



## ECONOMICS OF THE ADOPTION OF CLIMATE-SMART AGRICULTURAL PRACTICES AMONG SMALLHOLDER RICE FARMERS IN DUTSE, JIGAWA STATE, NIGERIA

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### ABSTRACT

The study examined the economics of adopting Climate-Smart Agricultural Practices among smallholder rice farmers in Dutse Local Government Area, Jigawa State, Nigeria. A multi-stage sampling technique was used in 131 smallholder rice farmers from the study area. Computer-Assisted Personal Interviews (CAPI) were used for data collection. The Principal Component Analysis (PCA) was employed to identify the climate-smart agriculture practices adopted by smallholder rice farmers. At the same time, the Benefit-Cost Ratio analysis was used to evaluate the economic viability of the adoption of CSAPs. PCA results showed a Cronbach's Alpha coefficient of 0.915, a Kaiser-Meyer-Olkin of 0.869 and the Bartlett's test of sphericity  $\chi^2$  (df) = 2500 (274),  $p < 0.000$ . The PCA extracted five (5) uncorrelated factor components, involving 24 CSA practices: Climate-resilient rice cultivation (21.5%), Soil and land-based management (16.8%), Water and nutrient management (14.8%), Technological and diversification (10.7%), and Ecologically-friendly pest management (10.5%) of the total variation of CSAPs adoption patterns. Despite the initial high cost of adopting CSA, the Benefit-Cost analysis yielded a ratio of 3.03, an index of economic viability of the adoption of CSA. The study concludes that the adoption of climate-smart agricultural practices has significant economic viability for smallholder rice farmers in the study area. The study therefore recommended that improving access to credit, cooperative action, and scaling affordable water-saving technologies are the recommended pathways for enhancing climate-resilient rice production.

**Keywords:** Rice, Production, Smallholder-farmers, Economies, Climate-smart, Agriculture.

### INTRODUCTION

Nigeria's agricultural system is largely dominated by smallholder farmers, constituting over 88% of the population that is actively engaged in agricultural production (FAO *et al.*, 2022). In reality, this smallholder farming system is highly susceptible to climate change and climate variability due to the heavy reliance on rainfall and weather vagaries (Cohn *et al.*, 2017). These vulnerabilities are well pronounced in Nigeria, especially the northern part of the country, where Jigawa State is a key player in the rice system.

Rice production is, no doubt, the most critical food subsector in Nigeria. However, the rice subsector has come under severe adverse effects of climate change, especially the changes in temperature, water availability, and extreme weather events (Aruneshwaeran *et al.*, 2025). These climate-induced stressors lead to yield fluctuations, rising production costs, and environmental degradation, undermining the profitability and sustainability of smallholder rice farmers in Jigawa State and other rice production belts.

In response to climate change challenges, the Jigawa state government entered a new partnership with the Africa Rice Centre (AfricaRice) to strengthen climate-smart rice production and accelerate agricultural transformation across the state. The partnership was critical in building a modern and competitive rice sector through improved farmers' access to new technologies, resilient seed varieties, and modern production techniques needed to position Jigawa as a leading rice-producing hub. Additionally, the partnership was aimed at enhancing the adoption of climate-smart production technologies to boost yields and conserve natural resources, improving post-harvest handling and value addition to reduce losses and enhance market competitiveness, capacity development and the use of digital agriculture tools to improve farm management and support extension services (Agro Climate News, 2025).



The applicability of CSA in rice production encompasses a wide range of practices, including the use of climate-resilient rice varieties, improved water and nutrient management, conservation-oriented soil practices, ecological pest management, and emerging digital and energy-efficient technologies, among others (Zakaria *et al.*, 2023). The economic implications of CSA, particularly to smallholder rice producers, remain largely less understood in many developing contexts (Ngonjock *et al.*, 2026). Additionally, the adoption of CSAPs often entails additional upfront costs related to improved seed varieties, irrigation infrastructure, labour requirements, or technological investments. For resource-constrained smallholders, these costs may pose significant barriers to adoption, even when long-term benefits are potentially high (Ngonjock *et al.*, 2026). The economics of adopting CSA practices in rice production is thus a necessary step in ascertaining the benefits thereof, that CSA offers in the face of the mounting challenges of its adoption and implementation. Therefore, an in-depth understanding of the economics of CSAP adoption is critical for determining the viability of CSAPs among the rice farming communities. The study therefore examined the initial costs associated with the adoption of CSA, the economic benefits in terms of increased yield and income, and cost efficiency to ascertain the profitability and sustainable pathway for smallholder rice farmers in climate-stressed environments.

