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ASSESSING THE ADOPTION OF CLIMATE-SMART AGRICULTURAL PRACTICES AMONG RURAL CASSAVA FARMERS IN BENUE STATE, NIGERIA

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ABSTRACT

This study assessed the adoption of Climate Smart Agricultural (CSA) practices among rural cassava farmers in Benue State, Nigeria. The population comprised all rural cassava farmers in Benue State. A sample size of 175 respondents was selected using a multi-stage selection technique comprising purposive, stratified, and simple random sampling. Data were collected using structured questionnaires. Data were analyzed using descriptive and inferential statistics. The findings revealed a balanced gender distribution, with women slightly outnumbering men (50.3%). The mean age of respondents was 28.4 years. Most farmers were married (49.7%), had small household sizes 4.8 persons and operated on modest farm holdings (mean farm size 2.2 hectares). Educational attainment was modest with 61.1% having secondary education, while Annual income levels were modest, with 41.1% earning between ₦100,000 and ₦300,000. Adoption of CSAPs varied significantly, improved cassava varieties were universally adopted (100%), followed by water conservation techniques (91.4%), organic fertilizer use (78.9%), crop rotation (65.7%), and agroforestry (54.3%). Farmers perceived CSAPs as beneficial, with increased yield ($\bar{x}$ = 3.20), enhanced food security ($\bar{x}$ = 3.00), and income growth ($\bar{x}$ = 2.80) rated as the top advantages. The study concludes that cassava farmers in Benue State are increasingly engaging with CSA practices, offering a pathway to sustainable agricultural development. Despite these benefits, adoption was hindered by several constraints like financial constraints adequate access to inputs poor extension services and cultural resistance to change. The study recommends targeted input subsidies, strengthened extension systems, and culturally sensitive awareness campaigns to improve CSAP uptake and foster sustainable cassava production in the State.

Keywords: Adoption, climate smart, Agriculture, cassava

Introduction

Cassava (*Manihot Spp*) stands as one of Nigeria's most vital staple crops, playing a pivotal role in ensuring national food security, supporting rural economies, and sustaining millions of lives (Otekunrin, and Sawicka, 2019). With an estimated annual production of approximately 63 million tons (Food and Agriculture Organization (FAO), 2022). Nigeria ranks as the world's largest producer of cassava a testament to the crop's centrality in the country's agricultural landscape. Its versatility as a food source, industrial raw material, and income generator makes cassava a cornerstone of both subsistence and commercial farming systems (FAO, 2022).

One of cassava's most remarkable attributes is its adaptability. It thrives across Nigeria's diverse agro-ecological zones from humid rainforests to semi-arid savannahs and demonstrates resilience to erratic weather patterns, poor soils, and prolonged dry spells. This hardiness positions cassava as a strategic crop in the face of intensifying climate change, which continues to disrupt traditional farming systems and threaten agricultural productivity (Akinola *et al*., 2017).

Despite its resilience and economic importance, cassava cultivation in Nigeria remains largely dependent on conventional farming practices. These methods, often characterized by low-input systems and limited technological innovation, leave farmers vulnerable to the adverse effects of climate variability such as drought, flooding, and soil degradation (Nwankwo and Okeke, 2024). The increasing unpredictability of weather patterns has amplified the urgency for more sustainable and adaptive agricultural approaches.

Climate-smart agriculture (CSA) emerges as a transformative solution to these challenges. CSA encompasses a suite of practices and technologies designed to sustainably increase productivity, enhance resilience to climate shocks, and reduce greenhouse gas emissions. For cassava farmers, CSA interventions such as intercropping, mulching, agroforestry, and the adoption of improved, climate-resilient cassava varieties offer promising avenues to safeguard yields and stabilize production. As Egesi (2013) emphasizes, continuous breeding and dissemination of improved cassava cultivars are essential to maintaining productivity under changing climatic conditions.

However, the widespread adoption of CSA practices among cassava farmers in Nigeria remains limited. Barriers such as inadequate access to information, financial constraints, weak extension services, and institutional bottlenecks hinder the transition toward more sustainable farming systems. Addressing these challenges requires a multi-stakeholder approach that integrates policy support, farmer education, research innovation, and investment in climate-resilient infrastructure.

