial bank loans (mean = 3.00). Their effectiveness may stem from targeted youth/women engagement and structured credit systems, which have been shown to improve CSA adoption rates (Akinola & Adekunle, 2020). Development partner grants (mean = 2.17) and impact investment funds (mean = 2.03) were also ineffective, echoing reports of inconsistent disbursement and limited farmer awareness (Eze et al., 2023). Overall, these results imply that while most public and donor-driven schemes are underperforming, gender-focused programs and commercial loans appear more impactful in fostering CSA practices among smallholders. Commercial bank loans are the most effective because they offer more reliable access, faster processing, and structured credit systems tailored to farmers' needs. Unlike bureaucratic government schemes, commercial loans provide predictable funding, clearer eligibility requirements, and stronger monitoring, which enhances timely adoption of CSA practices. Their flexibility and accessibility make them more impactful for smallholders.

**Table 4** Effectiveness of Financing Sources in the adoption of CSA practices among farmers

| Financing mechanisms for Climate Smart Agriculture | Not Very Effective | Not Effective | Effective | Very Effective | Mean | Rank order | Remark |
|---|---|---|---|---|---|---|---|
| Anchor Borrowers' Programme (ABP) | 78(37.1) | 55(26.2) | 42(20) | 35(16.7) | 2.2 | 3rd | Not effective |
| NIRSAL (Nigeria Incentive-Based Risk Sharing System for Agricultural Lending) | 69(32.9) | 77(36.7) | 33(15.7) | 31(14.8) | 2.12 | 5th | Not effective |
| Green Alternative (Agriculture Promotion Policy) | 81(38.6) | 63(30.0) | 27(12.9) | 39(18.6) | 2.11 | 6th | Not effective |
| CBN Agricultural Credit Guarantee Scheme Fund (ACGSF) | 90(42.9) | 66(31.4) | 34(16.2) | 20(9.5) | 1.92 | 10th | Not effective |
| National Agricultural Development Fund (NAFAD) | 83(39.5) | 74(35.2) | 29(13.8) | 24(11.4) | 1.97 | 9th | Not effective |
| Ecological Fund | 94(44.8) | 81(38.6) | 23(11.0) | 12(5.7) | 1.78 | 11th | Not effective |
| Youth and Women in Agriculture Programmes (e.g., N-Power Agro) | 22(10.5) | 27(12.9) | 74(35.2) | 87(41.4) | 3.08 | 1st | Effective |
| Agri-Fintech Platforms (e.g., Farm Crowdy, Thrive Agric) | 77(36.7) | 89(42.4) | 26(12.4) | 18(8.6) | 1.93 | 8th | Not effective |
| Commercial Bank Loans | 30(14.3) | 26(12.4) | 68(32.4) | 86(41.1) | 3.00 | 2nd | Effective |
| Impact Investment Funds (e.g., Sahel Capital) | 73(34.8) | 79(37.6) | 36(17.1) | 22(10.5) | 2.03 | 7th | Not effective |
| Development Partner Grants and Loans | 77(36.7) | 56(26.7) | 41(19.5) | 36(17.1) | 2.17 | 4th | Not effective |
| Private Insurance Schemes (Index-based Insurance) | 89(42.4) | 67(32.0) | 33(15.7) | 21(10.0 | 1.93 | 8th | Not effective |

Source: Field Survey, (2025). Note: Means≥2.5 is effective, means ≤ 2.5 not effective

### 3.5. Binary Logistic Regression showing the relationship between the socio-economic characteristics and their adoption of Climate-Smart Agriculture (CSA) practices

**The** binary logistic regression showing the relationship between the socio-economic characteristics and their adoption of Climate-Smart Agriculture (CSA) practices is presented in Table 5.

