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Assessment of The Utilization of Climate-Smart Agriculture (Csa) Among Arable Crop Farmers in Taraba State, Nigeria

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ABSTRACT
The study assessed the utilization of climate-smart agriculture among arable-crop farmers in Taraba State, Nigeria. The specific objectives were to describe the socio-economic characteristics of the respondents; and assess the extent of utilization of Climate Smart Agriculture (CSA) by respondents. A multi-stage sampling technique was used to select 278 respondents from seven local government areas. Primary data were collected through structured questionnaire and analyzed using descriptive statistics and likert-type rating scales as described by Best and Kahn (2006). Results revealed that the mean age of the farmers was 42 years, indicating that most respondents were in their active and productive years. Majorities (75.54%) were male, and most (86.33%) were married, with an average household size of nine persons. The mean farm size was 2.51 hectares, indicating that most respondents were smallholder farmers. A considerable proportion had secondary (33.45%) and tertiary education (30.94%), while 58.27% had access to credit and were members of cooperative societies. The findings further showed that commonly utilized CSA practices include early planting (mean=2.74), use of improved seed varieties (mean=2.65), and drought-tolerant crops (mean=2.57). However, the overall level of the utilization was moderate, indicating that although farmers are aware of CSA technologies their level of use remains suboptimal. It is therefore recommended that the government and relevant stakeholders strengthen extension services, improve access to credit, invest in rural infrastructure, and promote policies that support the utilization of climate-smart agriculture practices.

Keywords: Assessment, Utilization, Climate-Smart, Arable Crop, Taraba State

INTRODUCTION

Climate-Smart Agriculture (CSA) is an integrated approach that boosts agricultural productivity, enhances farmers' resilience to climate change through adaptive practices, and mitigates greenhouse gas emissions by promoting sustainable methods such as conservation tillage and agroforestry (FAO, 2018). CSA is an approach to agricultural development that aims to address the intertwined challenges of food security and climate change (Lipper et al., 2014). It is a set of agricultural practices aimed at increasing productivity, building resilience to various shocks, and mitigating the devastating impacts of climate change. The CSA has three interlinked pillars: sustainably increasing productivity, building capacity to adapt, and reducing greenhouse gas (GHG) emissions. CSA practices include drought-resistant or shorter-maturing varieties, integrated soil fertility management, crop rotation, intercropping, agroforestry, conservation agriculture, retention of residues, irrigation practices, reduced tillage, organic manure, organic fertilizers, and cover crops (Khatri-Chhetri et al., 2017; Muzangwa et al., 2017).

Climate change has increasingly affected agricultural production in Africa, with rising temperatures and more extreme weather events, including heat waves, droughts, and floods (Rosenstock et al., 2019). Farmers are badly affected due to their reliance on rain-fed agricultural systems. Prolonged droughts, reduced rainfall amounts, changed rainfall patterns, elevated temperatures, flooding, pest and disease outbreaks, and shortened planting seasons have adversely affected crop productivity and farmers' livelihoods (Ouédraogo et al., 2019; Zougmoré et al., 2016; Adebayo and Ojogu, 2019). CSA can provide significant benefits to farmers facing these climate-induced agricultural impacts by increasing productivity, building adaptive capacity, and reducing the effects of climate change (Lipper et al., 2014).

In Nigeria, climate change has become a major threat to agricultural production and rural livelihoods. Erratic rainfall, elevated temperatures, drought, flooding, and desertification have disproportionately affected arable farming, leading to reduced yields, water shortages, crop failures, and intensified pest and disease outbreaks (Musafiri et al., 2022). These challenges are particularly serious in northern Nigeria, where arable crop production is a key livelihood strategy. Recent severe flooding in states including Borno, Bauchi, Jigawa, Kano, Kogi, Niger, Taraba, Sokoto, and Zamfara has caused significant damage to rice and other arable crops, with serious implications for farmers' livelihoods and food security (Izuagbe et al., 2023; Kilani et al., 2023).

Although CSA has the potential to improve agricultural productivity and farmers' resilience, the utilization of these technologies remains low in developing countries due to limited access to climate information, lack of funds, poor extension services, socioeconomic and institutional constraints, and inadequate support systems (Izuagbe et al., 2023; Ekpa et al., 2021). The application of CSA practices also varies from place to place because of differences in biophysical, socioeconomic, and cultural factors (Mupangwa et al., 2021; Ngaiwi et al., 2023). In Taraba State, where arable farming is a principal means of survival, farmers are not yet able to effectively utilize these technologies in their

farming practices (Pelemo et al., 2019). It is therefore on this premise that this research work was conducted to assess the utilization of climate-smart agricultural technologies among arable crop farmers in Taraba State, Nigeria.

