



**ADOPTION OF CLIMATE-SMART AGRICULTURAL PRACTICES AMONG  
RICE FARMERS IN BOGORO AND DASS LOCAL GOVERNMENT AREAS OF  
BAUCHI STATE, NIGERIA**

**Sunday, G., Babaji, A. U. and Bala, A. H.**

Department of Agricultural Extension and Rural Development, Faculty of Agriculture and  
Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi.

**Corresponding Author's Email:** gdnsunday@gmail.com, **GSM:** 08136078470

**ABSTRACT**

The study assessed the adoption of climate-smart agricultural practices (CSAPs) among rice farmers in Bogoro and Dass Local Government Areas of Bauchi State, Nigeria. A multi-stage sampling technique was used to select 240 respondents. Data were collected through questionnaires and analyzed using descriptive and inferential statistics. The findings revealed that 55% of respondents were male, 69.6% were married, and most (29.7%) were within the active working age of 36–45 years. About 31.3% and 20.8% of the respondents attained secondary and OND/NCE education, respectively. Additionally, 45% of the respondents had 6–10 years of farming experience while 36.7% of the respondents had household sizes of 10–12 persons. Majority (67.1%) of the respondents were not members of cooperative societies. Friends and relatives, radio, and extension agents ranked 1st, 2nd, and 3rd, respectively, as sources of climate change information. Respondents demonstrated high awareness and adoption of CSAPs, particularly crop rotation ( $\bar{X} = 3.9$ ), organic fertilizer use ( $\bar{X} = 3.9$ ), and improved seed varieties ( $\bar{X} = 3.5$ ). Major constraints were inadequate extension services (ranked 1st), high cost of seeds (2nd), drought, and rainfall shortage (3rd). The study concluded that the respondents adopted CSAPs at various levels of adoption. It is recommended that Government, through the Agricultural Development Programmes (ADPs) and extension agencies, should strengthen extension service delivery by recruiting, training, and deploying more agents to rural communities

**Keywords:** Climate-Smart Agriculture, Rice Farmers, Adoption

**INTRODUCTION**

Agriculture is the largest sector of the Nigerian economy with 70% of the population working in agriculture and it contributes 23% of Gross Domestic Product (GDP) (Federal Ministry of Agriculture and Rural Development [FMARD], 2016). Since 2014 where there was a declined in global oil prices, Nigeria's economic growth has slowed down. The economy contracted by 1.7% in 2016, and it is expected to grow only by 1% in 2017, as compared to 6.3% in 2014 (World Bank, 2017). Critically at this time of declining oil revenues for the government, agriculture is becoming more important as it contributes 75% of all other export earnings (FMARD, 2016). Climate Smart Agricultural Practices (CSAPs) is defined as an approach that helps to transform agricultural systems to sustainably increase productivity, adapt and build resilience, and reduce or remove greenhouse gas (GHG) emissions so as to support food security (Hellin and Fisher, 2019). CSA combines devices and tools of conventional agriculture with innovative technologies (which may also be precise information or accurate data from datasets at the farm level or outside sources such as weather stations) to furnish farmers with recommendations for good decision-making in the face of uncertainties caused by climate change (Mizik, 2021). CSA is not “a one-size-fits-all practice” rather it is a mixture of practices (traditional and innovative) that are incorporated into an agricultural system for climate change adaptation thereby making it context-specific (Chitakira and Ngcobo, 2021).

The adoption of CSA practices by farmers has resulted in improved crop yields, nutrient and water use efficiency, enhanced food security, reduced GHG emissions and subsequently reduced the impact of climate change (Makate *et al.*, 2018; Issahaku and Abdulai, 2019). In spite of these benefits, the adoption and upscaling of CSA practices have remained very low (Issahaku and Abdulai, 2019; Trendov *et al.*, 2021). This is attributed in part to a lack of awareness of CSA technologies/practices, limited skills, and infrastructure (Chitakira and Ngcobo, 2021). Smallholders produce food and non-



food products on a small scale with limited external inputs, cultivating field and tree crops as well as livestock, fish and other aquatic organisms. However, there is no universally accepted definition of a small farm. 'Small' may refer to the number of workers; capital invested, or amount of land worked (Sabo *et al.*, 2017). Smallholder farmers in sub-Saharan Africa (SSA) are most vulnerable to the risks posed by climate change. This is due to over-reliance on rainfed agricultural systems and low adaptive capacity attributed to high poverty incidences. Dube *et al.* (2016) estimated that yield from rain-fed agriculture could decrease by about 50% in the next 30–35 years if adaptation measures are not put in place. With the advent of climate change, if we continue with business as usual (BAU), rain-fed agricultural production systems may not be sustainable. Climate change adaptation through promoting the adoption of Climate-Smart Agriculture (CSA) practices is an effective policy recommendation to deal with the risks posed by climate change. CSA, as defined by the Food and Agricultural Organization of the United Nations (FAO) is an approach for developing agricultural strategies to secure sustainable food security under a changing climate (FAO *et al.*, 2018).