Cassava's potential to drive agricultural transformation and climate resilience in Nigeria is immense but unlocking these potential hinges on the strategic implementation of climate-smart agriculture and the empowerment of farmers to embrace innovation.

Statement of the Problem

Climate change poses a profound threat to sub-Saharan Africa, intertwining with entrenched poverty and food insecurity, particularly in regions like Nigeria where agriculture is predominantly rain-fed and infrastructure remains underdeveloped. In Nigeria, erratic climate patterns manifesting as droughts, floods, and rising temperatures have severely impacted cassava production, jeopardizing the livelihoods of smallholder farmers who depend on traditional, weather-sensitive farming methods. These practices, including slash-and-burn agriculture and cultivation on marginal lands, not only degrade fragile ecosystems and reduce soil fertility but also contribute to greenhouse gas emissions and declining crop yields. Climate-Smart Agriculture (CSA) emerges as a promising solution, offering sustainable techniques such as conservation agriculture, agroforestry, efficient water management, and improved crop varieties to bolster resilience and productivity. However, widespread adoption of CSA remains constrained by knowledge gaps, and socio-economic barriers. While several studies have explored CSA uptake in select regions and crop systems, there is a notable little or lack of empirical research focused on cassava farmers in Benue State of Nigeria. Addressing this gap is germane for developing targeted interventions and policies that promote climate-resilient agriculture. Consequently, this study aims to assess the adoption of CSA practices among rural cassava farmers in Benue State, shedding light the CSA practices adopted by cassava farmers, benefits of adoption, and constraints to adoption, thereby informing future strategies for sustainable agricultural development.

Objectives of the Study

The broad objective of the study was to assess the adoption of Climate Smart Agricultural (CSA) practices among rural cassava farmers in Benue State, Nigeria. The specific objective of the study includes to:

i. describe the socio-economic characteristics of cassava farmers
ii. identify CSA practices adopted by cassava farmers
iii. determine benefits of adoption of CSA
iv. identify constraints to CSA adoption

Methodology

Research Design

This study adopted public opinion survey research design which made use of questionnaire for data collection.

The Study Area

The study was carried out in Benue State, Nigeria. Benue State was created in 1976 among the 7 states created at that time by Gen. Murtala Muhammed. The State is located in the Middle Belt Region of Nigeria. It is located between Latitudes 6.5° and 8.5° North, and Longitudes 7.47° and 10° East (Binitie and Esharive (2024). Benue State has a total land mass of 6,595 million hectares with an estimated population of 6,141,300 by United Nations population projection of 2022, using growth rate of 2.3% and 413,159 farm families/households (National Bureau of Statistics, (2022).

The State is divided into three agricultural zones, namely; Eastern zone, Northern and Central. Benue State is bounded on the south by Cross River, Ebonyi, and Enugu States, on the west by Kogi State, on the north by Nasarawa State, and on the northeast by Taraba State. The state is nicknamed "Food Basket of the Nation" as a result of its competitive advantage in agriculture. The state is traversed by River Benue (280Km long) and River Katsina-Ala (202km long) and has a total area of about 30,955km2 which is administratively divided into 23 Local Government Areas, namely; Ado, Agatu, Apa, Buruku, Gboko, Guma, Gwer, Gwer-West, Katsina-Ala, Konshisha, Kwande, Logo, Makurdi, Obi, Ogbadibo, Ohimini, Oju, Okpokwu, Otukpo, Tarka, Ukum, Ushongo, Vandeikya. The state is made up of several ethnic groups; Tiv, Idoma, Igede, Etulo, Jukun, Akweya, Ufia-utokon and Nyifon. Benue State has guinea savannah vegetation towards the north and deciduous forest vegetation type towards the south and eastern parts. This type of vegetation makes it possible to grow both crops that require savannah weather conditions as well as forest crops that require heavy rainfall such as sesame seed, soybeans, shea nuts, cotton, yams, maize and rice as cash crops. Yams, sorghum, millet, peanuts (groundnuts), and cassava are grown as staple foods. Tree crops such as cashew, mango, orange and guava are grown. Livestock such as cow, goat, pig, and poultry are reared and fishing activities are also carried out in the state. The State is blessed with abundant mineral resources such as clay, limestone, kaolinite, feldspar, gypsum (Soluap. (2023). Map of the study area is shown in figure 1.