#### *3.5.1. Age*

The regression results shows that age has a negative and non-significant relationship with Climate Smart Agriculture (CSA) adoption (B = -0.568; p = 0.055). This indicates that older farmers are less likely to adopt CSA practices, although the effect is not statistically significant. Older farmers are often more conservative and less willing to take risks with unfamiliar technologies, while younger farmers are generally more open to innovation. Wainaina et al. (2022) observed that younger farmers adopt CSA more due to their higher risk tolerance and longer planning horizons. Similarly, Akinyemi et al. (2020) found that age negatively influences adoption of climate-smart innovations because older farmers tend to rely on traditional farming practices.

#### *3.5.2. Education*

Education has a positive and significant influence on CSA adoption (B = 0.629; p = 0.017). This suggests that farmers with higher educational attainment are more likely to adopt CSA practices. Education enhances farmers' ability to access information, comprehend climate risks, and apply innovative technologies. Educated farmers are also more likely to attend training and use extension services, thereby improving their adaptive capacity. According to Ogisi and Begho (2023), education improves farmers' decision-making skills and their willingness to try new technologies. Similarly, Nnadi and Ezudike (2020) reported that education strongly predicts the adoption of agricultural innovations among Nigerian farmers.

#### *3.5.3. Gender*

Gender shows a negative and non-significant relationship with CSA adoption (B = -0.050; p = 0.797). This suggests that gender does not significantly influence farmers' decision to adopt CSA practices in the study area. Both male and female farmers appear to have relatively similar opportunities and constraints regarding CSA uptake. This aligns with the findings of Kemeze et al. (2020), who reported that gender was not a strong predictor of climate-smart practice adoption when both genders had similar access to productive resources. Likewise, Wainaina et al. (2022) found that gender differences become insignificant when controlling for access to credit, education, and extension services.

#### *3.5.4. Marital Status*

Marital status is negatively associated with CSA adoption but not significant (B = -0.309; p = 0.271). This implies that marital status does not substantially influence farmers' decisions to adopt CSA practices. Married and unmarried farmers appear to make similar adoption choices, likely driven more by access to resources than by household status. According to Akinyemi et al. (2020), marital status often shows weak or no statistical association with innovation adoption among farmers. Similarly, Wainaina et al. (2022) found that family composition and marital status have minimal influence when other socio-economic factors such as education and credit access are considered.

#### *3.5.5. Farm Experience*

Farm experience shows a positive and significant effect on CSA adoption (B = 0.850; p = 0.007). This suggests that farmers with more years of farming experience are more likely to adopt CSA practices. Experienced farmers may have better technical knowledge, understand the impacts of climate change, and be more willing to experiment with adaptive practices. Adebayo et al. (2021) found that longer farming experience enhances the adoption of sustainable practices. Similarly, Wainaina et al. (2022) reported that experienced farmers are more aware of climate variability and are better positioned to implement resilience-building strategies.

#### *3.5.6. Household Size*

Household size has a negative and non-significant association with CSA adoption (B = -0.116; p = 0.732). This indicates that the number of people in a household does not significantly influence CSA uptake. Larger households might provide more farm labour but could also face resource constraints, while smaller households may be more flexible in decision-making. Akinyemi et al. (2020) found that household size did not significantly predict CSA adoption in Nigeria. Likewise, Nnadi and Ezudike (2020) noted that household size has mixed effects, as larger households can either facilitate or constrain technology adoption depending on their income levels.

#### *3.5.7. Contact with Extension Agent*

Contact with extension agents has a negative and non-significant effect on CSA adoption (B = -0.177; p = 0.566). This suggests that access to extension services did not significantly influence CSA adoption among the farmers. This could be due to limited frequency, quality, or relevance of extension advice provided. According to Adebayo et al. (2021), the effectiveness of extension in promoting CSA depends on the quality and consistency of services. Similarly, Wainaina et al. (2022) reported that sporadic or inadequate extension contact limits farmers' ability to adopt climate-resilient technologies.

