

Original Research Article

Assessing the Adoption and Utilization Levels of Climate-Smart Agricultural Practices among Farmers in Benue and Nasarawa States, Nigeria

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Abstract: The study assessed the adoption and utilisation of Climate-Smart Agricultural Practices (CSAPs) among rice farmers in Benue and Nasarawa States, Nigeria. Primary data were collected from 400 rice farmers through a structured questionnaire using a multistage sampling technique. Descriptive statistics and the Ordered Probit regression model were employed to analyse the data. The results revealed that the mean age of farmers was 42 years, most were male (64.75%) and married (74.75%), and 63% had at least secondary education. The majority (62.75%) had access to extension services while only 16% accessed agricultural credit. The results also shows that the majority of rice farmers were medium and high users of CSAPs, indicating a relatively high adoption level in both states. Commonly adopted practices included wetland (Fadama) cultivation, crop rotation, cover cropping, minimum tillage, and the use of organic manure. Moreover, the Ordered Probit regression results showed that education ($p \leq 0.01$), household size ($p \leq 0.01$), family labour ($p \leq 0.05$), access to extension services ($p \leq 0.01$), ownership of communication tools ($p \leq 0.10$), sex ($p \leq 0.05$), livestock ownership ($p \leq 0.01$), and farm size ($p \leq 0.10$) had significant positive effects on CSAP utilisation. Conversely, age ($p \leq 0.10$) and distance to input markets ($p \leq 0.01$) exerted significant negative influences on utilisation levels. The study concludes that enhancing farmers' access to information, credit, and extension services is crucial for increasing CSAP adoption and utilisation. Therefore, the study recommends that government agencies and agricultural extension services should formulate and implement policies that promote farmer education, expand extension outreach, and provide accessible financial and infrastructural support to accelerate the widespread adoption of CSAPs in the region.

Keywords: Climate-Smart, Adoption, Utilization, Rice, Farmers.

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1.0 INTRODUCTION

Rice (*Oryza sativa* or *Oryza glaberrima*) is one of the most widely cultivated and consumed staple foods worldwide, providing sustenance to billions of people. It has been cultivated for over

10,000 years globally and about 3,000 years in Africa, making it a vital source of food and livelihood (University of Nebraska-Lincoln, 2024). In Africa, demand for rice is projected to more than double within the next 25 years due to population growth

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and rising consumption levels (Fuglie, Jelliffe, & Morgan, 2021). To meet this growing demand, the continent imports nearly 40% of its rice, and projections indicate that Africa may overtake Southeast Asia as the largest rice importer by 2030 (Durand-Morat & Bairagi, 2021). Nigeria, the largest rice producer in Sub-Saharan Africa, still faces a significant production-consumption gap. Although rice is cultivated across all geopolitical zones, domestic supply remains insufficient to meet national demand (Yakubu, Akpoko, Akinola, & Abdusalam, 2021; Alabuja *et al.*, 2025a). The United States Department of Agriculture–Foreign Agricultural Service (USDA-FAS, 2022) reported that Nigeria produces about 5.5 million tonnes of milled rice annually, compared to a consumption level of approximately 8 million tonnes, resulting in heavy dependence on imports despite substantial government investment.

Rice production in Nigeria is concentrated in the guinea savanna region, where favourable climatic and soil conditions support large-scale cultivation. Within this zone, Benue and Nasarawa States are major contributors to national rice output. Benue ranks second among Nigeria's leading producers with an annual capacity of about 1.5 million metric tonnes (Nigerian Infopedia, 2022, as cited in Ogebe, Abah, & Olagunju, 2022), while Nasarawa also contributes significantly to national production. Together, these states play a pivotal role in positioning Nigeria as the leading rice producer in West Africa, accounting for about 46% of the subregion's total harvest (Food and Agriculture Organization Statistics [FAOSTAT], 2023). However, most rice farmers in these states are smallholders who depend heavily on rainfall and use limited modern inputs or mechanized tools, resulting in low yields, declining soil fertility, and unstable incomes (Mekonnen, Tessema, Ganewo, & Haile, 2021; Phillip, Jayeoba, Ndirpaya, & Fatunbi, 2018).

The adverse effects of climate change, including erratic rainfall, floods, and rising temperatures, have further exacerbated these challenges, threatening rice productivity and farmers' livelihoods (Ugwoke, Gershonb, Becchioa, Corgnatia, & Leone, 2020). Moreover, only about 57% of domestic rice consumption is met locally, while 43% is supplied through imports and informal trade (KPMG Global Organisation, as cited in Abubakar, Adamu, & Aliyu, 2023; Alabuja *et al.*, 2025b). Similarly, Nigeria ranks 152nd out of 187 countries in climate vulnerability (ND-GAIN, 2021), with average yields of about 2 tonnes per hectare, far below Asia's 4–7 tonnes (USDA-FAS & International Production Assessment Division [IPAD], 2024).