MATERIALS AND METHODS

The Study Area

The study was conducted in Taraba State, located in the northeastern region of Nigeria. It is one of Nigeria's largest by land area, with extensive tracts of agricultural land, forests, and mountainous regions. It lies between longitudes $8^{o}00$ N and the latitude of $10^{o}30$ E of the Greenwich meridian (Figure 3.1). Taraba has a total land area of 54,473 km2 and a population of 2,294,800persons (NPC, 2006). However, using Taraba's mean annual growth rate of about 3.0% on this amount and projecting from the 2006 census of 2.3 million citizens to 2025 using the exponential population growth model, Taraba's population in 2025 would be projected at 4,023,428 people. The State's monthly temperature ranges from 21°C to 30°C (Bashir *et al.*, 2025). The area has two distinct seasons: the dry and rainy seasons. The rainy season starts in April and ends in October, while the dry season starts in November and ends in April. The average annual rainfall is between 800 mm and 2000 mm, while the maximum temperature is about 34^{o}C is recorded in April, while the lowest mean temperature of 20^{o}C is recorded in January and December. Sudan Vegetation, Northern Guinea Savanna, Southern Guinea Savanna, Forest-derived savanna, mountain forest, and grassland are the major vegetation types in the area (Ezra *et al.*, 2020). Sudan vegetation covers areas around Karim Lamido, Lau, Jalingo, Ardo Kola, Yorro, and Zing LGA, while Northern and Southern savanna cover the majority of the State and include LGAs such as Gassol, Ibi, Wukari, Donga, Bali, Takum, Ussa, Kurmi, and Gashaka LGA. (Ezra *et al.*, 2020) The State is distinguished by diverse topography, including expansive lowland plains, rolling hills, and significant highland areas. The Mambilla Plateau, located in the southeastern part of the state, is the most prominent feature, rising to an elevation of about 1,800 meters above sea level. The Mambilla Plateau is known for its temperate climate, fertile soils, and tea and coffee cultivation. The state's topography also includes numerous rivers, such as the Benue, Taraba, Donga, and Katsina-Ala, which contribute to its rich agricultural potential and hydroelectric power potential (Oruonye, 2019).

Sampling Techniques

The study was conducted across all four ADP zones: Northern Zone I, Central Zone II, Southern Zone III, and Western Zone IV. All the farmers in the selected zone constitute the target population for the study. A multi-stage sampling procedure was employed to select the respondents for the study. In the first stage, two LGAs in each ADP Zone (except the Sardurna zone, which stands alone due to its location on the Mambila Plateau) were purposively selected for the study based on their arable crop production to make a total of seven (7) LGAs. In the second stage, two wards were proportionately selected from each Local Government Area based on the relative level of arable crop production in that area. The third stage involves identifying arable-crop farmers in each selected ward using the snowball sampling technique, which is appropriate when the study population is not registered. The final stage involves the random selection of arable-crop farmers from each ward using the Yamane (1967) formula with a 5% margin of error. Consequently, a total of 282 respondents were proportionately drawn from the pre-field survey sampling frame of 952 farmers and administered to the respondents; however, only 278 were successfully retrieved and analyzed (Table 3.1).

The Yamane (1967) formula is given as:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where:

n = Sample size

N = Population under study

E = Margin of error (5% or 0.05)

1= Constant

Table 1: Sampling Frame and Sample Size

ADP ZONEs	LGAs	WARDs	SAMPLE FRAME	SAMPLE SIZE
Zone I	Ardo-kola	Alim Gora	67	20
		Ardo-kola	80	24
	Zing	Yakoko	70	21
		Zing Ai	56	17
Zone II	Bali	Suntai	84	25
		Bali A	60	18
	Gassol	Mutum Biu	87	26
		Gunduma	87	26
Zone III	Ussa	Jenuwa	68	20
		Kwanbai	62	18
	Takum	Tikari	45	13
		Yukuben	42	12
Zone IV	Sarduna	Gembu	65	19
		Nguroje	79	23
Total	7 LGAs	14 Wards	952 Farmers	282

Source: Field survey 2025

Methods of Data Analysis

The methods of data analysis for this study include both descriptive and measurement scale statistics. The descriptive and measurement scale statistics application is detailed below:

