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Climate-Smart Agriculture and Food Security: Role of Agricultural Extension Services in Adamawa State, Nigeria

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Abstract*—The paper examined the role of agricultural extension services in promoting the adoption of climate-smart agriculture (CSA) practices and food security in Adamawa State, Nigeria. The broad objective is to assess the role of agricultural extension services in facilitating CSA adoption in Adamawa state, while the specific objectives were to evaluate the impact of CSA practices on household food security and to ascertain the impact of CSA adoption on household food availability, accessibility and stability. A multi-stage sampling procedure was adopted using structured questionnaires to collect data from a sample of 210 respondents comprising 162 farmers and 48 extension agents. Descriptive statistics was employed to analyze the objectives of the study. The results showed that 60.49% of the respondents were within the age range of 30-50 years with majority (75.93%) males respondents and had one form of education or another with 32.09% secondary education. The results also revealed that 75% of farmers had adopted at least one CSA practice, with improved crop varieties (55.56%) and conservation agriculture (51.86%) being the most widely adopted. Extension services played a critical role, with 68% of farmers attributing their knowledge of CSA to extension agents. CSA practices were found to significantly improve food availability and stability, although adoption gaps remained for practices like rainwater harvesting. The study concluded that agricultural extension services are pivotal in scaling CSA practices and addressing food insecurity in Adamawa State. However, challenges Insufficient knowledge of CSA practice (95.06%), Cost of labour (79.63%), Inadequate extension services (88.89%) and Lack of policy support (90.12%) among others. The study therefore recommended that policymakers enhance extension systems, promote CSA awareness campaigns, and provision of resource support for farmers.

***Keywords:* Climate-Smart Agriculture (CSA), Food Security, Agricultural Extension Services, Adamawa State, Nigeria**

I. INTRODUCTION

Climate change poses significant challenges to global agricultural systems, particularly in developing countries like Nigeria. Increasing temperatures, erratic rainfall patterns, and extreme weather events have disrupted agricultural productivity, threatening food security and rural livelihoods (Prosekov and Ivanova, 2018). In Nigeria, agriculture is a key sector, employing a majority of the rural population, yet it remains highly vulnerable to the adverse impacts of climate change (Wudil *et al*., 2022). Climate-smart agriculture (CSA) has emerged as a transformative approach to mitigate these challenges by integrating practices that enhance productivity, resilience, and sustainability. However, the success of CSA heavily relies on effective agricultural extension services, which serve as the primary channels for disseminating knowledge and supporting farmers in adopting innovative practices (Saito, 2021). In Adamawa State, the interplay of climate variability and socio-economic factors has heightened concerns about food security. Despite the region's agricultural potential, persistent issues such as land degradation, inadequate farming practices, and limited access to CSA technologies hinder agricultural productivity (Giller, 2020). Agricultural extension services play a critical role in bridging these gaps by promoting CSA adoption and fostering sustainable agricultural development (Viana *et al*., 2021). Agricultural land systems are fundamental to supporting food security and achieving sustainable development goals. Studies highlight the role of sustainable land management in ensuring consistent food production, especially in regions vulnerable to climatic extreme (Viana *et al.,* 2021). In Sub-Saharan Africa, including Nigeria, food security remains precarious due to a combination of poor agricultural productivity, environmental degradation, and inadequate infrastructure (Wudil *et al.,* 2022). In Adamawa State, the unique interplay of climate variability and socio-economic constraints further exacerbates the challenge. CSA offers promising solutions by promoting sustainable practices such as agroforestry, soil conservation, and water

management, which can enhance productivity while preserving ecological balance (Giller, 2020). Adamawa State faces a pressing challenge of low CSA adoption, exacerbated by climate variability, insufficient extension services, and limited awareness among farmers. These issues contribute to poor agricultural yields, heightened vulnerability to food insecurity, and reduced household incomes. While CSA offers a pathway to address these challenges, its adoption remains suboptimal due to barriers such as resource constraints, lack of technical knowledge, and weak institutional support (Carthy *et al.*, 2018). The need to strengthen agricultural extension systems and tailor CSA interventions to the specific context of Adamawa State is therefore critical for achieving food security. Food security is a critical global challenge, defined as the availability, accessibility, and utilization of sufficient food for an active and healthy life. This concept has become increasingly complex in the face of climate change, population growth, and resource depletion (Prosekov & Ivanova, 2018). Addressing food security requires multi-faceted approaches that integrate sustainable agricultural practices with technological innovations (Carthy *et al.,* 2018). Climate-smart agriculture (CSA) has emerged as a key strategy to tackle these challenges by enhancing agricultural productivity, increasing resilience to climate change, and reducing greenhouse gas emissions (Giller, 2020). Effective adoption of CSA practices often depends on robust agricultural extension services, which act as conduits for disseminating information and providing technical support to farmers (Saito, 2021).