#### *3.5.8. Access to Credit*

Access to credit shows a positive and significant effect on CSA adoption (B = 0.604; p = 0.033). This implies that farmers who have access to credit are more likely to adopt CSA practices. Credit improves farmers' ability to purchase inputs, invest in improved technologies, and bear the risks associated with innovation. Adeagbo et al. (2022) found that access to finance is a key driver of CSA adoption among smallholders. Similarly, Wainaina et al. (2022) reported that credit access enhances smallholders' adaptive capacity by reducing financial barriers to technology adoption.

**Table 5** Binary Logistic Regression showing the relationship between the socio-economic characteristics and their adoption of Climate-Smart Agriculture (CSA) practices

| | | B | S.E. | Wald | Sig. | Exp(B) | 95% C.I.for EXP(B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| | Age | -.568 | .296 | 3.676 | .055 | .567 | .317 | 1.013 |
| | Education status | .629 | .263 | 5.728 | .017* | 1.875 | 1.121 | 3.137 |
| | Sex | -.050 | .194 | .066 | .797 | .951 | .650 | 1.392 |
| | Marital status | -.309 | .281 | 1.212 | .271 | .734 | .424 | 1.273 |
| | Farm experience | .850 | .314 | 7.336 | .007** | 2.340 | 1.265 | 4.329 |
| | Household size | -.116 | .340 | .117 | .732 | .890 | .457 | 1.732 |
| | Contact with extension agent | -.177 | .309 | .329 | .566 | .838 | .457 | 1.534 |
| | Access to credit | .604 | .283 | 4.542 | .033* | 1.830 | 1.050 | 3.189 |
| | Constant | -3.170 | 1.475 | 4.621 | .032* | .042 | | |

Source: field survey data, 2025

### 3.6. Challenges facing farmers and other stakeholders for innovative financing mechanisms that can support the adoption of Climate Smart Agriculture (CSA) practices

The results reveal that several challenges are considered severe (mean > 2.5) in hindering innovative financing for CSA adoption among farmers. High collateral requirements ranked as the most severe barrier (mean = 3.17), reflecting how stringent loan conditions limit smallholders' access to credit a finding consistent with Food and Agriculture Organization reports highlighting collateral as a key obstacle to agricultural financing (FAO, 2021). Similarly, high interest rates and short repayment periods (mean = 2.91), limited access to climate risk insurance (mean = 2.84), and high transaction costs (mean = 2.81) were severe challenges, aligning with Adeagbo et al. (2022), who noted that these financial constraints discourage smallholder engagement with climate-resilient investments.

Other severe challenges included inconsistent or delayed government support (mean = 3.04), weak policy and regulatory framework (mean = 2.64), currency and inflation risks (mean = 2.80), low financial literacy (mean = 2.67), and limited awareness and understanding of CSA (mean = 2.63). These results support assertions by Ojo and Akinola (2023) that policy instability, low knowledge levels, and macroeconomic volatility undermine innovative financing uptake. Only poor credit history or no bank accounts (mean = 2.49) was not a severe challenge, suggesting some progress in financial inclusion initiatives. Overall, these findings indicate that institutional, financial, and knowledge-related barriers significantly impede the effective financing of CSA, necessitating comprehensive policy reforms, financial literacy training, and insurance-based risk mitigation to improve smallholder participation.

**Table 6** Challenges facing farmers and other stakeholders for innovative financing mechanisms that can support the adoption of Climate Smart Agriculture (CSA) practices