To address these challenges, the adoption of Climate-Smart Agriculture (CSA) has been promoted

as a sustainable approach to enhance productivity, resilience, and mitigation of greenhouse gas emissions (FAO, 2021; Williams *et al.*, 2015). CSA integrates innovative practices such as improved seed varieties, efficient land and water management, conservation tillage, crop diversification, and integrated pest and nutrient management (Das, Ansari, & Ghosh, 2022). These Climate-Smart Agricultural Practices (CSAPs) enable farmers to adapt to changing climatic conditions, improve yields, and enhance welfare. However, adoption and utilisation among smallholders remain low and uneven due to poor access to extension services, limited credit, and weak institutional support (Rabin, 2013; Awe *et al.*, 2023; Ojoko, Akinwunmi, Yusuf, & Oni, 2023).

Previous studies in Africa (Marty, Etwire, & Abdoulaye, 2020; Maseko, Karuaihe, & Jourdain, 2023; Mossie, 2021) and Nigeria (Awe *et al.*, 2023; Ojoko *et al.*, 2023) have mainly focused on specific CSAPs or different regions, leaving a gap in understanding multiple-practice adoption and utilisation among rice farmers in Benue and Nasarawa States. Consequently, strengthening farmers' resilience and promoting sustainable rice production require an in-depth understanding of the socio-economic, institutional, and environmental factors influencing the adoption and utilisation of CSAPs.

Against this background, this study empirically assesses the adoption and utilisation levels of Climate-Smart Agricultural Practices among rice farmers in Benue and Nasarawa States, Nigeria.

Therefore, the broad objective of the study is to assess the adoption and utilisation levels of Climate-Smart Agricultural Practices (CSAPs) among rice farmers in Benue and Nasarawa States, Nigeria.

The specific objectives are to:

- i. describe the socio-economic characteristics of rice farmers in the study area;
- ii. identify the major Climate-Smart Agricultural Practices (CSAPs) adopted by the farmers;
- iii. determine the level of utilisation of these practices among rice farmers; and
- iv. analyse the socio-economic and institutional factors influencing the adoption and utilisation of CSAPs in the study area.

The findings are expected to provide useful evidence for policymakers, agricultural extension officers and development partners in designing targeted interventions that enhance CSAP adoption, promote sustainable rice production, and strengthen farmers' resilience to climate variability in Nigeria.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Benue and Nasarawa States, located in North-Central Nigeria. The region experiences a tropical continental climate with distinct wet (May–October) and dry (November–April) seasons, annual rainfall ranging from 1,200 to 1,500 mm, and temperatures between 23°C and 34°C, except during the Harmattan period. It is drought-prone, with climatic irregularities often leading to crop failures and yield reductions (Woomer *et al.*, 2014; Nwajiuba, Emmanuel, & Bangali, 2015). Benue State, known as the “Food Basket of the Nation,” covers about 34,059 km² and lies between longitudes 7°47′–10°00′ E and latitudes 6°25′–8°08′ N. It shares boundaries with Nasarawa, Taraba, Cross River, Enugu, and Kogi States, and its predominantly ultisol and oxisol soils support rice, yam, maize, cassava, soybean, and sesame cultivation. In 2023, Benue produced about 1.5 million metric tonnes of rice, contributing significantly to Nigeria’s total output of 5.6 million tonnes (Nigerian Investment Promotion Centre [NIPC], 2024). Nasarawa State, created in 1996 from Plateau State, lies between longitudes 8°20′–8°40′ E and latitudes 8°20′–8°38′ N, covering approximately 2,797.5 km². The state is largely plain, drained by the Benue and Mada rivers, and consists of thirteen Local Government Areas. Its major crops include rice, cassava, yam, and maize, while livestock such as cattle and goats are also common. In 2023, Nasarawa produced about 523,000 metric tonnes of rice, representing roughly 3% of national output (NIPC, 2024). Both states are major rice-producing areas and thus suitable for examining the adoption and utilisation of Climate-Smart Agricultural Practices aimed at enhancing productivity and resilience to climate variability.

2.2 Sampling Technique and Sample Size

A multistage sampling procedure was adopted to select rice farmers from the study area. The first stage involved the purposive selection of Benue and Nasarawa States in North Central Nigeria due to their prominence in rice production and vulnerability to climate change (Adejo, Amos, and Awolala, 2024; Aveuya, Unongo, and Bogbenda, 2023). In the second stage, eight Local Government Areas (LGAs) were purposively selected, five from Benue State and three from Nasarawa State, based on the relative proportion of LGAs in each state. The third stage involved the selection of rice-farming communities within the chosen LGAs, after which individual farmers were randomly selected for inclusion in the study. In total, 400 rice farmers were selected and interviewed, comprising 235 farmers from Benue State and 165 farmers from Nasarawa State. The sample size was determined using the Cochran (1977) approach, which is suitable for

populations of unknown size, with adjustments made to ensure adequate representation and account for possible non-responses.