Descriptive Statistics

Descriptive statistics such as frequency distribution, percentage, and mean were used to achieve objective i (described the socio-economic characteristics of the respondents); and a five-point Likert scale was used to

achieve objective ii (assess the extent of utilization of CSA production technologies among arable crop farmers)

Measurement of Level of Utilization of Climate-Smart Arable Crop Production Technologies

The level of utilization of climate-smart arable crop production technologies was measured using a five-point Likert-type scale comprising fifteen (15) climate-smart agricultural (CSA) practices. Respondents were asked to indicate the extent to which they utilized each technology on their farms. The response categories were scored as follows: Not at all = 1, To a very small extent = 2, To a moderate extent = 3, To a large extent = 4, and To a very large extent = 5, following the Likert scaling approach as described by Best and Kahn (2006). A Total Utilization Index (TUI) was computed for each respondent by summing the scores across the fifteen CSA technologies, giving a minimum obtainable score of 15 and a maximum of 75. To facilitate interpretation, the total score was divided by 15 to obtain the mean utilization score on the original five-point scale:

Mean Utilization Score $= \frac{Total\ utilzation\ score}{15}$

Following the approach used by Best and Kahn (2006), respondents were classified into three levels of utilization based on their mean scores as follows: Low utilization (1.00–2.49), Medium utilization (2.50–3.49), and High utilization (3.50–5.00). This classification enabled the assessment of the extent to which respondents utilized climate-smart arable crop production technologies.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Respondents

Age of Farmers

The results in Table 4.1 present a summary of descriptive statistics for the continuous variables used in the study. The result revealed that the mean age of the farmers was 42 years, with the youngest farmer being 24 years and the oldest being 69 years. This indicated that the majority of the farmers were still within their active and productive years, which may positively influence their ability to utilize climate-smart agricultural technologies. Farmers in this age bracket are likely to be energetic, innovative, and more willing to adopt improved farming practices. The standard deviation of 8.89 showed that there was moderate variation in the ages of the respondents. The skewness value of 0.397 revealed that the age distribution was slightly positively skewed, implying that there were relatively younger farmers than older ones. The kurtosis value of 3.169 indicated that the distribution was approximately normal. This findings lends credence to the report of Alabi *et al.* (2023), in a study on Factors influencing climate change adaptation strategies among arable crop farmers in Osun state, Nigeria, they opined that the age of majority of the arable crop farmers' in the study area ranged between 41-70 years, with a mean of 53.67 years, they further submitted that majority of the respondents were males while only few were females implying that the sampled farmers were adults, and mature enough to perceive the effects of climate change on arable crop production, and the ability to mitigate and adapt to the effects in order to improve their crop output. Similarly, Brede and Sanger (2022) conducted a study examining the impact of age on technology adoption among smallholder farmers in Nigeria. Their results indicated a significant generational divide, with the majority of younger farmers aged between 18-34 years adopting modern farming technologies compared to only a minority of farmers aged 50 and above. The finding highlights the need to target younger demographics for agricultural modernization initiatives, as they are more open to innovation.

Household Size

The result showed that the average household size among farmers was 9 persons, with a minimum of 1 and a maximum of 30 persons per household. This indicated that many of the farmers had relatively large households, which may provide family labour for farming activities and influence the utilization of climate-smart agricultural technologies. Larger households may reduce the cost of hired labour and enhance the implementation of labour-intensive CSA practices such as mulching, composting, and irrigation. However, large household sizes may also increase dependency pressure and reduce the funds available for investment in improved technologies. The standard deviation of 5.73 revealed considerable variation in household sizes among the respondents. The skewness value of 1.367 indicated a positively skewed distribution, meaning that more households were concentrated at the lower end, while a few households had very large sizes. The kurtosis value of 4.833 indicated that the distribution was more peaked than a normal distribution. This is in line with Ojoko *et al*. (2017), who reported in their study on factors influencing the level of use of climate-smart Agricultural practices in Sokoto, Nigeria, that about a simple majority had a household size of between 1 and 10, followed by a minority with a household size of 11 to 20 persons. A large household size is a source of family labour in rural Nigeria where farming is a major occupation.