| Challenges | Not very severe | Not severe | Severe | Very severe | Mean | Rank order | Remark |
|---|---|---|---|---|---|---|---|
| Limited Awareness and Understanding of CSA | 35(16.7) | 41(19.5) | 68(32.4) | 66(31.4) | 2.63 | 9th | Severe |
| Low Financial Literacy | 43(20.5) | 47(22.4) | 56(26.7) | 64(30.5) | 2.67 | 7th | Severe |
| High Collateral Requirements | 19(9.0) | 23(11.0) | 72(34.3) | 96(45.7) | 3.17 | 1st | Severe |
| Poor Credit History or No Bank Accounts | 49(23.3) | 51(24.3) | 69(32.9) | 41(19.5) | 2.49 | 10th | Not Severe |
| Limited Access to Climate Risk Insurance | 36(17.1) | 33(15.7) | 70(33.3) | 71(33.8) | 2.84 | 3rd | Severe |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| High Transaction Costs | 39(18.6) | 34(16.2) | 65(31.0) | 72(34.3) | 2.81 | 4th | Severe |
| Inconsistent or Delayed Government Support | 24(11.4) | 35(16.7) | 59(28.1) | 92(43.8) | 3.04 | 2nd | Severe |
| Weak Policy and Regulatory Framework | 38(18.1) | 53(25.3) | 66(31.4) | 53(25.2) | 2.64 | 8th | Severe |
| Currency and Inflation Risks | 34(16.2) | 40(19.0) | 69(32.9) | 67(31.9) | 2.80 | 6th | Severe |
| High interest rate and short repayment period | 42(20.0) | 46(21.9) | 57(27.1) | 64(30.9) | 2.91 | 5th | Severe |
| Low Offtakers | 50(23.8) | 51(24.3) | 69(32.9) | 40(19.0) | 2.49 | 11th | Not Severe |

Source: Field Survey, (2025). Note: Means≥2.5 is severe, means ≤ 2.5 not severe

## 4. Conclusion

This study examined the financing mechanisms influencing the adoption of Climate-Smart Agriculture (CSA) among farmers in Delta State, Nigeria highlighting key socio-economic characteristics, access to finance, and institutional factors. Findings revealed that most farmers were female, small-scale operators cultivating less than 3 hectares, with moderate education and farming experience. Despite their engagement in agriculture, access to formal financing mechanisms remained limited, with the majority relying on personal savings, cooperatives, and leasing land. Existing CSA financing schemes such as NIRSAL, Anchor Borrowers' Programme, and CBN Agricultural Credit Guarantee Scheme Fund demonstrated low effectiveness, often hindered by bureaucratic procedures, high collateral demands, and inadequate outreach.

Furthermore, innovative financing mechanisms like results-based financing, blended public-private investments, and digital CSA input vouchers received only moderate support, while digital finance and insurance tools were met with skepticism due to low trust and awareness. Regression analysis confirmed that education, farming experience, and access to credit significantly enhance CSA adoption, while financial mechanisms overall positively influence uptake.

### *Recommendations*

Based on the findings of this study several actionable recommendations are proposed to enhance CSA adoption and sustainability:

- Improve Access to Affordable Credit: Financial institutions such as NIRSAL, Anchor Borrowers' Programme, and CBN Agricultural Credit Guarantee Scheme Fund should lower collateral requirements, reduce interest rates, and extend repayment periods to make credit accessible to smallholders.
- Promote Financial Literacy and CSA Awareness: Government agencies and extension services should organize regular training to build farmers' understanding of CSA practices, financial management, and available funding opportunities, thereby enhancing their capacity to access and utilize credit effectively.
- Strengthen Cooperative Societies: Farmers should be encouraged to join cooperatives to pool resources, access group loans, and improve their bargaining power in obtaining CSA financing.
- Implement Blended and Results-Based Financing: Public-private partnerships should be promoted to de-risk CSA investments, while funds should be disbursed based on measurable CSA outcomes to ensure accountability and impact.
- Leverage Digital Finance Platforms: Agri-fintech platforms should be expanded with trust-building initiatives and local language interfaces to improve farmer participation in digital credit, insurance, and input support schemes.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

*Statement of informed consent*

"Informed consent was obtained from all individual participants included in the study."

## References


[1] Abegunde, V. O., & Adebayo, A. A. (2020). Socioeconomic determinants of farmers' access to agricultural credit in Nigeria. Scientific African, 9, e00507.