2.3 Method of Data Collection

This study utilized cross-sectional data obtained from primary sources. Data were collected using a well-structured questionnaire designed to capture information on the socio-economic characteristics of rice farmers, types of Climate-Smart Agricultural Practices (CSAPs) adopted, factors influencing the choice and level of utilisation of these practices, as well as data on inputs, outputs, household income, and expenditure. Trained enumerators administered the questionnaires using the KoboToolbox software to ensure accuracy and efficiency during data collection. Descriptive statistics such as means, frequencies, percentages and a four-point Likert scale were employed to summarise respondents’ socio-economic characteristics, the types of CSAPs adopted and their level of utilisation. The utilisation levels of CSAPs were measured in ordered categories: low, medium, and high. Inferential statistics, specifically the ordered probit model, were used to analyse the determinants influencing the level of CSAP utilisation among rice farmers in the study area.

2.4 Model Specification

The Ordered Probit Model was employed to estimate the determinants of Climate-Smart Agricultural Practices (CSAPs) utilisation among rice farmers in Benue and Nasarawa States. The model assumes that each farmer has an underlying, unobserved (latent) variable (Y^*), which represents the farmer’s propensity to utilise CSAPs. This latent variable is influenced by a vector of explanatory variables (X_i) and an error term (ϵ_i) that captures unobserved factors.

The relationship can be expressed as:

$$Y^* = X_i\beta + \epsilon_i \text{ eqn (1)}$$

Where:

Y^* = latent variable representing the farmer’s unobserved utilisation tendency

X_i = vector of explanatory variables

β = vector of parameters to be estimated

ϵ_i = random error term, assumed to follow a standard normal distribution

Although Y^* is unobserved, the observed dependent variable (Y_i) takes on ordered discrete values corresponding to the utilisation levels of CSAPs, defined as:

($Y_i = 0$ for no utilisation; $Y_i = 1$ for low utilisation; $Y_i = 2$ for medium utilisation; $Y_i = 3$ for high utilisation).

The explanatory variables (X_i) included in the model are:

- X_1 = Age of the farmer (years)
- X_2 = Sex (male = 1, female = 0)
- X_3 = Level of education (years of formal schooling)
- X_4 = Farming experience (years)
- X_5 = Household size (number of persons)
- X_6 = Family labour availability (man-days)
- X_7 = Farmland ownership (owned = 1, not owned = 0)
- X_8 = Membership of farmer associations (yes = 1, no = 0)
- X_9 = Access to extension services (yes = 1, no = 0)
- X_{10} = Ownership of communication tools (yes = 1, no = 0)
- X_{11} = Household income from rice (₦)
- X_{12} = Off-farm income (₦)
- X_{13} = Livestock ownership (yes = 1, no = 0)
- X_{14} = Size of rice farmland (hectares)
- X_{15} = Distance from farm to input market (kilometres)

3.0 RESULTS AND DISCUSION

3.1 Socio-Economic Characteristics of Rice Farmers in the Study Area

The socio-economic characteristics of the rice farmers, such as age, sex, marital status, household size, education, access to credit, income, farming experience, extension contact, and group membership, are presented in Tables 1 and 2. The age distribution indicates that most rice farmers in Benue (31.06%) and Nasarawa (40.00%) States were within 41 to 50 years, with a pooled mean of 42 years. This aligns with Echebiri and Onu (2019), who reported a similar mean age of 44 years among farmers in Akwa Ibom State. The predominance of middle-aged farmers suggests strong potential for CSAP adoption, as they combine physical strength and experience, while the presence of younger farmers further reflects a favourable demographic for innovation uptake.

Gender analysis reveals male dominance in rice farming, accounting for 69.36% in Benue and

58.18% in Nasarawa, with a pooled mean of 64.75%. This observation supports Zaknayiba and Tanko (2013), who reported male predominance in crop farming. Male farmers typically have greater access to land, credit, and extension services, which may enhance their capacity to adopt CSAPs. However, the substantial female participation (35.25%) highlights women's crucial yet often under-recognised role in rice production and climate adaptation.

The results further show that 74.75% of farmers were married, consistent with the findings of Tsukutoda, Rukwe, Bidoli and Orji (2022), who reported that marriage fosters stability and enhances long-term investment decisions among farming households. Married farmers are more likely to adopt sustainable agricultural practices that ensure household food security and income stability. The mean household size was nine persons in Benue and eight in Nasarawa, indicating that family labour remains an important input in rice farming.