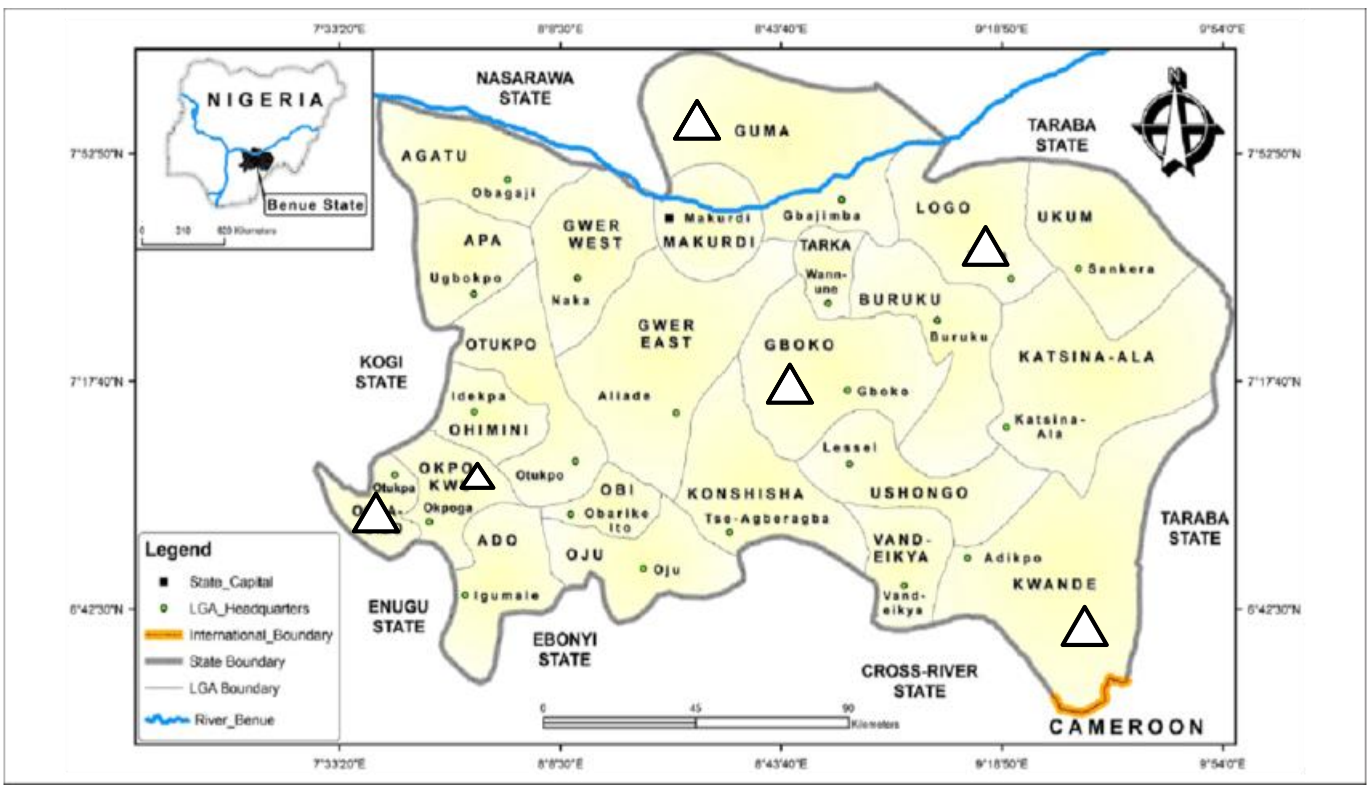

Figure 1: Map of Benue State showing the location of the study area

Key:

 - The Study area

Population and Sample Size Selection

The target population for this study comprised all cassava farmers in the three agro-ecological zones of Benue State namely Eastern, Northern, and Central. A multi-stage sampling technique was employed to ensure representativeness.