Farm size

The result further revealed that the mean farm size was 2.51 hectares, with the smallest farm being 0.5 hectares and the largest being 20 hectares. This showed that most of the respondents were smallholder farmers, though a few operated on a larger scale. Small farm sizes may limit farmers' capacity to experiment with or invest in certain climate-smart agricultural technologies, while larger farms may encourage adoption through economies of scale. The standard deviation of 2.25 indicated some variation in farm sizes among the respondents. The skewness value of 2.984 revealed a high positive skewness, suggesting that most farmers cultivated small farm sizes, while only a few had large farms. The kurtosis value of 18.218 indicated a highly peaked distribution with extreme values. The outcome is in line with the submission by Zikusooka and Irumba (2025), which reported that farm size distribution showed that less than half of farmers operated on 1-3 hectares, while a minority farmed on less than one hectare, indicating predominantly smallholder farming systems. Only a few farmers operated on farms larger than 3 hectares, reflecting the typical land tenure patterns in the study area. Additionally, Amafade *et al.* (2024), in their study on the adoption of climate-smart agricultural practices in Delta State, Nigeria, reported a mean farm size of 0.9 hectares. This observation underscores the prevalence of smallholder farming systems, a common characteristic in many developing agricultural economies. Small-scale farmers often face unique challenges in adopting climate-smart agricultural practices due to limited resources and land constraints

Annual farm income

The result also showed that the average annual income of the farmers was ₦1,511,022, with a minimum income of ₦56,000 and a maximum of ₦50,000,000. This indicated a wide gap in income levels among the respondents. Farmers with higher incomes may have better access to inputs, improved technologies, and information needed to adopt and utilize climate-smart agricultural technologies. On the other hand, low-income farmers may face financial constraints that

limit adoption. The very high standard deviation of 4,635,420 revealed substantial variation in annual income among the respondents. The skewness value of 8.441 showed that the income distribution was highly positively skewed, meaning that most farmers earned relatively low incomes while a few earned exceptionally high incomes. The kurtosis value of 83.513 indicated the presence of extreme outliers and a very peaked distribution. This wide variation in income may influence farmers' ability to adopt and use climate-smart agricultural technologies.

Table 1: Summary of Descriptive Statistics Results for Continuous Variables

Variables	Mean	Minimum	Maximum	Std. Dev.	Skewness	Kurtosis
Age	42	24	69	8.89	0.397	3.169
Household size	9	1	30	5.73	1.367	4.833
Farm size	2.51	0.5	20	2.25	2.984	18.218
Annual income	1511022	56000	50000000	4635420	8.441	83.513

Source: Field survey, 2026

Sex of the Respondents

The results in Table 2 show the distribution of respondents by sex in the study area. The finding revealed that 75.54% of respondents were male and 24.46% were female. This indicated that arable crop farming in Taraba State was dominated by men. The high proportion of male farmers may be due to their greater access to productive resources such as land, labour, and capital, which can influence the utilization of climate-smart agricultural technologies. The result also showed that female farmers were actively involved in arable crop production, although in smaller proportions. This suggested that women also contribute to farming activities and should be considered in programmes and policies aimed at promoting the utilization of climate-smart agricultural technologies in the study area. The result aligns with the findings of Agbaji and Terngu (2022), they study on socio-economic factors influencing the use of organic fertilizer among arable crop farmers in Benue State, Nigeria, and reported that the majority of farmers were male, with females making up a minority. This finding further emphasized ongoing gender disparity within the sector. In contrast, Okeke and Eze (2023) offered a different perspective in their study on gender and adoption of agricultural technologies among arable crop farmers in Anambra State, Nigeria, in which they found that the majority of respondents were female. This suggests that in certain regions, women may play a more significant role in arable farming. Additionally, research by Fasoranti and Olorunfemi (2021) in Ekiti State, titled Effect of Farmer Characteristics on the Productivity of Arable Crops, also found a gender imbalance: the majority of farmers were male, while a minority were female, indicating a moderate gender gap in agricultural participation. Further highlighting shifting gender dynamics, Yahaya and Suleiman (2023), in their study on Access to Extension Services and Its Impact on Arable Crop Production in Niger State, Nigeria, observed a relatively balanced gender distribution, with a simple majority of participants being male and less than half female.

Table 2: Sex Distribution of the Respondents

Sex	Frequency	Percentage
Male	210	75.54
Female	68	24.46
Total	278	100.00

Source: Field survey, 2026

Marital status of the Respondents

The results in Table 3 show the distribution of respondents by marital status in the study area. The finding revealed that 86.33% of the respondents were married, while 13.67% were single. This indicated that the majority of the arable crop farmers in Taraba State had family responsibilities. The high proportion of married farmers may influence the utilization of climate-smart agricultural technologies, as married farmers are more likely to have access to family labour and support for farming activities. The result also suggested that married farmers may be more willing to adopt and use improved agricultural technologies to increase productivity and meet household needs. The smaller proportion of single farmers showed that fewer unmarried individuals were engaged in arable crop farming in the study area. This is in line with Adebayo and Ojogu (2019), who studied the Assessment of the Use of Climate-Smart Agricultural Practices among Smallholder Farmers in Ogun State, Nigeria, and reported that the majority (53.0%) of the respondents were married. This further suggests that agriculture is very much practiced by married people to make ends meet and cater for their children.