The concept of climate-smart agriculture (CSA) is not entirely new, emerging from the philosophy of production that leverages the existing agricultural practices with innovative techniques aimed at the optimisation of resource use, increased agricultural yield, and enhanced farmers' adaptive capacity to climate change (FAO, 2013). Proposed by FAO (2010) as a veritable solution to transform agricultural systems and support food security in a changing climate, CSA has gained popularity and applicability over the decades, especially in climate-stressed climes like Nigeria (Gabriel *et al.*, 2023). In the view of Maguza-Tembo *et al.* (2017), CSA offers a transformative framework that addresses the interconnected challenges of food insecurity, climate challenges, and rural underdevelopment.

Climate-smart agriculture emerged in response to the global threats of climate change and the need to increase agricultural productivity and food security, while also preserving the environment (FAO, 2018). Conceptually, climate-smart agriculture (CSA) involves a systematic approach to transform farming that aims to deliver positive outcomes on three impact pillars: intensification, adaptation, and mitigation to support food security under the new realities of climate change (FAO, 2013; Lipper, 2013; Adebisi, 2022; Kanu and Przezbórska, 2025). CSA's outcome is to improve the integration of agricultural development and climate responsiveness, which culminates in improved food security under a changing climate and increasing food demand. CSA practices are particularly relevant in rice production, where climate change has exacerbated the incidence of droughts, floods, and the unpredictability of weather patterns, which significantly affect yields and livelihoods (Aslam *et al.*, 2023). Thus, the conceptual framework of CSA in rice farming is based on integrating adaptive and mitigative strategies to ensure sustainable production while minimising environmental degradation.

## **METHODOLOGY**

### **The Study Area**

The study was conducted in Dutse Local Government Area, Jigawa State, Nigeria. Situated at Latitude 11<sup>o</sup>42'04"N and Longitude 9<sup>o</sup>20'31"E, the area covers a total of about 420 square metres (1,089 km<sup>2</sup>) according to City Facts (<https://www.city-facts.com>). It shares borders with Ringim and Jahun LGA in the North, Birnin Kudu to the South, Kiyawa to the East and Gaya LGA to the West. As a semi-arid region, Dutse LGA experiences high temperatures (approximately 42-43 °C) during hot conditions, and 17 – 20 °C within December and February (harmattan period). The region has a distinct wet and dry season. The wet season typically lasts from May to September, with average annual rainfall of 900 mm (Barau, 2015), while the dry season lasts from October to April. The vegetation in Dutse LGA is primarily Sudan savannah, and agriculture is the main occupation of the people, with rice, maize, sorghum, millet, groundnut, and cowpea as major crops cultivated in the area.

### **Sampling Procedure and Sample Size**

This study employs a multi-stage sampling procedure in the selection of rice farmers. Firstly, a purposive selection of three communities (Jigawar Tsada, Kachi and Madobi) was made on the basis of

the intensity of rice production activities. Also, two villages from each community were selected. The third stage involved a simple random sampling of a representative proportion of rice farmers in each of the selected villages. A total of 134±3 respondents were sampled for the study. However, due to human error in data collection, 131 questionnaires were returned as valid and were hereby analysed.

The sample size was determined using the Krejcie & Morgan Formula (Krejcie & Morgan, 1970 as cited by Uakarn *et al.*, 2021), considering the population size was known, which provides an optimal sample size based on the total population of respondents involved in rice farming. Krejcie & Morgan's formula is expressed as:

$$n = \frac{\chi^2 N p (1-p)}{e^2 (N-1) + \chi^2 p (1-p)} = \frac{3.841 * 460 * 0.75 (1-0.75)}{0.075^2 (460-1) + 3.841 * 0.75 (1-0.75)} = 133.777 \approx 134$$

Where:

n = sample size, N = sample frame (population size/Total population), e = acceptable error of sample size (7.5% Conroy, 2018),  $\chi^2$  = Chi-square  $df=1$  and reliability level 95% ( $\chi^2 = 3.841$ ), p = the population proportions (Assumed to be 5%).

Bowley's formula is expressed as:

$$n_i = n \frac{N_i}{N}$$

Where:

$n_i$  = Sample size at each stratum, n = Total sample size,  $N_i$  = Population of a specific strata.

**Table 1: Sampling Frame and Sample Size of Rice Farmers in the Study Area**

LGA	Community	Village	Sample frame	Sample size
Dutse	Kachi	Burtulan	72	21
		Zai	90	26
	Jigawa Tsada	Maganda	46	13
		Jaudi	60	18
	Madobi	Baranda	115	34
		Jangawa	77	22
Total	3	6	460	134

**Source:** JARDA (2022).

### Method of Data Analysis

The data collected were analysed using diverse methodologies. Principal Component Analysis (PCA) was employed to identify and group the CSA practices adopted by smallholder rice farmers in Dutse LGA, Jigawa State. Further, the Cost-Benefit ratio Analysis (CBA) was used to determine the viability of the adoption of CSA among the rice farming communities.