This broad objective was to assess the role of agricultural extension services in promoting the adoption of CSA practices and food security among farmers in Adamawa State, Nigeria. The specific objectives were to evaluate the impact of CSA practices on household food security in the study area, ascertain the impact of CSA adoption on household food availability, accessibility and stability. and identify the challenges face by farmers in adopting the CSA practices in the study area.

II. METHODOLOGY

The study Area

The study was conducted in Adamawa State, Northeastern Nigeria. The state was carved out of Gongola state in 1991 becoming one of the 36 states of Nigeria. Adamawa state is characterized by a tropical climate with distinct wet and dry seasons, making it vulnerable to climate variability. The area is located between latitude 8^{o} 45^{I} and $9^{o}35^{I}$ North of the equator and longitude $12^{0}15^{I}$ and $13^{0}15^{I}$ East of the Greenwich meridian and the estimated land area of 39, 940 km^2. The state has a total population of 3,172.950 million in 2006 with the projected population of 5.6 million in 2025 (NPC, 2006). The state's economy is largely agrarian with farming being the primary livelihood for a significant portion of the population. A descriptive survey research design was adopted to examine the role of agricultural extension services in the adoption of Climate-Smart Agriculture (CSA) and its impact on food security. The study targeted farmers and extension agents, selecting a sample of 210 respondents, including 162 farmers and 48 extension agents through a multistage sampling technique. Data were collected using structured questionnaires designed to capture demographic characteristics, the extent of CSA adoption, and the influence of extension services on farmers' decisions. Statistical analyses, including descriptive and inferential methods were conducted using SPSS version 27 to interpret the results. These analyses helped to assess the relationship between extension services, CSA adoption, and food security outcomes in Adamawa State. Despite the growing body of literature on CSA and food security, significant gaps remain, particularly in the context of Adamawa State. There is limited empirical evidence on the effectiveness of CSA practices in addressing region-specific challenges such as erratic rainfall and land degradation. Furthermore, the role of agricultural extension services in facilitating CSA adoption in this region has not been adequately explored. This study seeks to fill these gaps by assessing the impact of CSA practices on food security in Adamawa State, with a focus on the mediating role of agricultural extension services.

III. RESULTS AND DISCUSSION

Table 1: Demographic Characteristics of the Respondents

Variables	Farmers (N=162)	Extension Agents (N=48)	Total (N = 210)
Age (Years)			
Below 30	36(22.22%)	10(6.17%)	46(21.90%)

30–50	98(60.49%)	28(17.28%)	126 (60.00%)
Above 50	28(17.28%)	10(6.17%)	38(18.10%)
Sex			
Male	123(75.93%)	32(19.75%)	155(95.68%)
Female	39(24.07%)	16(9.88%)	55(33.95%)
Education			
Primary	72(44.44%)	4(2.47%)	76(37.14%)
Secondary	52(32.09%)	20(12.35%)	72(34.29%)
Tertiary	38(23.46%)	24(14.81%)	62(38.27%)
Farm Size (Ha)			
Less than 1 Ha	68(41.97%)	-	68(41.97%)
1–3 Ha	74(45.68%)	-	74(45.68%)
More than 3 Ha	20(12.34%)	-	20(12.35%)
Experience (Years)			
Less than 5	48(29.6%)	10(6.17%)	58(27.62%)
6–10	60(37.04%)	17(13.58%)	77(36.67%)
11- 15	36(22.22%)	13(6.24%)	56(26.66%)
16 and above	18(11.11%)	8(3.84%%)	19(9.05%)
Total	162	48	100

Source: Field Survey (2025)

The results showed that majority (60.49%) of the respondents were within the age bracket of 30- 50 years with majority (75.93%) males respondents and had one form of education or another with (32.09%) secondary education. The findings further revealed that about (45.68%) of the respondents had 1-3 hectares of land with (37.04%) had a farming experience between 6-10 years' experience. This result is in consonance with the findings of Arikimi (2014) who reported that majority of rice farmers were within the age category of 31-50 years in Ebonyi State of Nigeria.

Table 2: Distribution of Respondents Based on the Types of CSA Practices Adopted

CSA Practice	Frequency	Percentage (%)
Conservation agriculture	84	51.85%
Agroforestry	72	44.44%
Improved crop varieties	90	55.56%
Integrated pest management	68	41.98%
Rainwater harvesting	62	38.27%

Source: Field Survey (2025)

***Multiple responses were recorded

The result from Table 2 showed that improved crop varieties (55.6%) and conservation agriculture (51.9%) were the most widely adopted CSA practices. However, rainwater harvesting remained underutilized despite its potential benefits for drought mitigation. Effective adoption of CSA practices often depends on robust agricultural extension services, which act as conduits for disseminating information and providing technical support to farmers (Saito, 2021).