Table 3: Marital Status Distribution of the Respondents

Marital status	Frequency	Percentage
Single	38	13.67
Married	240	86.33
Total	278	100.00

Source: Field survey, 2026

Educational Level of the Respondents

The results in Table 4 show the educational levels of the respondents in the study area. The finding revealed that 33.45% of the respondents had no formal education, while another 33.45% had secondary education. It also showed that 30.94% of respondents had tertiary education, 1.80% had primary education, and 0.36% had non-formal education. This indicated that the farmers in the study area were fairly evenly distributed across different levels of education, with a considerable proportion having at least a secondary or tertiary

education. The result suggested that a good number of the farmers were literate, which may enhance their ability to understand and utilize climate-smart agricultural technologies effectively. However, the presence of farmers with no formal education also indicated that some farmers may still face challenges in accessing, interpreting, and applying modern agricultural information and technologies in the study area. This finding is supported by Zikusooka and Irumba (2025), who studied Climate-Smart Agriculture and Drought-resistant crop varieties: A case study of the National Agricultural Research Organization (NARO), Uganda, and reported that less than half of farmers had primary education, while a minority had secondary education, and only a few had tertiary education. Notably, a few farmers had no formal education, which had implications for technology adoption and information processing capabilities. In a related study by Oluwasusi and Ajayi (2021), titled Determinants of Adoption of Improved Maize Varieties among Arable Crop Farmers in Oyo State, Nigeria, it was found that fewer than half of respondents had tertiary education, a minority held secondary qualifications, and only a very few lacked formal educations. This data suggests that a relatively high level of educational attainment facilitates the use of climate-smart technologies.

Table 4: Educational Level of the Respondents

Level of education	Frequency	Percentage
No formal education	93	33.45
Primary education	5	1.80
Secondary education	93	33.45
Tertiary education	86	30.94
Non-formal education	1	0.36
Total	278	100.00

Source: Field survey, 2026

Access to Credit by the Respondents

The results in Table 6 show that 58.27% of the respondents had access to credit, while 41.73% did not have access to credit. This indicated that a high proportion of the farmers were able to obtain financial support to enhance their farming activities. The result suggested that access to credit may enhance farmers' capacity to invest in climate-smart agricultural technologies, as greater availability of funds can facilitate the purchase of improved inputs and equipment. However, the considerable proportion of farmers without access to credit also indicated that financial constraints may still limit the adoption and utilization of climate-smart agricultural technologies in the study area. In contrast, Idiku *et al*. (2026) study on Utilization of Climate-Smart agricultural practices among rural farmers in Cross River State Nigeria, reported that credit access was the most striking finding: 82.6% of farmers lacked access to credit. This single factor casts a long shadow over all other adoption efforts. This finding strongly echoes the work of Baiyegunhi *et al*. (2022), who identified the high initial cost of CSA and a lack of capital as the primary economic constraints. Without financial resources, even the most knowledgeable and motivated farmers cannot invest in improved seeds, irrigation equipment, or other CSA inputs.

Table 6: Distribution of the Respondents Based on Access to Credit

Access to credit	Frequency	Percentage
Access	162	58.27
No access	116	41.73
Total	278	100.00

Source: Field survey, 2026

Membership of Cooperative Societies by the Respondents

A cooperative society is a self-help group with a strategy for acquiring social capital that is appropriate for attaining sustainable livelihoods. These groups of individuals operate at a cost that is owned, capitalized, and controlled by patrons, with risks and benefits shared in proportion to their participation. Membership in a group helps individuals to access information and capital. The cooperative membership in Table 7 shows that a slight majority (58.27%) of respondents were members of cooperative societies, while 41.73% were not. This indicated that a higher proportion of the farmers belonged to cooperative organizations in the study area. The result revealed that cooperative membership may enhance farmers' access to information, credit facilities and agricultural inputs, thereby positively influencing the utilization of climate-smart agricultural technologies. It also showed that farmers who were not members of cooperatives may have limited access to these benefits, which could affect their participation in improved agricultural practices. This result is consistent with the findings of Amafade *et al*. (2024), who studied the adoption of Climate-Smart Agricultural Practices by Cassava Farmers in Delta State, Nigeria, and revealed that the majority of cassava farmers are actively engaged as members of agricultural associations.