### Factor analysis

Factor Analysis, a multivariate statistical technique applied to a single set of variables when the interest is in determining which variables in the set form logical subsets that are relatively independent of one another (Shrestha, 2021). PCA was used to identify, group and summarise the CSA practices used in Dutse LGA, Jigawa State. In line with statistical practice, the appropriateness of the dataset for principal component analysis was tested using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (Antwi-Agyei and Amanor, 2023). The orthogonal rotation (Varimax rotation) method was employed, and the smaller number of highly correlated CSA practices were grouped under different components for easy interpretation and generalisation. This method has gained a wider application in climate-smart agricultural practices research in Kenya (Okumu, 2021; Wekesa *et al.*, 2018), Uganda (Galiwango *et al.*, 2025), Ghana (Antwi-Agyei and Amanor, 2023), and India (Goswami *et al.*, 2012; Singh *et al.*, 2023).

The PCA was modelled as;

$$y_j = \lambda_{j1}\eta_1 + \lambda_{j2}\eta_2 \dots \dots + \lambda_{jm}\eta_m + \varepsilon_j$$



Where,

$y$  = is an indicator;  $\lambda$  = is a factor loading;  $\eta$  = is a factor; and,  $\varepsilon$  = is a unique variance of  $y$ , respectively. Cost-Benefit Analysis (CBA) involves calculating the Net present value and the cost-benefit ratio.

Net Present Value (NPV):

$$NPV = \frac{\sum(B_t - C_t)}{(1 + r)^t}$$

Where:

$B_t$  = benefits in year  $t$ ;  $C_t$  = costs in year  $t$ ;  $r$  = discount rate;  $t$  = time period

$$\text{Benefit-Cost Ratio (BCR): } BCR = \frac{\sum B_t}{\sum C_t}$$

$B_t$  = benefits in year  $t$ ;  $C_t$  = costs in year  $t$ ; Cost indices include: Land preparation cost/ha (N); Labour cost/ha (N); Cost of seed/ha (N); Cost of inorganic fertilizer/ha (average cost in Naira); Cost of organic fertilizer/manure/ha (N); Cost of herbicides/ha (N); Pesticides cost/ha (N); Water/irrigation cost/ha (N); Other costs (N).

## RESULTS AND DISCUSSION

### Choice of CSA Adopted by Rice Farmers: Principal Component Analysis Approach

Results of the reliability analysis and assumption checks in Tables 2 and 3 revealed that the Bartlett's test of sphericity yielded a chi-square  $\{\chi^2 (df) = 2500 (274)^{***}\}$ , confirming the factorability of the dataset. The observed Kaiser-Meyer-Olkin of 0.869 implies that the variables used are sufficiently correlated, compacted and suitable for factor analysis (Rojas-Valverde *et al.*, 2020). Also, the reliability analysis of the CSAPs adoption scale was tested using Cronbach's Alpha. The overall result yielded an alpha coefficient of 0.915, indicating excellent internal consistency among the items. This suggests that the measurement scale used in the study is reliable and suitable for data analysis. These checks were done before factor extraction to ascertain the suitability of PCA for the study.

The principal factor analysis reduced the 24 CSAPs and extracted five distinct components with eigenvalues greater than 1 (Kaiser's criterion), explaining 76.0% of the total variance in the use of climate-smart agricultural practices among small-scale farmers in Dutse LGA, Jigawa State, Nigeria (Table 4). Based on the conventional 70 – 80% threshold (Galinwago *et al.*, 2025; Antwi-Agyei and Amanor, 2023; Hair *et al.*, 2019), the results showed that the retained factors captured CSAPs variation effectively, suggesting the multidimensionality of the adoption of CSAPs, which is driven by clusters of complementary practices rather than isolated technologies.

**Table 2:** Assumption Checks

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		<b>0.869</b>
Total Variance Explained		76.0
Bartlett's Test of Sphericity	Approx. Chi-square	2500
	Df	276
	Sig.	0.000