[2] Abioye, O. E., Adegbite, O. O., & Adeniran, A. O. (2021). Agricultural credit access and climate-smart agriculture adoption in Nigeria. Journal of Agricultural Finance and Development, 11(2), 45–58.

[3] Adams, A., Adaji, A., & Adesope, O. M. (2019). Climate change impacts on agriculture: Evidence from selected Local Government Areas in Kebbi State, Nigeria. International Journal of Environmental Science and Technology, 16(4), 1765-1776.

[4] Adeagbo, M. O., Adebayo, O. O., & Lawal, A. I. (2022). Financial barriers to climate-smart agriculture adoption among smallholder farmers in Nigeria. Journal of Sustainable Finance & Investment, 12(4), 1056–1072.

[5] Adebayo, O. O., Lawal, A. I., & Adeagbo, M. O. (2021). Education and adoption of climate-smart agriculture practices among smallholder farmers. Environment, Development and Sustainability, 23(6), 8791–8808.

[6] Adesina, J. B., & Mwaura, F. (2020). Role of extension services in promoting climate-smart agriculture among smallholder farmers. Climate and Development, 12(7), 617–625.

[7] Ahmed, H. (2020). Determinants of access to credit among smallholder farmers in Kebbi State, Nigeria. CBN Journal of Applied Statistics, 11(1), 113-134.

[8] Akinola, A. O., & Adekunle, I. A. (2020). Youth-inclusive financing and adoption of climate-smart agriculture in Sub-Saharan Africa. Environment, Development and Sustainability, 22(7), 6341–6357.

[9] Akinyemi, B. E., Afolami, C. A., & Adeoti, A. I. (2022). Socioeconomic factors influencing the adoption of climate-smart agricultural practices among smallholder farmers in Nigeria. Scientific African, 15, e01022.

[10] Akinyemi, O., Oyekale, A. S., & Adebayo, O. O. (2020). Determinants of adoption of climate-smart agricultural practices among smallholder farmers in Nigeria. Climate and Development, 12(8), 728–737.

[11] Ali, A., Abdulai, A., & Goetz, R. (2020). Credit access and climate-resilient farming. Agricultural Finance Review, 80(5), 677–692.

[12] Ali, A., Abdulai, A., & Mishra, A. (2021). The adoption of climate-smart agricultural practices: The role of farming experience and risk attitudes. Technological Forecasting and Social Change, 167, 120734.

[13] Aliero, B. L., & Ekaette, G. B. (2018). Agriculture and food security in Kebbi State, Nigeria. International Journal of Scientific z, 8(9), 152-156.

[14] Ayanlade, A., & Radeny, M. (2020). Climate-smart agriculture in Africa: A review of strategies and impacts. Climate and Development, 12(8), 629–639.

[15] Bamire, A. S., Oyesola, O. B., & Adeniyi, A. (2021). Extension services and climate-smart agriculture adoption among smallholder farmers in Nigeria. Journal of Agricultural Extension, 25(3), 45–58.

[16] Bose, M., Abdullah, A., Kasim, I., Harun, R., Mande, K., & Abdullahi, A. (2015). Rainfall Trend Detection in Northern Nigeria over the Period of 1970-2012. Journal of Environment and Earth Science.

[17] Central Bank of Nigeria (CBN). (2015). Anchor Borrowers' Programme. Available at.

[18] Central Bank of Nigeria (CBN). (2021). 2021 Central Bank of Nigeria Statistical Bulletin.

[19] Eze, C. I., Okoye, C. U., & Nwafor, F. C. (2023). Institutional financing constraints and climate-smart agriculture adoption among smallholder farmers. Sustainability, 15(4), 3321.

[20] Food and Agriculture Organization (FAO). (2015) Climate Change and Food Security: Risks and Responses. Food And Agriculture Organization Of The United Nations; Rome, Italy:.