Rice is an important food and cash crop cultivated in all agro ecological zones of Nigeria. The production of the crop has been on the increase over the years owing to its uses in various forms. The cereal is widely consumed all over the country regardless of cultural, religious or geographical boundaries. Thus, a strategic commodity in the Nigerian economy (Dauna *et al.*, 2019). Rice is a staple food crop in Nigeria and among the main crops being promoted under the Agriculture Promotion Policy (APP) (2016 – 2020) of Buhari's administration (FMARD, 2016). Agriculture in Nigeria has been identified as a high climate sensitive sector, thus drawing attention to the impact of climate change on its performance. Whilst acknowledging the efforts made by successive governments in Nigeria towards coping effect climate change the adverse effects of inconsistency in rainfall on rain-fed crops and other agricultural yield has remained a major source of worry to stakeholders in the agricultural sector. It is noteworthy that food security in Nigeria is vulnerable to climate change because of the dependence on rain-fed agriculture which relies directly or indirectly on climate change and variability. Besides, large proportions of agricultural activities in Nigeria from planting to harvesting are dependent either directly or indirectly to climate change and variability, thus drawing attention to issues of climate change. Consequently, the agricultural sector in Nigeria, particularly in the Bogoro and Dass Local Government Areas (LGAs) of Bauchi State, faces significant challenges due to climate variability and change. Rice farmers in these regions are especially vulnerable, as traditional farming practices may no longer be sustainable in the face of evolving climatic conditions. The adoption of Climate Smart Agricultural (CSA) practices presents a viable solution to enhance resilience, increase productivity, and ensure food security. However, the extent to which rice farmers in Bogoro and Dass LGAs have adopted these practices remains unclear, necessitating a thorough investigation.

The broad objective of the study was to analyse the adoption of climate smart agricultural practices in Bogoro and Dass Local Government Areas of Bauchi state, Nigeria and specifically to describe the socioeconomic characteristics of the respondents in the study area, examine the climate smart agricultural practices adopted by the respondent, and identify the constraints faced by the respondent in the adoption of climate smart agricultural practices

## RESEARCH METHODOLOGY

### The Study Area

The study area were Bogoro and Dass Local Government Areas (LGAs) of Bauchi State, Nigeria. Bogoro LGA is located at Latitude: 9.668° N and Longitude: 9.605° E, which is approximately 83 km away from the state capital and is located in the southern part of state capital. Its headquarters is in the town of Bogoro. Za'ar or Sayawa people are the majority of its inhabitants. According to the National Population Commission (NPC, 2006), the population of Bogoro Local Government Area was 84,215 during the 2006 national census. To obtain the current estimate, the Bauchi State average annual population growth rate of 3.7% was applied using a year-by-year compounding method from 2007 to 2024. This projection yielded an estimated population of approximately 161,960 persons in 2024. Bogoro LGA is located between latitude 9.300 and 1200



north of the equator and longitude 8.50 and the Greenwich meridian and has latitude of about 690.2 m above sea level. In terms of local government boundaries, it is bordered by Kanke Local Government Area of Plateau state to the south, Tafawa Balewa local government area of Bauchi state to the north, west and to the eastern parts, respectively. Bogoro local government area experience both rainy (cropping) and dry seasons which occur between late October and April, while the Rainy (cropping) season occur between early May and late October. The mean annual rainfall is 680 mm; the temperature ranges from as low as 110C to as high as 400C sometimes. The landscape of this area is slightly undulating towards the South and toward the East. The vegetation compositions comprise both scanty and thick vegetation (Bogoro LGA, 1999). The major economic activity of the area is agriculture with a combination of trade, art and craft practiced by some people. The major crops in the area are Maize, Groundnut, Rice, Acha and Sorghum. In addition, Livestock types found in the area include Cattle, Sheep, Goats, Pigs and Poultry (Bogoro LGA, 1999).