**Source:** Jamovi output, 2025



**Table 3: Item Reliability Statistics**

CSA practices	Mean	SD	Cronbach's $\alpha$
<b>Overall</b>	<b>2.98</b>	<b>0.501</b>	<b>0.915</b>
Water harvesting/irrigation	3.52	0.560	0.915
Contour ploughing	3.19	0.766	0.920
Use of renewable energy (solar pumps, bioenergy)	2.41	1.102	0.917
Crop diversification	2.69	0.842	0.910
Use of smart farming technologies (IoT, remote sensing, smart irrigation etc)	3.01	0.799	0.911
Integrated soil fertility management (organic & inorganic fertilizers)	2.40	0.909	0.912
Use of biopesticides	3.27	0.742	0.910
Integrated pest management (IPM)	3.13	0.826	0.912
Raised bed or ridges	3.48	0.599	0.914
Minimum/zero tillage	2.60	0.983	0.910
Seed treatment and priming	2.98	0.804	0.911
Cover cropping	3.36	0.904	0.911
Proper fertilizer application after soil testing	3.14	0.848	0.908
Mulching	2.71	0.864	0.910
Aerobic rice cultivation	2.74	0.828	0.910
Use of sandbags to prevent flooding	2.74	0.847	0.909
Reduce the use of chemical fertilizer	3.01	0.760	0.911
Agroforestry (Shade tree planting)	2.31	0.902	0.909
Early planting/adjusted planting calendar	3.12	1.089	0.908
Early maturing variety	2.78	1.055	0.912
Direct-seeded rice	3.11	1.069	0.908
Use of improved rice varieties	3.23	0.828	0.911
System rice intensification	3.23	0.891	0.908
Alternative wetting and drying (efficient water management)	3.47	0.612	0.911

**Source:** Jamovi output, 2025

The results in Table 4 revealed that the results of the component analysis show a clear hierarchy in the contribution of each cluster of Climate-Smart Agricultural (CSA) practices to the total variance explained. The first component (Climate-Resilient Rice Cultivation and Management Practices) explains 21.5% of the total variance and is dominated by high loadings on use of improved rice varieties (0.826), direct-seeded rice (0.794), early planting or adjusted planting calendar (0.750), early-maturing varieties (0.743), system of rice intensification (0.743), cover cropping (0.711), and aerobic rice cultivation (0.491). This shows that climate-resilient crop production strategies, especially rice-based innovations, are aimed at coping with rainfall variability, drought, flooding, and shortened growing seasons in climate-stressed climes like Dutse-Jigawa State.

Component two (Soil Fertility Management and Land-Based Practices) accounts for 18.6% of the total variance and loads heavily on integrated soil fertility management (0.847), agroforestry (0.836), use of sandbags to prevent flooding (0.783), minimum/zero tillage (0.742), proper fertilizer application after soil testing (0.735), and mulching (0.642). By implication, rice farmers in the area give priority to practices that directly enhance crop resilience and yield stability. Component three (Water and Nutrient Management) explains 14.8% of the variance and is characterised by strong loadings on raised beds or ridges (0.807), alternative wetting and drying (0.755), reduced use of chemical fertilizer (0.661), water harvesting/irrigation (0.656), and contour ploughing (0.523). This component reflects the growing importance of efficient resource use and sustainable input management, especially in areas facing water scarcity or high fertilizer costs. Additionally, the association with reduced chemical fertilizer use suggests a shift towards environmentally friendly production systems, possibly driven by cost considerations and climate-induced nutrient losses.



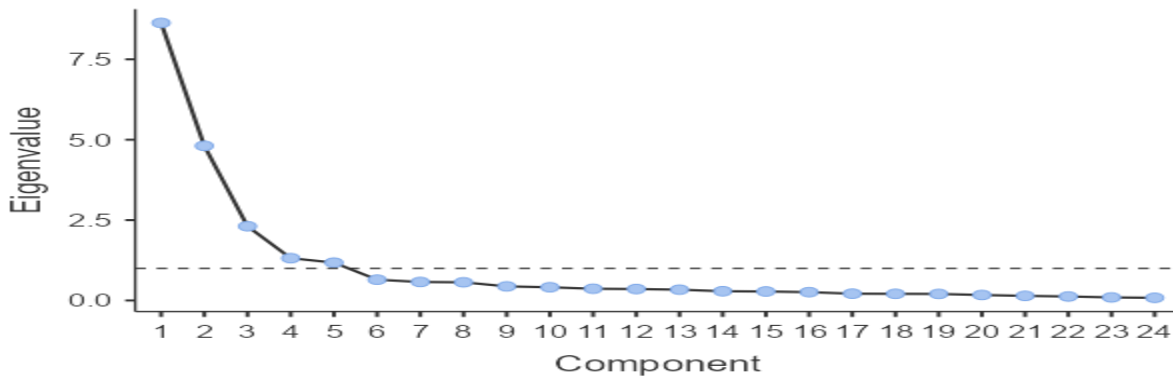
Component four (Technological and Diversification Practices) accounts for 10.7% of the explained variance, with high loadings on crop diversification (0.824), use of smart farming technologies such as IoT and remote sensing (0.751), and use of renewable energy, including solar pumps and bioenergy (0.683). The recognition of practices such as crop diversification serves as a traditional risk-spreading mechanism, while the adoption of smart technologies and renewable energy reflects emerging responses to climate variability and rising energy costs. The adoption of these practices certainly requires higher capital investment and technical know-how. Component five (Eco-friendly Pest and Seed Enhancement Practices) explains 10.5% of the total variance and loads strongly on integrated pest management (0.752), use of biopesticides (0.731), and seed treatment and priming (0.730). Though ranked last, component five is relevant because it demonstrates farmers' gradual adoption of environmentally sound pest and soil health practices. These findings are consistent with Khatri-Chhetri *et al.* (2022) and FAO (2024), who emphasised that CSA is an integrated framework combining technological, ecological, and management-based approaches to strengthen agricultural resilience.