Table 4.7: Distribution of the Respondents Based on Membership of Cooperative

Membership of cooperative	**Frequency**	**Percentage**
Yes	162	58.27
No	116	41.73
Total	278	100.00

Source: Field survey, 2026

Sources of Farmland for Arable crop farming by the respondents

The results in Table 4.10 show the distribution of respondents by land source in the study area. The result showed that 48.20% of the respondents owned/inherited the land they cultivated. This indicates that a greater proportion of arable crop farmers in Taraba State own farmland, which may encourage them to adopt and use climate-smart agricultural technologies, as they have full control over the land and can make long-term farming decisions. Furthermore, 11.51% of the respondents rented farmland, while 7.91% had free use of land. This indicates that some farmers rely on temporary or informal land arrangements for cultivation. Such arrangements may discourage investment in long-term climate-smart practices because of uncertainty about continued access to the land. Lastly, the results showed that only 29.86% of respondents purchased land, while 2.52% accessed communal land. This shows that land inaccessibility is not a major challenge for most farmers in the study area. These findings are in line with Keovilignavong and Suhardiman (2020), in their study on Linking land tenure security with food security: unpacking farm households' perceptions and strategies in the rural uplands of Laos, who opined that land tenure security is closely linked to the ability to recover agricultural production costs and secure future returns. Clear and stable land rights ensure that agricultural investments yield long-term benefits, boosting farmers' confidence to adopt and utilized improved practices. As a result, land tenure security plays a significant role in facilitating the utilization of climate-smart agriculture (CSA) practices. Similarly, Antwi-Agyei et al. (2021) examined motivations, enablers, and barriers to adopting climate-smart agricultural practices among smallholder farmers in Ghana's transitional and savannah agro-ecological zones and found that land tenure security directly influences farmers' decisions to adopt CSA practices. For example, in regions such as the West African Sahel, Bangladesh, and Chile, well-defined land ownership encourages farmers to pursue agricultural benefits and adopt and use CSA practices.

Table 4.8: Distribution of the Respondents Based on Sources of Farm Land

Types of Access	Frequency	Percentage
Purchased	83	29.86
Owned/Inheritance	134	48.20
Communal	7	2.52
Rented	32	11.51
Free use	22	7.91
Total	278	100.00

Source: Field survey, 2026

Extent of Utilization of Climate-Smart Arable Crop Production Technologies

The extent of utilization of climate-smart agricultural (CSA) production technologies among arable crop farmers is important for understanding not only whether farmers adopt these technologies, but also the degree to which they apply them in their farming operations. While utilization shows whether a technology is used or not, the extent of utilization reveals the intensity or frequency of use, which reflects farmers' level of commitment, perceived effectiveness, affordability, and accessibility of such technologies. Therefore, assessing the extent of utilization provides deeper insight into the climate-smart practices that are fully embraced by farmers and those that are still underutilized, thereby guiding policymakers, extension agents, and development partners in designing appropriate interventions for improved climate adaptation and sustainable agricultural production. Results in Table 4.13 reveal the extent of utilization of climate-smart arable crop production technologies among respondents in the study area. The results showed that some CSA technologies were used extensively, while others were used to a limited or negligible extent. The findings indicated that drought-resistant crop varieties were used extensively, with a mean score of 3.34. The results revealed that 47.84% of respondents used it to a moderate extent, 37.77% to a large extent, 5.04% to a very large extent, and only 4.12% did not use it at all. This suggests that farmers recognize the importance of drought-resistant varieties in coping with erratic rainfall and prolonged dry spells.