Stage 1: Benue State was stratified into three zones: Eastern, Northern, and Central.

Stage 2: Two Local Government Areas (LGAs) were purposively selected from each zone based on their involvement in cassava production: Logo and Kwande (Eastern), Guma and Gboko (Northern), and Ogbadibo and Okpokwu (Central).

Stage 3: Two rural communities were randomly selected from each LGA, resulting in twelve communities.

Stage 4: A sampling frame was developed for each community, yielding a total population of 17,532 cassava farmers. To determine the appropriate sample size, Yamane's (1967) formula was applied:

$$n = \frac{N}{1+Ne^2}$$

Where:

- (n) = sample size
- (N) = population size (17,532)
- (e) = margin of error (0.05)

$$n = \frac{17532}{1+17532(0.05)^2} = 391$$

The ideal sample size was 391 respondents. However, due to logistical and resource constraints, the sample size was adjusted to 175 respondents. This adjustment still provides a statistically acceptable margin of error (~7.5%) for exploratory research. Respondents were proportionally allocated across the twelve communities based on each community's share of the total population.

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The table below presents the sampling frame, proportional calculation, and final sample size:

Zone	LGA	Community	Sampling Frame	Calculation	Sample Size
Eastern	Logo	Gaambe	1,092	(1,092 ÷ 17,532) × 175 = 10.92	11
		Kpav	798	(798 ÷ 17,532) × 175 = 7.97	8
	Kwande	Nanev	350	(350 ÷ 17,532) × 175 = 3.49	4
		Ikurave-Ya	1,232	(1,232 ÷ 17,532) × 175 = 12.30	12
Northern	Guma	Mbasaan	1,203	(1,203 ÷ 17,532) × 175 = 12.00	12
		Mbagwen	3,853	(3,853 ÷ 17,532) × 175 = 38.47	38
	Gboko	Yandev	896	(896 ÷ 17,532) × 175 = 8.94	9
		Mbayion	3,221	(3,221 ÷ 17,532) × 175 = 32.15	33
Central	Ogbadibo	Efugo	1,094	(1,094 ÷ 17,532) × 175 = 10.93	11
		Adepe	1,174	(1,174 ÷ 17,532) × 175 = 11.71	12
	Okpokwu	Okpoga	970	(970 ÷ 17,532) × 175 = 9.68	10
		Ichama	1,649	(1,649 ÷ 17,532) × 175 = 16.44	16
Total	—	—	**17,532**	—	**175**

Data Analysis Techniques

Descriptive and inferential statistics were used for data analysis. Objective i, ii and iii, were analyzed using descriptive statistics such as frequency, percentage, mean scores. Objective v was analyzed using Factor Analysis.

Results and Discussion

The socio-economic characteristics of rural cassava farmers in Benue State revealed a balanced gender distribution, with women slightly outnumbering men (50.3%). This underscores the critical role women play in cassava cultivation, particularly in planting, harvesting, and processing. This is in line with Aboajah *et al.* (2018) that showed a near-balanced gender distribution, with women slightly outnumbering men at 50.3%, highlighting their indispensable role in cassava cultivation. The majority of farmers fall within the youthful age bracket of 21–30 years, with a mean age of 28.4 years, indicating a vibrant and potentially innovative farming population. Most respondents are married (49.7%) and operate within small household units of 1–5 members (98.3%), which may influence labor availability and decision-making dynamics on the farm.

Educational attainment is modest, with 61.1% having completed secondary education. This suggests a basic literacy level sufficient for understanding and applying straightforward climate-smart practices, especially when supported by extension services. Farming is the predominant occupation (94.9%), and most farmers have between 1–5 years of experience, cultivating small plots of 1–3 hectares. Annual income levels are modest, with 41.1% earning between ₦100,000 and ₦300,000, which may constrain their ability to invest in advanced technologies. Notably, 89.3% of farmers reported some contact with extension agents, though only 5.1% are members of farmer associations, highlighting a gap in collective engagement and access to group-based resources. This finding is in with Soom *et al* (2018) that while cassava farming is profitable, 70% of farmers lacked access to credit and 79% were not part of any cooperative association, limiting their ability to scale operations and access group-based resources.