The scree plot analysis (Figure 1) was conducted to validate the retained components extracted. The plot showed a distinct inflection after the 5<sup>th</sup> component, suggesting that subsequent components contributed minimally to the variance. The retained five components were therefore consistent with Kaiser's criterion (Eigenvalues >1) as supported by the scree-plot. The five factors with eigenvalues of 8.6328, 4.8081, 2.3083, 1.3156 and 1.1772, respectively, were retained.

**Table 4: Principal Component Analysis**

Items	Component					Uniqueness
	1	2	3	4	5	
Use of improved rice varieties	0.826					0.290
Direct-seeded rice	0.794					0.161
Early planting/planting calendar	0.750					0.182
Early maturing variety	0.743					0.210
System rice intensification	0.743					0.295
Cover cropping	0.711					0.288
Aerobic rice cultivation	0.491					0.289
Integrated soil fertility management		0.847				0.191
Agroforestry (Shade tree planting)		0.836				0.202
Use of sandbags		0.783				0.235
Minimum/zero tillage		0.742				0.114
Proper fertilizer application after soil testing		0.735				0.264
Mulching		0.642				0.302
Raised bed or ridges			0.807			0.250
Alternative wetting and drying (efficient water management)			0.755			0.228
Reduced use of chemical fertilizer			0.661			0.379
Water harvesting/irrigation			0.656			0.209
Contour ploughing			0.523			0.278
Crop diversification				0.824		0.165
Use of smart farming technologies (IoT, remote sensing, smart irrigation)				0.751		0.252
Use of renewable energy				0.683		0.218
Integrated pest management (IPM)					0.752	0.276
Use of biopesticides					0.731	0.210
Seed treatment and priming					0.730	0.269
SS loading	5.17	4.46	3.54	2.56	2.52	
% of variance	21.5	18.6	14.8	10.7	10.5	
Cumulative %	21.5	40.1	54.9	65.5	76.0	

Note. 'varimax' rotation was used. **Source:** Jamovi output, 2025



**Figure 1:** The Graphical Representation of the Eigenvalues of the Components.

### Cost and Benefit Analysis of CSAPs Adoption

The results in Tables 5 and 6 showed that the total cost of adopting CSA practices per hectare was ₦710,902.50. The major cost components included inorganic fertilizer (₦201,221.37; 28.31%), water/irrigation (₦163,324.32; 22.97%), and other miscellaneous costs (₦117,804; 16.57%). These findings indicate that input-intensive components, particularly fertilizers and irrigation, account for the largest proportion of production expenses among smallholder rice farmers in Dutse. This observation is consistent with Shehu (2024), who reported that fertilizer and irrigation costs are the primary expenditure items affecting CSA adoption among smallholder farmers in Northern Nigeria. Arimi *et al.* (2023) similarly noted that high input costs constrained full adoption of sustainable soil management practices.

The results in Table 6 highlight the economic performance of farmers using CSA practices based on farm size, productivity, and market price. The mean hectareage of 2.18 ha indicates that the respondents are predominantly smallholder farmers. The relatively small farm size is typical of rice farmers in northern Nigeria and is consistent with previous studies reporting average holdings of 1–3 hectares among small-scale producers. Despite the small farm sizes, CSA practices still enable the farmers to achieve meaningful returns. The average yield of 1,857.26 kg/ha reflects productivity under CSA adoption. Although yield levels vary across farmers, this value indicates that CSA practices have enhanced crop performance compared to conventional systems, especially through improved varieties, better water management, and integrated nutrient practices. This aligns with existing evidence that CSA practices often lead to higher and more stable yields. The average selling price of ₦492.21 per kg shows that rice produced through CSA practices attracts a competitive market value.