Dass LGA is located at latitude Latitude: 10.000° N and Longitude: 9.517° E with an estimated population of 200,987 (Information Department Dass Local Government Area, 2017). The climate is characterized by two distinct seasons, dry and wet seasons. The area recorded rainfall of about 1000mm annually. The people of Dass Local Government Area engage in various form of farming activities for livelihood. Different varieties of crops are produced in the area which include rice, millet, sorghum, beans, spinach, sugar cane, groundnut and soya beans. Also, people engaged in livestock production such as sheep, goat and cattle, among others.

#### **SAMPLING TECHNIQUES AND SAMPLING SIZE**

Multi stage sampling technique was used for the study, in the first stage a purposive selection of two LGAs, that is, Bogoro and Dass. The two LGAs were selected based on the concentration of rice farmers in the study areas. In the second stage two districts were randomly selected from each of the LGAs selected making a total of four districts (Bogoro, Mwari, Bundot and Bagel). In the third stage two communities were randomly selected from each of the selected districts, making a total of eight communities (Gwaska Bom, Yola, Mallar, Dinki, Bagel, Bundot, Baraza and Durr). In the fourth stage, proportionately 15% of the registered Rice farmers were selected and this gave a sample size of 240 farmers. These 240 respondents formed the final sample for the study.

**TABLE 1: SAMPLE SIZE AND SAMPLING FRAME**

LGAs	Districts	Communities	Sampling frame	Sample Size (15%)
Bogoro	Bogoro	Gwaska Bom	200	30
		Yola	187	28
	Mwari	Mallar	213	32
		Dinki	152	23
		Baraza	248	37
Dass	Dass	Durr	191	29
		Bagel	209	31
	Bagel	Bagel	209	31
		Bundot	200	30
<b>Total</b>			<b>1600</b>	<b>240</b>

#### **Method of Data Collection**

Primary data were collected through the administration of questionnaire to the communities selected with the aid of trained enumerators. The sections of the questionnaire include; section A (Socio Economic background of the respondent), section B (sources of information to Rice Farmers on CSAP), section C (Level of Adoption on CSAP), section D (Constraints to adoption of CSAP).

#### **Method of Data Analysis**

Data were analyzed using descriptive statistics such as frequency, percentage and mean.

#### **Mean score**

Mean score of  $\geq 3$  = adopted/aware, while mean score of  $< 3$  = mean is not adopted/aware.

#### **Adoption index**

Adoption index will used to assess the level of adoption of rice production technologies of climate smart agricultural practices by the farmers as follows;



Adopted=4, Fairly Adopted=3, Less adopted=2, Not Adopted =1.

An index of <3 indicates that the technology was not adopted by the farmers. While the index of  $\geq 3$  indicates the technology was adopted.

## RESULTS AND DISCUSSION

### SOCIOECONOMIC CHARACTERISTICS OF THE RESPONDENTS (N=240)

The results from Table 2a indicate that respondents were in their productive ages, with 29.6% aged 36–45 years and 25% aged 46–55 years, suggesting readiness to adopt climate-smart agricultural practices (CSAPs) for improved productivity and income. In terms of farming experience, 45% of respondents had 6–10 years, while 22.9% and 18.8% had 11–15 years and 16–20 years, respectively, reflecting substantial knowledge of rice production and climate variability. This implies that most respondents had the capacity to adopt CSAPs as a means of mitigating climate risks, consistent with studies showing that younger and more experienced farmers are more receptive to innovations (Okeke *et al.*, 2024; Zakari *et al.*, 2025).

Household size and income distribution further highlight factors influencing adoption. About 36.7% and 25.4% of respondents had households of 10–12 and 7–9 persons, indicating availability of family labor to implement labor-intensive CSAPs. In addition, 29.2% and 27.9% of respondents earned between ₦750,001–₦1,000,000 and ₦500,001–₦750,000 annually, showing relatively good income levels that can support investment in improved seeds, fertilizers, and irrigation. Farm size also played a role, as 68.8% cultivated 1–5 hectares, enabling experimentation with CSAPs. These findings collectively suggest that socio-economic attributes such as age, experience, household size, income, and land access significantly shape adoption decisions (Onyeneke *et al.*, 2021; Abegunde *et al.*, 2024).