Table 2: Socio-Economic Characteristics of Cassava Farmers (n = 175)

Characteristic	Category	Frequency	Percentage (%)	Mean
Sex	Female	88	50.3	–
	Male	87	49.7	–
Age (years)	≤20	12	6.9	
	21–25	60	34.3	
	26–30	54	30.9	
	31–35	28	16.0	
	36–40	15	8.6	
	>40	6	3.4	28.4
Marital Status	Single	53	30.3	–
	Married	87	49.7	–
	Divorced	21	12.0	–
	Widowed	14	8.0	–
Household Size	1–5	172	98.3	
	6–10	1	0.6	
	>10	2	1.1	4.8
Education Level	Primary	46	26.3	–
	Secondary	107	61.1	–
	Tertiary	22	12.3	–
Occupation	Farming	166	94.9	–
	Trading	95	54.3	–
	Artisan	8	4.6	–
	Civil Service	21	12.0	–
Farming Experience (yrs)	1–5	167	95.3	
	11–15	8	4.7	3.9
Farm Size (ha)	1–3	140	80.0	
	3.1–5	19	10.9	
	5.1–7	1	0.6	

Characteristic	Category	Frequency	Percentage (%)	Mean
	>7	15	8.6	2.2
Annual Income (₦)	<100k	54	30.9	
	100–300k	72	41.1	
	300–500k	36	20.6	
	>500k	13	7.4	₦215,000
Extension Contact (per yr)	1–3	67	89.3	
	4–5	8	10.7	2.1
Association Membership	Yes	9	5.1	–
	No	166	94.9	–

In terms of adoption, improved cassava varieties lead with a 100% adoption rate, followed closely by water conservation techniques (91.4%) and organic fertilizer use (78.9%). Intercropping (73.1%) and mulching (49.1%) also show substantial uptake. These figures indicate that farmers prioritize practices that offer immediate benefits in yield and resilience. However, the relatively lower adoption of mulching may be attributed to labor intensity and resource constraints. This finding aligns with Tagher *et al*. (2024), who reported widespread uptake of improved varieties such as TMS 0505 and TME 419 due to their superior performance under local conditions.

Table 3: Adoption of CSA Practices by Cassava Farmers

Practice	Adoption Rate (%)
Improved cassava varieties	100.0
Water conservation techniques	91.4
Organic fertilizer	78.9
Intercropping	73.1
Mulching	49.1

Farmers perceive significant benefits from CSA practices, with increased yield ($\bar{x}$ =3.20), food security ($\bar{x}$ =3.00), and income growth ($\bar{x}$ =2.80) rated as major advantages. Pest control ($\bar{x}$ =2.50) and soil health improvement ($\bar{x}$ =2.60) also rank highly, reinforcing the value of these practices in enhancing productivity and resilience. The uniformity in responses, indicated by low standard deviations, suggests widespread agreement on the benefits across farming communities. This finding corroborates Tagher *et al*. (2024), that CSA practices such as improved cassava varieties, intercropping, and organic fertilization have led to measurable gains in yield and resilience across Benue State.

Table 4: Perceived Benefits of CSA Practices

Benefit	Mean	Remark
Increased yield	3.20	Major Benefit
Food security	3.00	Major Benefit
Income growth	2.80	Major Benefit
Pest control	2.50	Moderate Benefit
Soil health improvement	2.60	Major Benefit
Labor reduction	2.70	Major Benefit

Cutoff mean = 2.5

The adoption of Climate-Smart Agricultural Practices (CSAPs) is significantly influenced by three major categories of constraints: socio-economic, technological, and institutional. Among these, socio-economic constraints emerged as the most dominant, with high factor loadings such as high cost of farm inputs (0.8500), non-profitability of new technology (0.7800), incompatibility with traditional norms (0.8200), lack of access to credit facilities (0.8000), low level of income (0.7500), inadequate input access (0.7800), and traditional beliefs and practices (0.8500). These figures indicate that financial limitations and cultural resistance are major barriers to CSAP adoption.