Table 3: Role of Extension Agents in CSA Adoption Dissemination

Extension Role	Frequency	Percentage (%)
Organizing training sessions	54	33.33%
Demonstrating CSA techniques	31	19.14%
Providing advisory services	40	24.69%
Distributing CSA inputs	37	22.84%
Total	162	100

Source: Field Survey (2025)

Among the CSA practices adopted, improved crop varieties and conservation agriculture stood out as particularly impactful. The adoption of drought-resistant and early-maturing crop varieties has been widely acknowledged as an effective strategy for mitigating climate risks while maintaining high yields (Giller, 2020). Similarly, conservation agriculture—characterized by minimal soil disturbance, crop rotation, and organic soil cover-has been shown to enhance soil fertility, improve moisture retention, and boost overall farm productivity (Viana *et al.*, 2021). The results from Table 3 revealed that 33.33% of the extension agents were involved in organizing a training sessions and awareness campaign to the respondents on how to adopt the CSA practices on food security. The results further indicated that 24.69% extension agents were involved in providing advisory services to the respondents then followed by distributing CSA inputs with 22.84% and finally demonstrating CSA techniques with 19.14%. This results aligns with previous research finding of (Prosekov and Ivanova, 2018). who reported that access to extension services significantly influences farmers' ability to adopt sustainable farming methods that enhance productivity and resilience to climate change.

Table 4: Impact of CSA Adoption on Food Availability, Accessibility and Stability

Food Security Aspect	Improved	No Change	Worsened
Food Availability	118(72.84%)	36(22.22%)	8(4.94%)
Food Accessibility	112(69.1%)	40(24.7%)	10(6.17%)
Food Stability	104(64.18%)	48(29.63%)	10(6.17%)

Source: Field Survey (2025)

Results from Table 4 indicated that CSA adoption significantly improved food availability with (72.84%) and food accessibility with (69.18%). However, minority of respondents reported no change or worsened outcomes, possibly due to implementation barriers or external factors like market access. This findings is in contrast with the broader literature, which underscores the role of sustainable land management in strengthening agricultural resilience and food security (Allee *et al,* 2021).

Table 5: Distribution of Respondents Based on Challenges Faced in Adopting CSA Practices

Challenges	Frequency	Percentage (%)
Limited access to credit	137	84.57%
High quality seeds	102	62.96%
Insufficient knowledge of CSA practice	154	95.06%
Cost of labour	129	79.63%
Inadequate extension services	118	72.84%
Lack of policy support	146	90.12%
Land tenure system	133	82.10%
Emergence of pest and diseases	117	72.22%

Sources: Field Survey (2025)

***Multiple Reponses were recorded

Results from Table 5 shows the challenges faced by the respondents in adopting the CSA practices in the study area. It is revealed that most (95.06%) of the respondents compliant on insufficient knowledge of CSA practices, lack of policy support (90.12%), limited access (84.57%), land tenure system (82.10%), cost of labour (79.63%), inadequate extension services (72.84%) and finally emergence of pests and diseases (72.22%) as the least challenge found in the study area. The study reaffirms that strengthening extension systems and addressing key implementation barriers are essential for sustaining the benefits of CSA in Adamawa State. By expanding extension outreach, improving farmer training, and ensuring access to CSA-related resources, the long-term impact on food security can be significantly enhanced (Saito, 2021; Wudil *et al*., 2022).

IV. CONCLUSION AND RECOMMENDATIONS

This study examined the role of agricultural extension services in promoting the adoption of

climate-smart agricultural (CSA) practices and their subsequent impact on food security in Adamawa State, Nigeria. The findings revealed that CSA practices, such as improved crop varieties and conservation agriculture, were widely adopted, with significant contributions from extension agents through training, advisory services, and demonstrations. The adoption of CSA practices positively influenced household food availability, accessibility, and stability, demonstrating their potential to address food security challenges in the context of climate change variability. However, despite the positive impacts of CSA adoption on food security Adamawa State, major challenges faced by farmers were lack of policy support (90.12%), limited access (84.57%), land tenure system (82.10%), cost of labour (79.63%), inadequate extension services among others. Finally, the gaps remain in the distribution of CSA inputs and the adoption of practices like rainwater harvesting. These challenges highlight the need for strengthened extension systems and targeted interventions to enhance CSA adoption and ensure sustainable food security outcomes in the region.

RECOMMENDATIONS

i. Increase the capacity of extension agents through regular training on advanced CSA techniques.
ii. Provide financial and material support to enable farmers to access critical CSA inputs such as improved seeds, fertilizers, and water management tools.
iii. Develop community-based input distribution systems to reduce logistical barriers.
iv. Conduct awareness campaigns to promote the benefits of rainwater harvesting as a climate adaptation strategy.
v. Provide subsidies or incentives for farmers to adopt water harvesting technologies.
vi. Advocate for policies that prioritize climate-smart agriculture in national and state-level agricultural development plans.
vii. Collaborate with development partners to mobilize funding and technical assistance for CSA initiatives.
viii. Incorporate digital platforms for CSA knowledge dissemination, including mobile apps and SMS-based advisory services.
ix. Investigate barriers to the adoption of underutilized CSA practices, such as integrated pest management and rainwater harvesting.

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