**TABLE 2A: QUANTITATIVE SOCIOECONOMIC CHARACTERISTICS OF THE RESPONDENTS (N=240)**

Variables	Frequency	Percentage	Mean
<b>Age (years)</b>			
15-25	35	14.6	42
26-35	40	16.7	
36-45	71	29.6	
46-55	60	25.0	
56-65	24	10.0	
above 65	10	4.2	
<b>Years of farming experience</b>			
1-5	32	13.3	10
6-10	108	45.0	
11-15	55	22.9	
16-20	45	18.8	
<b>Household size</b>			
1-3	16	6.7	8
4-6	39	16.3	
7-9	61	25.4	
10-12	88	36.7	
<b>Annual income (₦)</b>			
<100,000	8	3.3	742,000
100,000-250,000	20	8.3	
250,001-500,000	26	10.8	
500,001-750,000	67	27.9	
750,001-1,000,000	70	29.2	
Above 1,000,000	49	20.4	
<b>Farm size (ha)</b>			
<1	36	15.0	3.3
1-5	165	68.8	
above 6	39	16.3	

**Source:** Field Survey, (2024)



The results from Table 2b show that 55% of respondents were male and 45% female, reflecting the dominance of men in rice production due to cultural norms and the labor-intensive nature of farming. This gender disparity is important, as male farmers generally have greater access to resources and opportunities to adopt climate-smart agricultural practices (CSAPs), while women often face barriers in land access, inputs, and training (Adelekan *et al.*, 2023; Ojo *et al.*, 2024). Occupational distribution revealed that 42.5% engaged in mixed cropping and 32.5% in mixed farming, while smaller proportions were civil servants (12.5%), rice farmers only (7.9%), and traders (4.6%). These findings suggest that multiple livelihood strategies enhanced household income and food security, enabling farmers to better invest in CSAPs such as soil fertility management and crop diversification (Okeke *et al.*, 2024). Marital status also played a role, with 69.6% of respondents married, implying a greater likelihood of adopting long-term strategies to safeguard family livelihoods (Zakari *et al.*, 2025).

Educational attainment further underscored the capacity for adoption, as 31.3% had secondary education, 20.8% OND/NCE, and smaller percentages attained HND, primary, or university education, with only 5% having MSc/PhD qualifications. This indicates that most respondents had some level of education, which enhances understanding of extension messages and uptake of CSAPs (Abegunde *et al.*, 2024). Institutional factors also influenced adoption, with 70% of respondents having access to credit, enabling investments in inputs and climate-resilient technologies (Kanu & Przezbórska-Skobiej, 2025). Sources of capital were dominated by personal savings (48.3%), followed by commercial banks (23.8%) and friends/family (15.8%), while cooperatives (8.8%) and money lenders (3.3%) played smaller roles. However, 67.1% of respondents were not members of cooperatives, limiting their access to collective resources and extension support, despite evidence that cooperatives enhance adoption through shared services and input access (Okeke *et al.*, 2024; Abegunde *et al.*, 2024).





**TABLE 2B: QUALITATIVE SOCIOECONOMIC CHARACTERISTICS OF THE RESPONDENTS (N=240)**

Variables	Frequency	Percentage
<b>Sex</b>		
Male	132	55.0
Female	108	45.0
<b>Occupation</b>		
rice production only	19	7.9
mixed farming	78	32.5
mixed cropping	102	42.5
civil servant	30	12.5
Trader	11	4.6
<b>Marital status</b>		
Single	41	17.1
Married	167	69.6
Widowed	25	10.4
Divorce	7	2.9
<b>Educational/ Qualification</b>		
Primary	35	14.6
Secondary	75	31.3
OND/NCE	50	20.8
HND	39	16.3
Bachelor degree	29	12.1
MSs/PhD	12	5.0
<b>Access to credits</b>		
Yes	72	30.0
No	161	67.1
<b>Source of capital</b>		
Personal saving	116	48.3
Loan from bank	57	23.8
Friends and family	38	15.8
Cooperatives	21	8.8
Money lenders	8	3.3
<b>Cooperative membership</b>		
Yes	79	32.9
No	161	67.1

**Source:** Field Survey, (2024)

### **Sources of Information on Climate Smart Agricultural Practices**

The result from Table 3 shows the major sources of information on climate change by the respondents. The finding shows that friends/relatives, radio and extension agents were the major sources of information on climate change by the respondents and were ranked 1st, 2nd and 3rd, respectively. Similar findings were reported by Ojo et al. (2024), who noted that interpersonal networks such as friends and relatives remain important sources of agricultural information among smallholder farmers, especially in rural areas. Likewise, radio has been identified as a highly accessible and trusted medium for disseminating agricultural and climate-related information in Nigeria (Ajao & Ogunniyi, 2019), while extension agents continue to play a critical role in improving awareness and adoption of CSAPs (Abubakar *et al.*, 2021).