In terms of education, 41.25% of respondents had secondary education, while 22% attained tertiary education. This finding contrasts with Pelemo *et al.*, (2019), who reported lower literacy levels among farmers in Kogi State, but aligns with Babalola, Megbope, and Agbola (2017), who observed moderate literacy among rural farmers in Ogun State. Education enhances farmers' ability to comprehend and implement new agricultural technologies, including CSAPs.

Access to agricultural credit was generally low across both states, with only 16% of respondents having received credit facilities. This aligns with the study of Pelemo *et al.*, (2018), who found that limited access to credit constrains farmers' capacity to adopt improved farming practices. Access to credit remains a critical determinant of technology adoption since CSAPs often require financial investment in inputs, irrigation systems, and equipment.

Table 1: Socioeconomic Characteristics of Rice Farmers in the Study Area

Socioeconomics Variables	Benue State (n=235) Percentage (%)	Nasarawa State (n=165) Percentage (%)	Pooled Mean (N=400) Percentage (%)
Rice Farmers' Age (Yrs)			
30 and less	46(19.75)	14(8.48)	60(15.00)
31-40	71(30.21)	53(32.12)	124(31.00)
41-50	73(31.06)	66(40.00)	139(34.75)
51-60	37(15.74)	28(16.97)	65(16.25)
Above 60	8(3.40)	4(2.42)	12(3.00)
Mean	42	43	42
Sex of Rice Farmers			
Female	72(30.64)	69(41.82)	141(35.25)
Male	163(69.36)	96(58.18)	259(64.75)
Marital Status of Rice Farmers			
Married	180(76.60)	119(72.12)	299(74.75)
Single	36(15.32)	27(16.36)	63(15.75)
Widowed	8(3.40)	12(7.27)	20(5.00)
Divorced/Separated	11(4.68)	7(4.24)	18(4.50)
Household Size Range			
1-5	28(11.91)	55(33.33)	83(20.75)
6-10	136(57.87)	84(50.91)	220(55.00)
Above 10	71(30.21)	26(15.76)	97(24.25)
Mean	9	8	9
Rice Farmers' Education			
No Formal Education	33(14.04)	58(35.15)	91(22.75)
Primary Education	32(13.62)	19(11.52)	51(12.75)
Quranic Education	1(0.43)	4(2.42)	5(1.25)
Secondary Education	121(51.49)	44(26.67)	165(41.25)
Tertiary	48(20.43)	40(24.24)	88(22.00)
Access to Agricultural Credit (Number)			
No Access	193(82.13)	143(86.67)	356(84.00)
Access	42(17.87)	22(13.33)	64(16.00)

*Figures in parentheses represent frequency percentages

Source: Field Survey, 2024.

Table 2 further presents additional socioeconomic and institutional characteristics of the respondents. The results show variations in income, farming experience, extension access, and group membership. The pooled data indicate that 37.75 percent of respondents earned between ₦25,001 and ₦50,000 monthly, while 24 percent earned above ₦100,000, with a mean income of ₦103,535.90. This suggests that most farmers earn moderate income levels capable of supporting household needs and farm reinvestment, consistent with Wango (2016) and Pelemo *et al.*, (2018), who noted that higher income enhances adoption of climate-resilient technologies.

In terms of farming experience, the majority (54.50%) had between 1 and 10 years of experience, with an average of 11 years across both states. This indicates that most farmers have adequate knowledge of rice cultivation, although some may still need further exposure to advanced climate-smart practices. This finding supports Nwaleji (2016), who noted that farming experience enhances skill

acquisition and effective utilization of sustainable agricultural practices. Similarly, access to extension services was moderate, with 62.75 percent of respondents reporting contact with extension agents. Such interaction promotes awareness and technical capacity for adopting CSAPs, consistent with findings of Durba *et al.*, (2019), who highlighted the vital role of extension networks in disseminating climate-resilient innovations and supporting smallholder adaptation.

Furthermore, 64.25% of respondents belonged to at least one agricultural or farmers' group, indicating a high level of social participation. This finding is in line with Mba, Ezeano, and Onwusika (2017), who observed that farmer group membership promotes information exchange and cooperative access to inputs and services. Barnabas, Pelemo, and Ajibola (2019) also reported that collective action through group participation enhances innovation diffusion and livelihood outcomes among smallholder farmers.

The findings indicate that rice farmers in Benue and Nasarawa States have moderate income, considerable farming experience, and fair access to institutional support such as extension services and

farmer groups. When effectively harnessed, these factors can greatly enhance the adoption and sustained utilisation of Climate-Smart Agricultural Practices in the study area.