**Table 5:** Costs and Benefits of Adopting CSA Practices

Items	Range	Minimum	Maximum	Sum	Mean	Std. Dev.	Skewness Statistic	Std. error
Land preparation cost/ha (N)	95500	4500	100000	5387000	41438.46	20497.023	0.822	0.212
Labour coat/ha (N)	145000	15000	160000	6717000	51274.81	24822.773	1.322	0.212
Cost of seed/ha (N)	78000	10000	88000	5168000	39450.38	22522.113	0.915	0.212
Cost of inorganic fertilizer/ha (average cost in Naira)/	400000	50000	450000	26360000	201221.37	51557.629	1.009	0.212
Cost of organic fertilizer/manure/ha (N)	85000	5000	90000	5757400	47191.8	20303.945	-0.213	0.219
Cost of herbicides/ha (N)	40000	10000	50000	3623000	27869.23	13090.406	0.633	0.212
Pesticides cost/ha (N)	83000	2000	85000	2730000	21328.12	15296.214	1.257	0.214
Water/irrigation cost/ha (N)	370000	30000	400000	6043000	163324.32	89955.252	1.098	0.388
Other costs (N)	880000	20000	900000	14725500	117804	85711.371	6.274	0.217
Total cost (N)	2176500	16277.78	258111.11	8501211.1	78989.166	38195.19	1.457	0.233
Average hectarage (ha)	7	1	8	284	2.18	1.363	1.750	.212
Average yield/ha	3700	800	4500	243301	1857.26	689.752	0.265	0.212
Unit price	250	350	600	64480	492.21	27.771	-0.782	0.212
Total yield	18400	800	19200	567891	4335.0458	3435.3237	1.685	0.212
Total income	9247900	352100	9600000	282299900	2154961.1	1711586.2	1.673	0.212

**Source:** Author's Computation, 2025

**Table 6: Cost Analysis of Adopting CSA Practices/ha**

Items	Mean values	% of TC
Land preparation cost/ha (N)	41,438.46	5.83
Labour coat/ha (N)	51,274.81	7.21
Cost of seed/ha (N)	39,450.38	5.55
Cost of inorganic fertilizer/ha (average cost in Naira)	201,221.37	28.31
Cost of organic fertilizer/manure/ha (N)	47,191.8	6.64
Cost of herbicides/ha (N)	27,869.23	3.92
Pesticides cost/ha (N)	21,328.12	3.00
Water/irrigation cost/ha (N)	163,324.32	22.97
Other costs (N)	117,804	16.57
Total cost (N)	710,902.5	100

**Source:** Field Survey, 2025

The relatively high price may be attributed to better grain quality or improved post-harvest handling facilitated by CSA techniques. Higher product quality often results in favourable pricing, contributing to increased farm profitability. The total yield figure represents the overall output from the average farm size of 2.18 ha (Table 7). This output level demonstrates that CSA practices support efficient resource use and better resilience against environmental stresses. With adequate water management and improved agronomic practices, farmers achieve substantial production volumes even on small plots. The total income of approximately ₦2.15 million indicates the gross returns farmers derive from adopting CSA practices. This income level shows that CSA adoption is financially rewarding, offering considerable economic benefits per farming cycle. The combination of moderate farm size, high-quality output, and favourable market prices results in substantial gross revenue. This aligns with recent studies highlighting CSA as a profitable and sustainable approach to agricultural production.

The results in Table 8 show that the mean total income per hectare was ₦2,154,961.10, with a gross margin of ₦1,444,058.60 and a benefit–cost ratio (BCR) of 3.03. A BCR greater than 1 indicates that CSA adoption is economically viable and profitable. These results align with the FAO (2021), which highlights that climate-smart agriculture—through improved water management, soil fertility enhancement, and stress-tolerant crop varieties- can significantly improve productivity and profitability for smallholder farmers. *et al.* (2024) also reported that adoption of CSA practices leads to higher production efficiency, crop income and enhanced food security.

**Table 7: Gross return/Benefits of Adopting CSA Practices/ha**

Items	Mean values
Average hectarage (ha)	2.18
Average yield/ha	1,857.26
Unit price	492.21
Total yield	4,335.0458
Total income	2,154,961.1

**Source:** Field survey, 2025

**Table 8: Costs and Benefits of Adopting CSA Practices**

Cost and Return	Unit	Production/cycle
A. Gross return	₦	2,154,961.1
B. Total Cost (TC)	₦	710,902.5
C. Gross margin (A -B)	₦	1,444,058.6
D. Benefit-Cost Ratio (A÷B)	₦	3.03

**Source:** Field survey, 2025



## CONCLUSION AND RECOMMENDATION

The study concludes that the cost–benefit analysis demonstrates that adoption of climate-smart agricultural practices in the study area is viable, indicating that returns substantially outweigh adoption and production costs. The study recommends the mainstreaming of CSA into agricultural and climate change adaptation policies as a response to climate change interventions. Additionally, enhanced credit schemes, climate-smart input subsidies, and cooperative-based financing are critical to overcoming initial cost barriers among smallholder rice farmers.