The finding also shows that workshop, television, social media and cooperatives were ranked 4th, 5th, 6th and 7th by the respondents as their sources of information on climate change in the study area. This aligns with the observation of Nazifi et al. (2024), who highlighted that training workshops and farmer field schools enhance farmers' knowledge and skills on climate-smart practices. Similarly, television and social media have been recognized as emerging platforms that complement traditional information sources, particularly among younger and literate farmers (Yakubu *et al.*, 2024). Farmer cooperatives also provide collective platforms for knowledge sharing and access to climate-related



innovations, as emphasized by Bello et al. (2023). This finding implies that most of the respondents had access to different sources of reliable information on climate change and its adverse effects on rice production in the study area.

**TABLE 3: MAJOR SOURCES OF INFORMATION ON CLIMATE SMART AGRICULTURAL PRACTICES.**

Variables	Percentage	Rank
Friends/relatives	61.7	1 <sup>st</sup>
Radio	61.3	2 <sup>nd</sup>
Extension agents	60.4	3 <sup>rd</sup>
Workshop	38.3	4 <sup>th</sup>
Television	37.9	5 <sup>th</sup>
Social media	36.9	6 <sup>th</sup>
Cooperatives	35.7	7 <sup>th</sup>

**Source:** Field Survey, (2024)

### Adoption of Climate Smart Agricultural Practices (CSAPs)

The findings in Table 4 show that respondents widely adopted improved seed varieties ( $\bar{X} = 3.44$ ), crop rotation ( $\bar{X} = 3.25$ ), and use of organic fertilizers ( $\bar{X} = 3.64$ ), indicating preference for practices that directly enhance yield and soil fertility. Similarly, mulching ( $\bar{X} = 3.38$ ), intercropping with cover crops ( $\bar{X} = 3.68$ ), and minimum/zero tillage ( $\bar{X} = 3.43$ ) were embraced, reflecting farmers' awareness of conservation agriculture and its benefits in improving soil moisture retention and reducing risks. These results align with earlier studies, which reported high adoption of such practices because they are affordable, accessible, and significantly improve productivity and resilience among smallholders (Asfaw *et al.*, 2016; Zougmore *et al.*, 2024; Ojo *et al.*, 2024).

Conversely, the adoption of water management practices ( $\bar{X} = 2.63$ ) and use of mobile phones to access weather forecasts ( $\bar{X} = 2.45$ ) was very low. This indicates continued dependence on rain-fed farming systems, largely due to inadequate irrigation infrastructure and the high costs of water-related technologies (Usman *et al.*, 2023). Limited use of mobile phones for climate information reflects digital literacy gaps, low trust in weather forecasts, and restricted access to reliable ICT-based services. This supports previous findings that, although mobile technologies have potential to support CSAP adoption, their uptake in rural farming communities remains constrained by infrastructural and knowledge-related barriers (Yakubu *et al.*, 2024).

**Table 4: Climate Smart Agricultural Practices Adopted**

Variables	Mean	Rank
Improved seed varieties	3.44	Adopted
Crop rotation	3.25	Adopted
Use of organic fertilizers	3.64	Adopted
Mulching	3.38	Adopted
Intercropping with cover crops (legumes)	3.68	Adopted
Minimum/zero tillage practice	3.43	Adopted
Water management practices	2.63	Not adopted
Use of mobile phone to access weather conditions	2.45	Not adopted

**Source:** Field Survey, (2024)

Decision rule;  $<3.0$  = Not adopted,  $\geq 3.0$  = adopted

### The Constraints Toward Rice Farmers' Adoption of Climate Smart Agricultural Practices

The result from Table 5 shows the constraints faced by the respondents toward adoption of CSAPs in the study area.

The finding shows that the major constraints to adoption of CSAPs by the respondents were inadequate extension services, high cost of seeds, drought and shortage of rainfall which were ranked 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup>, respectively by the respondents. These were followed by deforestation, poverty, inadequate organic fertilizers and pest/disease which were ranked 5<sup>th</sup>, 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup>, respectively.