Table 2: Socioeconomic Characteristics of Rice Farmers in the Study Area (continued)

Socioeconomic Characteristics	BenueState(n=235) Frequency (%)	NasarawaState(n=165) Frequency (%)	PooledMean(n=400) Frequency (%)
Household Monthly Income (₦)			
1-25,000	58(24.68)	16(9.70)	74(18.50)
25001 – 50000	96(40.85)	55(33.33)	151(37.75)
50001 – 75000	18(7.66)	34(20.61)	52(13.000)
75001-100000	12(5.11)	15(9.09)	27(6.75)
Above 1000000	51(21.70)	45(27.70)	96(24.00)
Mean	100,506.8	107,825	103,535.9
Rice Farming Experience (Year)			
1-10	110(46.81)	108(65.45)	218(54.50)
11-20	104(44.26)	44(26.67)	148(37.00)
Above 20	21(8.93)	12(7.27)	33(8.25)
No Experience	(0)	1(0.61)	1(0.25)
Mean	12	10	11
Access to Extension Agent's Services (Number)			
No Agent Services	89(37.87)	60(36.36)	149(37.25)
Agent Services	146(62.13)	105(63.64)	251(62.75)
Agricultural Group Membership (Number)			
No Membership	75(31.91)	68(41.21)	143(35.75)
Membership	160(68.09)	97(58.79)	257(64.25)

*Figures in parentheses represent frequency percentages

Source: Field Survey, 2024.

3.2 Climate-Smart Agricultural Practices Adopted by Rice Farmers in the Study Area

The study identified and ranked Climate-Smart Agricultural Practices (CSAPs) adopted by rice farmers in Benue and Nasarawa States, Nigeria, using a 4-point Likert Scale. Weighted Sum (WS) and Weighted Mean (WM) were employed to determine utilisation levels, while the practices were classified into agronomic, land and cultivation, livestock and pasture management, and soil management categories. These results were presented in Table 3.

In the land and cultivation practices category, the use of wetland (Fadama) was the most utilised CSAP in Benue State (WS = 662, WM = 2.82) and second in Nasarawa State (WS = 441, WM = 2.67). This reflects its critical role in improving soil fertility and ensuring water availability for rice production. Planting cover crops ranked fourth in both states, indicating farmers' awareness of soil protection and fertility enhancement. Moreover, minimum tillage ranked seventh in Benue but third in Nasarawa, suggesting a higher appreciation of its labour-saving and soil conservation benefits in Nasarawa. Agroforestry ranked low in both states (10th and 12th, respectively); however, it remains vital for

improving ecosystem balance and long-term sustainability.

Regarding agronomic practices, crop rotation ranked second in Benue (WS = 622, WM = 2.65) and fifth in Nasarawa (WS = 415, WM = 2.52), confirming its relevance in enhancing soil health, pest control, and long-term productivity. Planting based on weather conditions ranked third in Benue and eighth in Nasarawa, showing adaptive responses to climatic variability. However, the adoption of drought-tolerant rice varieties was modest sixth in Benue and tenth in Nasarawa, possibly due to limited access or awareness. Furthermore, rice/legume intercropping ranked ninth in Benue but first in Nasarawa, underscoring the importance of diversification for soil enrichment and income stability.

Moreover, for livestock and pasture management, overgrazing control was moderately adopted, ranking fifth in Benue (WS = 607; WM = 2.58) and seventh in Nasarawa (WS = 394; WM = 2.39). Managing grazing intensity is essential for preventing land degradation and maintaining ecosystem balance in mixed crop-livestock systems.

Furthermore, in soil management practices, the use of organic manure was most prominent, ranking eighth in Benue (WS = 544; WM = 2.31) and fifth in Nasarawa (WS = 415; WM = 2.52). Organic manure enhances soil structure and nutrient availability, making it a sustainable alternative to chemical fertilisers. Fertiliser deep placement ranked tenth in Benue and eleventh in Nasarawa, reflecting low awareness or access to the required tools, even though it improves nutrient use efficiency and reduces runoff. Mulching ranked lowest in Benue (12th) and ninth in Nasarawa, but its contribution to moisture conservation and weed suppression makes it an essential component of climate-resilient soil management.

The ranking of CSAPs reveals that rice farmers in the study area prioritise practices that directly enhance yield, conserve soil, and ensure resource efficiency. The variations in adoption levels between Benue and Nasarawa reflect differences in environmental conditions, institutional support, and access to information. These findings align with previous studies across Sub-Saharan Africa (Abdussalam & Adebayo, 2022; Fapojuwo *et al.*, 2018; Wahab *et al.*, 2020), which reported that organic manure application, crop rotation, minimum tillage, drought-resistant varieties, cover cropping, and Fadama farming are among the most preferred CSA strategies.