[21] Food and Agriculture Organization (FAO). (2021). The state of food and agriculture 2021: Making agrifood systems more resilient to shocks and stresses. Rome: FAO.

[22] Intergovernmental Panel on Climate Change (IPCC). (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the IPCC. Geneva: IPCC.

[23] Kemeze, F. H., Degrande, A., & Tchoundjeu, Z. (2020). Gender and the adoption of climate-smart agriculture: Evidence from Cameroon. Climate and Development, 12(9), 792–802.

[24] Makate, C., Makate, M., & Mango, N. (2019). Farm credit and climate-smart agriculture adoption. Technological Forecasting and Social Change, 146, 616–623.

[25] Nnadi, F. N., & Akwiwu, C. D. (2020). Influence of farmers' educational level on agricultural innovation adoption in Nigeria. Journal of Agricultural Extension, 23(4), 14–24.

[26] North, D. C. (1990). Institutions, Institutional Change and Economic Performance. Cambridge: Cambridge University Press.

[27] Nwankwo, C. S., Okoro, E. M., & Eze, C. C. (2021). Socio-economic factors influencing adoption of climate-smart agriculture practices by smallholder farmers in Nigeria. Environment, Development and Sustainability, 23(5), 7070–7087.

[28] Ogisi, O.D., Begho, T., (2023). Adoption of climate-smart agricultural practices in sub-Saharan Africa: a review of the progress, barriers, gender differences and recommendations. Farming Syst. 1, 100019 https://doi.org/10.1016/j. farsys.2023.100019.

[29] Ogunleye, A. S., & Adeyemi, O. A. (2020). Socioeconomic determinants of climate-smart agricultural practices among smallholder farmers in Nigeria. Journal of Agricultural Extension, 24(3), 45–56.

[30] Ogunleye, A. S., Adebayo, O. O., & Yusuf, T. (2021). Credit access and adoption of climate-smart agriculture in Nigeria. African Journal of Agricultural Economics, 9(1), 45–56.

[31] Ojo, T. O., & Akinbode, S. O. (2020). Determinants of climate change adaptation strategies among farming households in Nigeria. Climate and Development, 12(8), 689–697.

[32] Ojo, T. O., & Akinola, A. O. (2023). Policy and institutional constraints to climate-smart agriculture financing in Sub-Saharan Africa. Environmental Economics and Policy Studies, 25(1), 143–162.

[33] Ojo, T. O., & Baiyegunhi, L. J. S. (2021). Determinants of climate change adaptation strategies and their impact on productivity of smallholder farmers in Nigeria. Land Use Policy, 99, 105120.

[34] Oladimeji, Y. U., & Abdulsalam, Z. (2020). Socioeconomic determinants of climate-smart agriculture practices among smallholder farmers in Nigeria. Journal of Agricultural Extension, 24(4), 51–63.

[35] Oladipo, F., Adeoye, A., & Yusuf, T. (2022). Cooperative membership and farmers' access to credit in Nigeria. Journal of Agricultural Finance, 12(2), 88–97.

[36] Samuelson, P. A. (1954). The Pure Theory of Public Expenditure. Review of Economics and Statistics, 36(4), 387-389.

[37] Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics, 70(1), 65-94.

[38] United States Environmental Protection Agency (EPA). (2022) Climate Change Indicators: Seasonal Temperature. United States Environmental Protection Agency; Washington, DC, USA:. https://www.epa.gov/climate-indicators/climate-change-indicators-seasonal-temperature

[39] Wainaina, P. N., Mwangi, M., & Mutua, J. (2022). Socioeconomic determinants of climate-smart agriculture adoption among smallholder farmers. Journal of Agricultural Extension and Rural Development, 14(3), 132–141.

[40] Yelwa, M. A. (2019). Climate change and agricultural productivity in Kebbi State, Nigeria: Implications for food security. In Proceedings of the International Conference on Sustainable Development (Vol. 2, No. 1, pp. 29-34).