Others were inadequate infrastructure, inadequate policy support and flooding which were ranked 9<sup>th</sup> and 10<sup>th</sup>, respectively in the study area. This finding implies that despite the level of knowledge and adoption of CSAPs by the respondents there are institutional and natural factors hindering smooth adoption of CSAPs in the study area by the respondent (Salisu, 2022; Anuga *et al.*, 2019; Chitakira & Ngcobo, 2021; Waaswa *et al.*, 2021).

**TABLE 5:** DISTRIBUTION OF RESPONDENTS BASED ON THE CONSTRAINTS TO ADOPTION OF CSAPs

Variables	Percentage	Rank
Inadequate extension service	67.5	1 <sup>st</sup>
High cost of seeds	62.9	2 <sup>nd</sup>
Poverty	62.1	3 <sup>rd</sup>
Deforestation	61.7	5 <sup>th</sup>
Drought	60.7	6 <sup>th</sup>
Inadequate organic fertilizers	57.9	7 <sup>th</sup>
Pest and disease	52.0	8 <sup>th</sup>
Inadequate infrastructure	40.4	9 <sup>th</sup>
Inadequate policy support	38.3	10 <sup>th</sup>
Flooding	38.8	10 <sup>th</sup>

**Source:** Field survey, (2024)

## CONCLUSION AND RECOMMENDATIONS

Majority of the respondents adopted Climate Smart Agricultural Practices (CSAPs) at various levels of adoption only that the adoption in some instances was constrained by limited extension services and the high cost of inputs, which restricted farmers' access to timely information and affordable technologies which if fully addressed the practices would have been fully adopted. These challenges were particularly severe for resource-poor farmers who lacked the means to invest in improved practices.

Based on the finding of the study the following recommendations were made;

- Government, through the Agricultural Development Programmes (ADPs) and extension agencies, should strengthen extension service delivery by recruiting, training, and deploying more agents to rural communities.
- Agencies such as the Federal Ministry of Agriculture and Rural Development (FMARD) and input supply agencies should provide subsidized seeds and fertilizers to reduce the high cost of inputs and encourage wider adoption.
- Government should improve rural infrastructure such as roads, storage, and irrigation systems, while policymakers should enact supportive agricultural policies to create an enabling environment for CSAP adoption.

## REFERENCES

- Abegunde, V. O., Olorunfemi, T. O., & Adesanya, A. A. (2024). Determinants of climate-smart agricultural practices adoption among smallholder farmers in Nigeria. *Journal of Agricultural Extension*, **28**(1): 45–59.
- Adelekan, A. I., Adebayo, O. O., & Adekunle, A. O. (2023). Gender and access to climate-smart agricultural practices among smallholder farmers in Southwest Nigeria. *International Journal of Agricultural Policy and Research*, **11**(3): 22–34.
- Ajao, A. O., & Ogunniyi, L. T. (2019). Sources of agricultural information among smallholder farmers in rural Nigeria. *Journal of Agricultural Extension*, **23**(2): 110–120.
- Anuga, S. W., Gordon, C., Boon, E., & Adiku, S. (2019). Determinants of climate-smart agriculture (CSA) adoption among smallholder food crop farmers in Ghana. *Journal of Environmental Management*, **235**: 142–150.