Table 3: Likert Scale Ranking of Climate-Smart Agricultural Practices Adopted by Rice Farmers in the Study Area

Climate smart agricultural practices	Benue result			Nasarawa result		
	WS	WM	Rank	WS	WM	Rank
Land and Cultivation Practices						
Use of wetland (Fadama)	662	2.82	1 st	441	2.67	2 nd
Planting cover crops	608	2.59	4 th	426	2.58	4 th
Minimum Tillage	562	2.39	7 th	431	2.61	3 rd
Agroforestry	514	2.19	10 th	360	2.18	12 th
Agronomic Practices						
Crop rotation	622	2.65	2 nd	415	2.52	5 th
Planting based on weather	614	2.61	3 rd	383	2.32	8 th
Planting drought-tolerant rice variety	577	2.46	6 th	369	2.24	10 th
Rice/legume intercropping	540	2.30	9 th	443	2.68	1 st
Livestock and Pasture Management						
Overgrazing control	607	2.58	5 th	394	2.39	7 th
Soil Management Practices						
Use of organic manure	544	2.31	8 th	415	2.52	5 th
Fertilizer deep placement	514	2.19	10 th	365	2.21	11 th
Mulching	504	2.14	12 th	381	2.31	9 th

Source: Field Survey, 2024.

Note: WS=Weighted Sum; WM = Weighted Mean

3.3 Level of Utilisation of Climate-Smart Agricultural Practices by Rice Farmers

The level of utilisation of Climate-Smart Agricultural (CSA) practices is critical for enhancing productivity, resilience, and sustainability in rice farming systems. The results presented in Figure 1 categorize rice farmers into four groups based on their degree of CSA utilisation: no-utilisation, low-utilisation, medium-utilisation, and high-utilisation. In Benue State, a significant proportion of farmers were medium (41.28%) and high users (30.21%) of CSA practices, indicating a relatively strong adoption rate. In Nasarawa State, the distribution pattern differed slightly, with a higher proportion of high users (33.33%) but also notable shares of low users (29.09%) and non-users (10.91%).

The pooled results revealed that the majority of rice farmers belonged to the medium-user category (35.25%), followed by high users (31.50%).

This distribution reflects a substantial level of engagement with CSA practices across the study area, suggesting that most farmers recognize the importance of adaptive and sustainable production methods. The higher percentages of medium and high users are encouraging, as greater utilization of CSA practices is often associated with improved productivity, enhanced resilience to climate shocks, and higher household income, ultimately contributing to better food security and welfare.

However, the presence of 15.75% non-users highlights persistent barriers to adoption, such as limited access to information, credit, or extension support. This indicates the need for intensified capacity-building programmes, targeted awareness campaigns, and improved institutional support to encourage wider adoption of CSA practices among rice farmers in Benue and Nasarawa States.

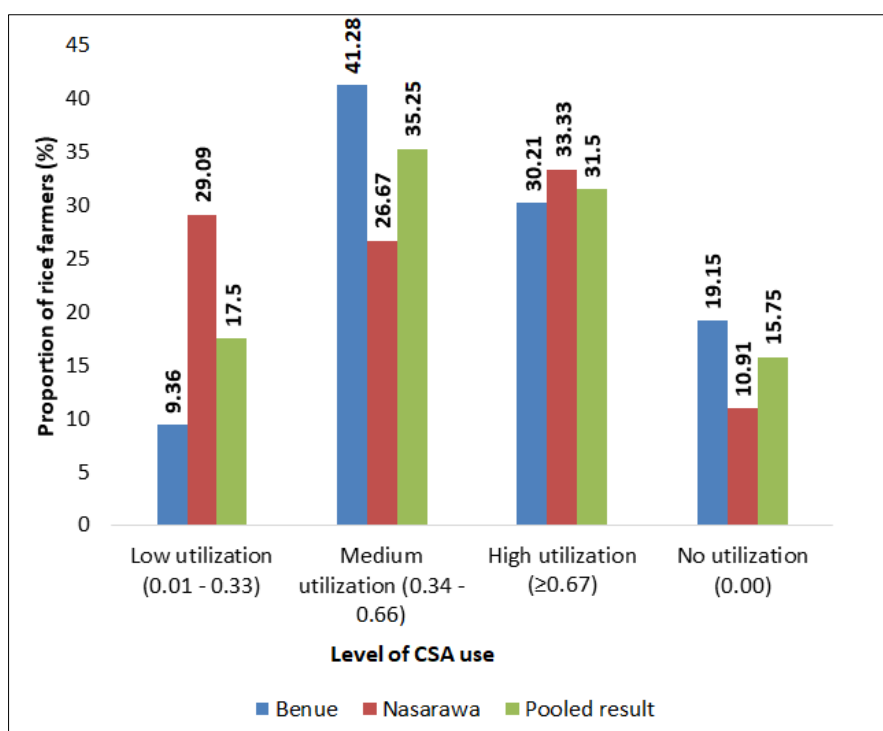


Figure 1: Distribution of Rice Farmers According to Their Level of Climate-Smart Agriculture Utilisation
Source: Field Survey, 2024.