Similarly, early planting or a change in the planting calendar was utilized to a great extent, with a mean score of 3.62. The findings showed that 45.32% of the respondents utilized it to a moderate extent, 40.65% to a large extent, and 11.87% to a very large extent. This implies that farmers actively adjust their planting dates to suit changing weather conditions and rainfall patterns. Organic fertilizers or compost were also used to a significant extent, with a mean score of 3.21. The results indicated that 66.91% of respondents used it to a moderate extent, while 25.90% used it to a large extent. This may be due to farmers' awareness of the role of organic inputs in improving soil fertility and maintaining soil health. Minimum or zero-tillage farming was used to a significant extent, with a mean score of 3.29. The findings revealed that 64.75% of respondents used it to a moderate extent, and 26.98% to a large extent. This suggests a growing awareness of conservation farming practices among the respondents. This finding is in line with Idiku *et al*. (2025), who examined the utilization of climate-smart agricultural practices among rural farmers in Cross River State, Nigeria. The study found that farmers extensively utilized improved crop varieties, mulching, crop diversification, and timely planting. However, the use of irrigation facilities, mechanization, and weather-based advisory services was relatively low due to inadequate financial resources and weak institutional support. Similarly, Pelemo *et al*. (2024) assessed the adoption and use of climate-smart agricultural practices among arable-crop farmers in Kogi State, Nigeria. The findings revealed that the extent of utilization varied across CSA practices. Early planting, improved crop varieties, crop rotation, and mixed cropping were widely utilized, whereas irrigation, agroforestry, and conservation tillage recorded relatively low utilization due to financial and technical constraints.

Table 9: Extent of Utilization of Climate-Smart Arable Crop Production Technologies by Respondents

CSA Production Technologies	Not at all	To a very small extent	To a moderate extent	To a large extent	To a very large extent	Mean	Remark
Use of drought-resistant crop varieties	12(4.12)	14(5.04)	133(47.84)	105(37.77)	14(5.04)	3.34	ME
Early planting or a change in the planting calendar	0(0.00)	6(2.16)	126(45.32)	113(40.65)	33(11.87)	3.62	LE
Use of organic fertilizers or compost	4(1.44)	12(4.32)	186(66.91)	72(25.90)	4(1.44)	3.21	ME
Minimum or zero tillage farming	6(2.16)	5(1.80)	180(64.75)	75(26.98)	12(4.32)	3.29	ME
Mulching to retain soil moisture	171(61.51)	14(5.04)	70(25.18)	22(7.91)	1(0.36)	1.80	SE
Crop rotation	11(3.96)	10(3.60)	177(63.67)	77(27.70)	3(1.08)	3.18	ME
Agroforestry practices	235(84.53)	17(6.12)	20(7.19)	4(1.44)	2(0.72)	1.27	NA
Efficient water management (e.g., control irrigation)	115(41.37)	16(5.76)	107(38.49)	39(14.03)	1(0.36)	2.26	SE
Planting of cover crops	14(5.04)	24(8.63)	175(62.95)	61(21.94)	4(1.44)	3.06	ME
Soil conservation measures (e.g., terracing, contour bunding)	1(0.36)	10(3.60)	187(67.27)	73(26.26)	7(2.52)	3.26	ME
Use of improved seed varieties	0(0.00)	1(0.36)	100(35.97)	130(46.76)	47(16.91)	3.80	LE
Application of integrated pest and disease management (IPM)	3(1.08)	5(1.80)	183(65.83)	80(28.78)	7(2.52)	3.29	ME
Intercropping (mixed farming)	1(0.36)	4(1.44)	126(45.32)	105(37.77)	42(15.11)	3.65	LE
Use of post-harvest technologies (e.g., improved storage)	0(0.00)	5(1.80)	58(20.86)	129(46.40)	86(30.94)	4.06	LE
Rainwater harvesting	6(2.16)	2(0.72)	126(45.32)	132(47.48)	12(4.32)	3.51	LE

Source: Field survey, 2026,

NB: LE=Large extent, ME=Moderate extent; SE=Small extent; NA=Not at all; N.B: figures in parenthesis are percentagesResults in Table 4.9 further revealed that crop rotation had a mean score of 3.18 and were utilized to a significant extent. The results showed that 63.67% of respondents used it to a moderate extent, while 27.70% used it to a large extent. This may help farmers improve soil fertility and reduce pest and disease infestation. Planting of cover crops was also utilized to a significant extent, with a mean score of 3.06. The findings indicated that 62.95% of respondents used it to a moderate extent, while 21.94% used it to a large extent. Soil conservation measures such as terracing and contour bunding were utilized to a significant extent, with a mean score of 3.26. The results revealed that 67.27% of respondents used them to a moderate extent, and 26.26% to a large extent. This indicates that farmers are making efforts to reduce soil erosion and maintain land productivity. Intercropping was used extensively, with a mean score of 3.65. The findings showed that 45.32% of the respondents utilized intercropping to a moderate extent, 37.77% to a large extent, and 15.11% to a very large extent. The high utilization of intercropping implies that arable crop farmers in the study area have widely embraced this climate-smart agricultural practice as an effective strategy for enhancing crop productivity, improving resource-use efficiency, reducing climate-related production risks, and strengthening household food security and resilience to climate change.