- Asfaw, S., McCarthy, N., Lipper, L., Arslan, A., & Cattaneo, A. (2016). Climate change, weather risk and the adoption of conservation agriculture in Zambia. *Journal of Agricultural Economics*, **67**(1): 255–274.
- Bello, M. A., Usman, I., & Ahmed, S. (2023). Role of farmer cooperatives in promoting climate-smart agriculture in Northern Nigeria. *African Journal of Sustainable Agriculture*, **19**(2): 88–101.
- Chitakira, M., & Ngcobo, N. (2021). Scaling up climate-smart agriculture: Insights from smallholder farmers in Southern Africa. *Sustainability*, **13**(5): 1–14.
- Dauna, A. A., Musa, A., & Ibrahim, Y. (2019). Rice production and food security in Nigeria: Emerging issues and policy options. *Nigerian Journal of Agricultural Economics*, **9**(1): 12–25.
- Dube, T., Moyo, P., & Moyo, S. (2016). Climate change and potential impacts on agriculture in Sub-Saharan Africa. *Environment and Natural Resources Research*, **6**(3): 45–52.
- Federal Ministry of Agriculture and Rural Development (FMARD). (2016). *The agriculture promotion policy (2016–2020): Building on the successes of the ATA, closing key gaps*. Abuja: FMARD.
- Food and Agriculture Organization (FAO), IFAD, UNICEF, WFP, & WHO. (2018). *The state of food security and nutrition in the world 2018*. Rome: FAO.
- Hellin, J., & Fisher, E. (2019). Climate-smart agriculture and participatory research: Testing the boundaries of scaling out. *Agricultural Systems*, **171**: 1–9.
- Issahaku, G., & Abdulai, A. (2019). Adoption of climate-smart practices and its impact on farm performance and risk exposure among smallholder farmers in Ghana. *Australian Journal of Agricultural and Resource Economics*, **63**(3): 632–656.
- Kanu, S. A., & Przezbórska-Skobiej, L. (2025). Access to credit and adoption of climate-smart agricultural technologies in sub-Saharan Africa. *Journal of Rural Development Studies*, **47**(2): 77–93.
- Makate, C., Makate, M., & Mango, N. (2018). Farm household typologies and adoption of climate-smart agriculture practices in southern Africa. *Sustainability*, **10**(5): 1–17.
- Mizik, T. (2021). Climate-smart agriculture: A review. *Sustainability*, **13**(16): 1–15.
- Nazifi, I. U., Ibrahim, M. A., & Abdullahi, A. (2024). Effectiveness of farmer field schools in promoting climate-smart agriculture in Northwestern Nigeria. *Journal of Agricultural Extension and Rural Development*, **16**(1): 12–22.
- Ojo, T. O., Kehinde, M. O., & Ayinde, O. E. (2024). Adoption of climate-smart agriculture among smallholder farmers in Nigeria: Evidence from Ogun State. *Journal of Agricultural and Rural Development in the Tropics and Subtropics*, **125**(1): 55–66.
- Okeke, C. A., Eze, A. V., & Umeh, J. C. (2024). Socioeconomic determinants of climate-smart agriculture adoption among rice farmers in Southeast Nigeria. *Journal of Agricultural Extension*, **28**(2): 72–85.
- Onyeneke, R. U., Nwajiuba, C. U., & Igberi, C. O. (2021). Determinants of climate-smart agriculture adoption among smallholder rice farmers in Nigeria. *International Journal of Climate Change Strategies and Management*, **13**(4): 401–417.
- Sabo, E., Aliyu, M., & Ibrahim, M. (2017). Defining smallholder farmers in Nigeria: Implications for agricultural development. *Journal of Rural Studies*, **54**: 187–195.
- Salisu, A. (2022). Institutional barriers to adoption of climate-smart agriculture in Nigeria. *African Journal of Agricultural Research*, **17**(8): 1123–1134.
- Trendov, N. M., Varas, S., & Zeng, M. (2021). Digital technologies in agriculture and rural areas: Status report. *Food and Agriculture Organization Journal of Innovation in Agriculture*, **3**(2): 15–29.



- Usman, M., Bello, A., & Musa, H. (2023). Adoption of water management practices for climate-smart agriculture among rice farmers in Nigeria. *Nigerian Journal of Agricultural Extension*, **24**(3): 144–156.
- Waaswa, B., Mutesasira, H., & Nabirye, S. (2021). Constraints to adoption of climate-smart agricultural practices among smallholder farmers in East Africa. *International Journal of Agricultural Sustainability*, **19**(6): 589–604.
- World Bank. (2017). *Nigeria economic report*. Washington, DC: World Bank.
- Yakubu, A., Ibrahim, A., & Lawal, M. (2024). Digital extension services and climate-smart agriculture adoption among farmers in Northern Nigeria. *Journal of Information Technology for Development*, **30**(1): 99–115.
- Zakari, M., Mohammed, A., & Abdullahi, L. (2025). Socioeconomic determinants of climate-smart agricultural practice adoption among smallholder farmers in Northern Nigeria. *African Journal of Agricultural Economics and Rural Development*, **13**(2): 66–80.
- Zougmore, R., Partey, S., Ouédraogo, M., & Totin, E. (2024). Scaling climate-smart agriculture in West Africa: Lessons and perspectives. *Climate and Development*, **16**(3): 211–223.