3.4 Determinants of the Level of Utilisation of Climate-Smart Agricultural Practices

The ordered probit regression results on the determinants of Climate-Smart Agricultural Practices (CSAPs) utilisation among rice farmers in Benue and Nasarawa States are presented in Table 4. The Wald Chi-square values were statistically significant ($p \leq 0.01$) across all models, indicating a good overall fit and confirming that the explanatory variables jointly explain variations in the level of CSAP utilisation. The estimated threshold parameters (μ) followed an ascending order ($\mu_3 > \mu_2 > \mu_1 > \mu_0$), validating the ordered categorisation of utilisation levels.

The results revealed that age had a negative and significant influence on CSAP utilisation in Nasarawa State ($p \leq 0.01$) and in the pooled model ($p \leq 0.10$). This implies that older farmers were less likely to adopt or intensively use CSAPs, possibly due to their resistance to new ideas or preference for traditional methods. Conversely, younger farmers tend to be more innovative and receptive to change. This is consistent with the findings of Edeh (2021) and Tadesse and Ahmed (2023), but contradicts Ojoko (2021) and Ukwuaba and Ilekka (2024), who reported a positive relationship between age and CSAP adoption.

Moreover, the sex of farmers had a significant influence in Benue ($p \leq 0.10$) and in the pooled sample ($p \leq 0.05$), revealing that male farmers were more likely to utilise CSAPs. This may be attributed to male dominance in rice farming and

their greater access to land, capital, and information. However, it also highlights the persistent gender gap in agricultural innovation. Similar findings were reported by Edeh (2023) and Tadesse and Ahmed (2023). Therefore, gender-sensitive interventions that empower female farmers are essential to ensure inclusive adoption of CSAPs.

Similarly, education was found to have a positive and significant effect on the utilisation of CSAPs in Benue ($p \leq 0.10$), Nasarawa ($p \leq 0.01$), and the pooled model ($p \leq 0.01$). Educated farmers are more likely to understand the technical and economic benefits of CSAPs, leading to higher adoption intensity. This agrees with the results of Abegunde *et al.*, (2019), Edeh (2021), and Ojoko *et al.*, (2017), who observed that education enhances farmers' awareness and capacity to adopt sustainable technologies.

Furthermore, farming experience had a significant and positive influence on CSAP utilisation only in Benue State ($p \leq 0.05$). Experienced farmers are more exposed to agricultural innovations and can better appreciate the long-term benefits of sustainable practices. This finding aligns with Ojoko *et al.*, (2017). Thus, using experienced farmers as peer mentors could enhance learning and diffusion of CSAPs.

In addition, household size was significant in Nasarawa ($p \leq 0.10$) and the pooled model ($p \leq 0.01$). Larger households typically provide more family

labour, enabling greater implementation of labour-intensive CSAPs. This is consistent with the observations of Tadesse and Ahmed (2023) and Ukwuaba and Iлека (2024). Likewise, family labour positively influenced CSAP utilisation in Benue ($p \leq 0.01$), Nasarawa ($p \leq 0.10$), and the pooled sample ($p \leq 0.05$), implying that households with more available labour can undertake multiple CSAPs effectively.

Moreover, ownership of farmland had a positive and significant effect in Nasarawa State ($p \leq 0.05$), suggesting that farmers with secured land tenure are more willing to invest in sustainable practices. This finding agrees with Edeh (2021), who noted that land security encourages long-term agricultural investment. Access to extension services was positive and highly significant in Benue ($p \leq 0.05$), Nasarawa ($p \leq 0.01$), and the pooled model ($p \leq 0.01$). Farmers with frequent contact with extension agents were more likely to adopt multiple CSAPs. This underscores the critical role of extension networks in facilitating technology dissemination and farmer capacity building, and is consistent with the findings of Durba *et al.*, (2019).

Similarly, ownership of communication tools such as radios and mobile phones had a positive influence on CSAP utilisation in Benue ($p \leq 0.05$) and the pooled sample ($p \leq 0.10$). Farmers with access to information technology are better informed about climate forecasts, new technologies, and input availability. This observation is in line with the findings of Edeh (2021). Household income from rice

production was positively significant in Benue ($p \leq 0.01$) and Nasarawa ($p \leq 0.05$), suggesting that wealthier farmers are better positioned to afford the costs associated with CSAP implementation. This supports the results of Abegunde *et al.*, (2019). Hence, improving farmers' income through better market access and pricing can stimulate further adoption.