Technological constraints also play a critical role, with notable loadings including lack of understanding of new packages (0.7500), superiority of old technology (0.6800), and lack of access to information and technologies (0.7800). These suggest that knowledge gaps and skepticism toward new methods hinder progress.

Meanwhile, institutional constraints are reflected in high loadings such as lack of regular contact with extension agents (0.8500), lack of access/control over production resources (0.7800), inconsistency with farming systems (0.7200), and lack of labour (0.7200). These point to systemic issues in agricultural support and infrastructure. The findings align with Onyeneke *et al*. (2023), which highlights that systemic gaps in infrastructure, credit access, and extension services continue to impede climate-resilient farming in the region

Table 5: Constraints to Adoption of Climate-Smart Agricultural Practices

Constraint	Factor 1	Factor 2	Factor 3
High cost of farm inputs	**0.8500**	0.1200	0.0800
Non-profitability of the new technology	**0.7800**	0.2000	0.1500
Incompatibility with traditional norms	**0.8200**	0.1000	0.1200
Lack of understanding of new packages	0.1500	**0.7500**	0.1800
Superiority of old technology	0.2000	**0.6800**	0.2200
Lack of regular contact with extension agents	0.1200	0.1000	**0.8500**
Lack of access/control over production resources	0.2500	0.1500	**0.7800**
Inconsistency with farming systems	0.1800	0.2200	**0.7200**
Lack of access to credit facilities	**0.8000**	0.1000	0.1200
Low level of income	**0.7500**	0.1800	0.1000
Lack of access to information and technologies	0.1500	**0.7800**	0.1000
Lack of labour	0.2000	0.1200	**0.7200**
Inadequate input access	**0.7800**	0.1500	0.1000
Traditional beliefs and practices	**0.8500**	0.1000	0.0800

Kaiser varimax Rotational method
Factor 1 (Socio-Economic constraints)
Factor 2 (Technological Constraints)
Factor 3 (Institutional constraints)

Conclusion

The findings from this study revealed a dynamic and youthful cassava farming population in Benue State, with women playing a slightly dominant role in cultivation activities a trend that aligns with the observations of Aboajah *et al*. (2018), who revealed the indispensable contribution of women in cassava production. The socio-economic profile, marked by modest education, limited income, and small farm sizes, suggests both potential and vulnerability in the adoption of Climate-Smart Agricultural Practices (CSAPs). While the high adoption of improved cassava varieties and water conservation techniques reflect farmers' responsiveness to yield-enhancing innovations, the fluctuating uptake of practices like mulching and intercropping points to underlying resource and labor constraints, consistent with Tagher *et al*. (2024), who noted that adoption is often shaped by perceived benefits and contextual limitations. Furthermore, the dominance of socio-economic constraints particularly high input costs, low profitability, and cultural resistance alongside technological and institutional barriers, reinforces the assertion by Onyeneke *et al*. (2023) that systemic gaps in infrastructure, credit access, and extension services continue to hinder the full realization of climate-smart agriculture in the region. Together, these findings underscore the need for targeted interventions that address financial, informational, and institutional deficiencies to foster sustainable cassava production.

Recommendations

i. Benue State Ministry of Agriculture and Natural Resources should Prioritize cassava farmers especially women and youth in state-level subsidy schemes for fertilizers, improved varieties, and irrigation tools.

ii. Non-Governmental Organizations and Development Partners should Provide targeted input packages (e.g., improved seeds, organic fertilizers) to vulnerable farmer groups through donor-funded initiatives.

iii. Government should deploy more trained extension agents with a mandate to conduct regular, hands-on demonstrations of Climate-Smart Agricultural Practices (CSAPs).

iv. Government should facilitate registration and training of cassava farmer groups to improve access to credit, markets, and technical support.

v. Government should develop culturally appropriate communication strategies using radio, drama, and community influencers to shift perceptions around climate-smart farming.

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