Utilization of post-harvest technologies such as improved storage facilities ranked highest with a mean score of 4.06 and was utilized to a high extent. The result revealed that 46.40% utilized it to a large extent and 30.94% to a very large extent. This suggests that farmers are highly concerned about reducing post-harvest losses and preserving the quality of produce.

Rainwater harvesting also recorded high utilization, with a mean score of 3.51. The findings indicated that 47.48% of respondents used it to a large extent, while 45.32% used it to a moderate extent. The findings suggest that farmers recognize rainwater harvesting as an effective climate-smart agricultural strategy for addressing water-related production challenges. On the other hand, some CSA technologies were not utilized extensively. Mulching to retain soil moisture had a low mean score of 1.80. The results showed that 61.51% of respondents did not use mulching at all, while only 7.91% used it to a large extent. This may be due to labour constraints or a lack of mulching materials. Agroforestry practices were among the least utilized with a mean score of 1.27. The findings revealed that 84.53% of respondents did not use agroforestry. This may be attributed to land scarcity, inadequate awareness, and the long-term nature of benefits from tree planting. Efficient water management practices, such as controlled irrigation, were not used to a great extent, with a mean score of 2.26. The results indicated that 41.37% of respondents did not use such technologies, while 38.49% used them to a moderate extent. This may be due to high installation costs and poor access to irrigation infrastructure.

The use of improved seed varieties had a high mean score of 3.80, indicating that 46.75% of the respondents used them to a large extent. Similarly, the application of integrated pest and disease management (IPM) had a mean score of 3.29, indicating that 65.83% of respondents used the technology to a moderate extent, while 28.78% used it to a large extent. This finding is in consonance with Sam *et al*. (2020), who evaluated the Utilization of climate-smart agricultural technologies and practices among smallholder farmers in Ghana. The findings showed that crop diversification, improved seed varieties, integrated soil fertility management, and conservation agriculture were utilized to varying degrees, from moderate to high. However, irrigation technologies and agroforestry practices were underutilized due to high establishment costs and limited technical knowledge.

As reported in Table 4.10, the overall level of utilization of climate-smart arable crop production technologies among the respondents was classified into low, medium, and high utilization categories based on the mean utilization scores derived from the 15 CSA practices. The classification followed the decision rule adapted from Likert (1932) and Best and Kahn (2006), where mean scores of 1.00–2.49 represent low utilization, 2.50–3.49 represent medium utilization, and 3.50–5.00 represent high utilization. The results in Table 4.14 revealed that the majority of respondents (83.81%) fell within the medium utilization category, with a mean utilization score of 3.11. This indicates that most farmers used climate-smart agricultural practices to a moderate extent, suggesting that while the technologies are being adopted, their intensity of use remains suboptimal. This medium level of utilization may be attributed to partial awareness, limited access to resources, and varying levels of capacity to fully implement all recommended CSA practices. Furthermore, 12.23% of respondents were classified as high utilizers, indicating that only a small proportion of farmers extensively used climate-smart agricultural technologies in their farming activities. This group likely represents farmers with better access to information, resources, and extension support, enabling them to adopt and intensify the use of improved practices.

On the other hand, 3.96% of the respondents were in the low utilization category, showing that a very small proportion of farmers made minimal use of climate-smart agricultural technologies. This may be due to constraints such as limited awareness, financial limitations, or inadequate technical support.

Table 10: Classification of Overall Level of Utilization of Climate-smart Arable Crop Production Technologies by Respondents

Level of utilization	Frequency	Percentage	Mean
Low utilization	11	3.96	3.11
Medium utilization	233	83.81	
High utilization	34	12.23	
Total	278	100.00	

Source: Field survey, 2026

CONCLUSION

The study assesses the utilization of climate-smart agriculture among arable crop farmers in Taraba State, Nigeria. The findings indicate that some climate-smart agricultural technologies were less utilized in the study area. The low level of utilization of these technologies could be attributed to limitations posed by their socioeconomic characteristics. The study concludes that utilization of climate-smart agricultural technologies is moderate overall in the study area. The recommendations emphasize strengthening extension services and improving farmers' access to affordable credit to enhance the utilization of climate-smart agricultural (CSA) technologies. They also call for investment in rural infrastructure and improved farmer participation in cooperatives to facilitate access to inputs, markets, information, and other agricultural support services.

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