## REFERENCES

- Adebisi, L. O., Adebisi, O. A., Jonathan, A., Oludare, O. T., & Egbodo, B. E. (2022). Effect of climate-smart agricultural practices on food security among farming households in Kwara state, North Central Nigeria. *Pesq. Agropec. Trop.*, **52**: 705-718.
- Agro Climate News (2025). Jigawa, AfricaRice sign new deal to advance climate-smart rice production. <https://www.agroclimatenews.com/2025/11/14/jigawa-africarice-sign-new-deal-to-advance-climate-smart-rice-production>
- Antwi-Agyei, P., & Amanor, K. (2023). Typologies and drivers of the adoption of climate-smart agricultural practices by smallholder farmers in rural Ghana. *Current Research in Environmental Sustainability*, **5**(2): 100-112.
- Arimi, K., Godonu, K., Orowole, P., & Adenubi, O. (2025). Constraints to Climatesmart Soil Management Practices in Ogun State, Nigeria: A Probit Model Approach. *International Journal of Food Science and Agriculture*, **9**(4): 338-345. DOI: 10.26855/ijfsa.2025.12.010
- Aruneshwaeran, A., Ragunath, K. P., Pazhanivelan, S., Jagadeeswaran, R., Dheebakaran, G. A., & Tarun, T. K. (2025). Impact of climate change on rice crop yield: challenges and solutions. *Plant Science Today*, **12**(1): <https://doi.org/10.14719/pst.8910>
- Aslam, M., Rasool, M., Qadir, I.U., Zahid, U., Hayat, R., Ahmed, M. (2023). Key Challenges and Financial Needs to Promote Climate-Smart Agriculture (CSA) in Pakistan: A Case Study of Hunza, Pakistan. In: Ahmed, M., Ahmad, S. (eds) *Disaster Risk Reduction in Agriculture. Disaster Resilience and Green Growth*. Springer, Singapore. [https://doi.org/10.1007/978-981-99-1763-1\\_25](https://doi.org/10.1007/978-981-99-1763-1_25)
- Barau, R. M. (2015). Urban Morphology Dynamics and Environmental Changes in Kano, Nigeria. *Land Use Policy*, **3**: 307-317.
- Cohn, A. S., Newton, P., Gil, J. D. B., Kuhl, L., Samberg, L., Ricciardi, V., Manly, R. M., Northrop, N. (2017). Smallholder Agriculture and Climate Change. *Annual Review of Environment and Resources*. **42**: 347-375. <https://doi.org/10.1146/annurev-environ-102016-060946>
- Conroy, R. M. (2018). The RCSI Sample size handbook A rough guide, May 2018 version. Royal College of Surgeons in Ireland. DOI: 10.13140/RG.2.2.30497.51043
- FAO (2013). *Climate-Smart Agriculture: Managing Ecosystems for Sustainable Livelihoods*. FAO Knowl. Repos. 2013. Available online: <https://openknowledge.fao.org/3/a-an177e.pdf>
- FAO (2010). *Food and Agriculture Organization of the United Nations (FAO). Climate-Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. 2010. Available online: <http://www.fao.org/docrep/013/i1881e/i1881e00.pdf>
- FAO (2024). *FAO Conceptual Framework for Integrated Land and Water Resources Management*. <https://openknowledge.fao.org/server/api/core/bitstreams/965aab0f-068d-4b54-aeda-b1ccdbd190c7/conten>
- FAO, (2018). *Climate-Smart Agriculture Case Studies 2018. Successful approaches from different regions*. Rome. 44 pp. Licence: CC BY-NC-SA 3.0 IGO.
- FAO, European Union and CIRAD. (2022). *Food Systems Profile – Nigeria. Catalysing the sustainable and inclusive transformation of food systems*. Rome, Brussels and Montpellier, France. <https://doi.org/10.4060/cc3380en>
- FAO. (2021). *The state of food and agriculture 2021: Making agrifood systems more resilient*. Food and Agriculture Organization.