Furthermore, livestock ownership had a significant and positive effect on CSAP utilisation in Nasarawa ($p \leq 0.05$) and the pooled model ($p \leq 0.01$). Livestock ownership not only provides supplementary income but also manure for soil fertility improvement, reinforcing the benefits of integrated crop–livestock systems. This is consistent with the findings of Tadesse and Ahmed (2023). Farm size also influenced the level of utilisation positively in the pooled model ($p \leq 0.10$). Larger farms typically have greater access to resources, enabling investment in technologies such as improved seeds, irrigation, and soil management practices.

Conversely, distance to input markets negatively and significantly affected CSAP utilisation in Benue ($p \leq 0.01$) and in the pooled sample ($p \leq 0.01$). Farmers located farther from markets faced higher transaction costs and limited access to inputs, thereby discouraging adoption. This contradicts the findings of Ojoko (2021) and Abegunde *et al.*, (2019). Improving rural infrastructure, road networks, and input distribution channels is therefore essential to enhance farmers' access and promote CSAP adoption in the region.

Table 4: Ordered Probit Regression Estimates of Determinants of the Level of Utilisation of Climate-Smart Agricultural Practices by Rice Farmers in the Study Area

Factors	Benue State		Nasarawa State		Pooled result	
	Coef.	p>/z/	Coef.	p>/z/	Coef.	p>/z/
Age of rice farmer	0.0014	0.89 (0.13)	-0.0270	0.012** (-2.51)	-0.0107	0.098* (-1.65)
Sex of rice farmer	0.3448	0.053* (1.93)	-0.0405	0.843 (-0.20)	0.2637	0.035** (2.11)
Education of rice farmer	0.0391	0.058* (1.89)	0.0958	0.000*** (4.69)	0.0727	0.000*** (5.63)
Rice farming experience	0.0268	0.030** (2.16)	-0.0175	0.239 (-1.18)	0.0098	0.257 (1.13)
Household size	0.0106	0.696 (0.39)	0.0489	0.057* (1.90)	0.0458	0.012*** (2.51)
Family labour	0.0224	0.011*** (2.54)	0.0001	0.088* (1.70)	0.0001	0.023** (2.27)
Farmland ownership	-0.2796	0.214 (-1.24)	0.4369	0.043** (2.02)	0.0808	0.548 (0.60)
Membership in agricultural group	0.0011	0.997 (0.02)	-0.3117	0.186 (-1.32)	-0.1654	0.349 (-0.94)
Access to extension agent services	0.5159	0.046** (2.00)	1.0650	0.000*** (4.11)	0.7737	0.000*** (4.98)
Communication tools ownership	0.7200	0.032**	0.2145	0.367	0.3324	0.074*

		(2.14)		(0.9)		(1.79)
Household income from rice	0.0003	0.001*** (3.47)	0.0001	0.048** (1.98)	-0.0001	0.151 (-1.44)
Off-farm income	0.0001	0.226 (1.21)	-0.0002	0.980 (-0.02)	0.0001	0.925 (0.09)
Livestock ownership	0.2733	0.215 (1.24)	0.4797	0.016** (2.40)	0.6924	0.000*** (5.12)
Size of rice farmland	0.0204	0.774 (0.29)	0.0492	0.448 (0.76)	0.1007	0.083* (1.73)
Distance to input market	-0.0454	0.000*** (-6.66)	0.0295	0.127 (1.52)	-0.0398	0.000*** (-7.81)
Diagnostic statistic						
Wald Chi-square	173.77***		131.51***		221.75***	

Note: ***, **, * stands for 1%, 5%, and 10% probability levels of significance respectively.

Source: Field Survey, 2024.

4.0 CONCLUSION AND RECOMMENDATIONS

The study concludes that Climate-Smart Agricultural Practices (CSAPs) have gained considerable adoption and utilisation among rice farmers in Benue and Nasarawa States, with most farmers operating at medium to high utilisation levels. Key socio-economic and institutional factors such as education, farming experience, access to extension services, credit, and communication tools were found to significantly influence utilisation levels. However, constraints such as low access to credit, inadequate extension contact, distance from input markets, and limited awareness among older and less educated farmers hinder full-scale adoption. Therefore, it is recommended that policies and programs promoting CSAPs should prioritise farmer education and capacity building through strengthened and inclusive extension services. Access to credit facilities, land tenure security, and agricultural inputs should be improved to enhance farmers' ability to invest in sustainable practices. Furthermore, gender-sensitive interventions and cooperative group formations should be encouraged to ensure equitable participation and information sharing among farmers. Enhancing infrastructure such as rural roads and market access will further promote the widespread adoption of CSAPs, contributing to increased productivity, resilience, and welfare of farming households in the study area.

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