- Gabriel, I., Olajuwon, F., Klauser, D., Michael, B., & Renn, M. (2023). State of climate-smart agriculture (CSA) practices in the North Central and Northwest zones, Nigeria. *CABI Agriculture and Bioscience*, **4**: 33-42. <https://doi.org/10.1186/s43170-023-00156-4>
- Galiwango, H., Miro, R., Egeru, A., & Turyahabwe, N. (2025). Continued use of climate-smart agricultural practices in central Uganda cattle corridor: a farming household typology perspective. *Front. Sustain. Food Syst.* **9**: 166-173. doi: 10.3389/fsufs.2025.1662991
- Goswami R, Biswas MS, Basu D. (2012). Validation of participatory farming situation identification: a case of rainfed rice cultivation in selected area of West Bengal, India. *Indian J Tradit Knowl.* **11**: 471–479.
- Kanu, I. M., & Przezbórska, S. L. (2025). Socio-Economic Determinants of Climate-Smart Agriculture Adoption: A Novel Perspective from Agritourism Farmers in Nigeria. *Sustainability*, **17**: 5521. <https://doi.org/10.3390/su17125521>
- Khatri-Chhetri, A., Aggarwal, P. K., Joshi, P. K., and Vyas, S. (2017). Farmers' prioritization of climate-smart technologies. *Agricultural Systems*, **151**: 184–191
- Kifle, T., Ayal, D. Y., & Mulugeta, M. (2022). Factors influencing farmers' adoption of climate-smart agriculture to respond to climate variability in Siyadebrina Wayu district, Central Highland of Ethiopia. *Clim. Serv.*, **26**, 100290.
- Krejcie, R.V., & Morgan, D.W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, **30**: 607 – 610.
- Lipper, L., & Thornton, P. (2014). Climate-smart agriculture for food security. *Nature Climate Change*, **4**(12): 1068–1072.
- Maguza-Tembo, F., Edriss, A.-K., & Mangisoni, J. (2017). Determinants of Climate-Smart Agriculture Technology Adoption in the Drought-Prone Districts of Malawi Using a Multivariate Probit Analysis. *Asian J. Agric. Ext. Econ. Sociol.*, **16**: 1–12.
- Ngonjock, J., Ali, E., & Soh Wenda, B. (2026). Climate-smart agriculture adoption and technical efficiency of smallholder farms in Northern Togo. *Mitig Adapt Strateg Glob Change*, **31**: 4-12. <https://doi.org/10.1007/s11027-025-10259-0>
- Okumu, J. J., Sibiko, K. W., and Mose, P. B. (2021). Drivers of perceived sustainability of climate smart Agricultural projects in Kakamega County, Kenya. *East African Agricultural and Forestry Journal*, **85**(3 and 4), 12–22.
- Orifah, M. O., Muktar, B. G., Sanusi, M. S., Mukhtar, U., Bello, O. G., Makinta, U., Garba, U., Haruna, U. (2024). Adoption of Climate-Smart Agricultural Practices among Smallholder Rice Farmers in Dutse, Jigawa State, Nigeria. ISPEC 14. International Conference on Agriculture, Animal Science & Rural Development, March 22-24, 2024, At: Izmir/TÜRKİYE
- Rojas-Valverde, D., Pino-Ortega, J., Gómez-Carmona, C. D., & Rico-González, M. (2020). A Systematic Review of Methods and Criteria Standard Proposal for the Use of Principal Component Analysis in Team Sports Science. *International Journal of Environmental Research and Public Health*, **17**(23): 8712. <https://doi.org/10.3390/ijerph17238712>
- Saadu, B., Ibrahim, H. Y., Nazifi, B., & Mudashiru, A. (2024). Adoption of climate-smart agricultural practices and its impact on smallholder farming households in some rural areas of North-Western Nigeria. *Agricultura Tropica Et Subtropica*, **57**(4): 23–34. DOI: 10.2478/ats-2024-0003
- Shehu, H. (2024). Assessment of Small-Holder Farmers' Adoption of Climate-Smart Agriculture Practices in Borno State, Nigeria. *Journal of Agricultural Economics, Environment and Social Sciences*, **10**(2): 101-111. Retrieved from <https://jaeess.com.ng/index.php/jaeess/article/view/247>
- Singh, A.K., Ashraf, S.N., Sharma, S.K. (2023). Farmer's Perception on Climatic Factors and Socio-economic Characteristics in the Agricultural Sector of Gujarat. *Research on World Agricultural Economy*. **4**(1): 788. <http://dx.doi.org/10.36956/rwae.v4i1.788>
- Uakarn, C., Chaokromthong, K., & Sintao, N. (2021). Sample Size Estimation using Yamane and Cochran and Morgan and Green Formulas and Cohen Statistical Power Analysis by G\*Power and Comparisons. *Apheit International Journal*, **10**(2): 76-88.



*Nigerian Journal of Agriculture and Agricultural Technology (NJAAT)*  
**Volume 6, Number 1A, March 2026**  
**ISSN (Print): 2811-1885; ISSN (Online): 2811-1893**



- Wekesa, B. M., Ayuya, O. I., and Lagat, J. K. (2018). Effect of climate-smart agricultural practices on household food security in smallholder production systems: Micro-level evidence from Kenya. *Agric. Food Secur.* 7: 1–14. doi: 10.1186/s40066-018-0203-9
- Zakaria, F. F. (2023). Application of Climate Smart Agriculture Approach for Agricultural Development to African Food Security and Sustainability of Agriculture as well as Adaptation to Future Climate Changes. *FARA Research Report*, 7(3): 375-394. <https://doi.org/10.59101/frr072330>