

Determinants of the intensity of climate-smart agricultural practices among smallholder millet farmers in Jigawa state, Nigeria

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This study examines the determinants of the intensity of Climate-Smart Agricultural Practices (CSAPs) among smallholder millet farmers in Jigawa State, Nigeria. While previous studies have largely focused on the adoption or impact of CSAPs on food security, limited attention has been given to the frequency and intensity of usage of these practices. Using primary data collected from 262 smallholder millet farmers through a multistage sampling technique, the study constructed a composite CSAP intensity index based on the frequency of use of 13 climate-smart practices measured on a 4-point Likert scale. Descriptive statistics and Tobit regression analysis were employed to identify factors influencing the intensity of CSAP usage. The results revealed that the majority of farmers were medium users of CSAPs, indicating partial integration of climate-smart practices into farming systems. The Tobit regression results showed that education, farm size, household income, access to extension services, and cooperative membership positively and significantly influenced the intensity of CSAP usage, while age and household size exhibited mixed effects. The study concludes that socio-economic and institutional factors play a critical role not just in the adoption, but in the sustained and frequent use of CSAPs. It recommends strengthening extension services, improving access to credit, and promoting farmer-based organizations to enhance the intensity of CSAP usage and improve agricultural resilience.

Keywords: Climate smart agriculture practices, determinants, smallholders, adoption, Nigeria

INTRODUCTION

Agriculture remains central to rural livelihoods and economic development in developing countries such as Nigeria, where a significant proportion of the population depends on small-scale farming for income and sustenance (Food and Agriculture Organization, 2021). In Jigawa State, agriculture plays a vital role in household income generation, employment creation, and food availability. However, increasing climate variability has made agricultural production more uncertain and risky, particularly for resource-poor smallholder farmers who rely heavily on rain-fed systems (Adelekan et al., 2021). Rising temperatures, erratic rainfall patterns, prolonged droughts, and occasional flooding have contributed to declining agricultural productivity and increased vulnerability of farming households (IPCC, 2019; World Bank, 2022).

Millet (*Pennisetum glaucum*) is one of the most important staple crops cultivated in the semi-arid regions of northern Nigeria due to its tolerance to drought, high temperatures, and poor soil conditions (International Crops Research Institute for the Semi-Arid Tropics, 2020; Ndiaye et al.,

2021). Despite its resilience, millet production has experienced fluctuations in recent years due to climate-related shocks, soil degradation, pest infestations, and limited access to improved agricultural technologies (Ismaila et al., 2020; Obi et al., 2020). These challenges underscore the need for sustainable and climate-resilient agricultural practices that can enhance productivity and improve farmers' adaptive capacity.

Climate-Smart Agriculture (CSA) has been widely promoted as a strategic approach to addressing the challenges posed by climate change in agriculture. CSA aims to sustainably increase agricultural productivity, enhance resilience to climate change, and reduce greenhouse gas emissions (Food and Agriculture Organization, 2013; Lipper et al., 2019). Climate-Smart Agricultural Practices (CSAPs) include improved crop varieties, conservation agriculture, agroforestry, integrated soil fertility management, crop rotation, and efficient water management techniques (Partey et al., 2018; Oyawole et al., 2020). These practices are particularly relevant for smallholder farmers, who often face constraints such as limited access to credit, extension services, and modern inputs (Mutengwa et al., 2023).

While there is growing awareness and promotion of CSAPs, existing studies have largely focused on the adoption of these practices or their impact on outcomes such as food security and income (Branca et al., 2021; Ogunniyi et al., 2021). However, adoption alone does not necessarily guarantee sustained benefits, as farmers may adopt practices without applying them consistently or effectively. The intensity of use of CSAPs, defined as the frequency and extent to which farmers apply these practices, is crucial in determining their effectiveness in improving agricultural productivity and resilience (Khatri-Chhetri et al., 2017).

Despite its importance, empirical evidence on the determinants of CSAP usage intensity remains limited, particularly among smallholder millet farmers in Jigawa State. Understanding the factors that influence how frequently and extensively farmers use climate-smart practices is essential for designing effective policies and interventions that promote sustained adoption and maximize the benefits of CSA. This study, therefore, seeks to fill this gap by examining the determinants of the intensity of Climate-Smart Agricultural Practices among smallholder millet farmers in Jigawa State, Nigeria.

Objectives of the study

The main objective of the study is to examine the determinants of the intensity of Climate-Smart Agricultural Practices among smallholder millet farmers in Jigawa State, Nigeria. The specific objectives are to:

- Describe the socio-economic characteristics of smallholder millet farmers in the study area.
- Assess the level of intensity of Climate-Smart Agricultural Practices among smallholder millet farmers.
- Determine the socio-economic and institutional factors influencing the intensity of Climate-Smart Agricultural Practices among smallholder millet farmers.

METHODOLOGY

Study area

The study was conducted in Jigawa State, located in the north-western region of Nigeria. The state lies within latitudes 11°N and 13°N and longitudes 8°E and 10°E, and is characterized by a semi-arid climate with distinct wet and dry seasons. Annual rainfall ranges between 600 mm and 1000 mm, while temperatures are generally high, particularly during the dry season. Agriculture

constitutes the primary livelihood of the population, with millet, sorghum, and cowpea being the dominant crops cultivated across the state. For agricultural administration, Jigawa State is divided into four Agricultural Development Programme (ADP) zones: Birnin Kudu, Gumel, Hadejia, and Kazaure.

Sampling design and sample size

A stratified multistage sampling technique was employed to obtain a representative sample of smallholder millet farmers. In the first stage, the four ADP zones were considered as strata to capture spatial and agro-ecological variations within the state. In the second stage, key millet-producing Local Government Areas (LGAs) were selected from each zone based on their prominence in millet cultivation. Subsequently, farming communities were randomly selected within each LGA to ensure geographical spread.

At the final stage, individual millet farmers were selected using simple random sampling from farmer lists obtained at the community level. The sample size comprised 262 respondents, determined to ensure adequate representation and statistical reliability. Proportional allocation was applied to distribute respondents across selected communities based on their population sizes.

Data collection

Primary data were collected through the administration of a structured questionnaire. The instrument was designed to capture information on farmers' socio-economic characteristics, institutional variables, and the frequency of use of various Climate-Smart Agricultural Practices (CSAPs). The questionnaire incorporated both closed-ended and scaled questions to facilitate quantitative analysis.

The intensity of CSAP usage was measured using a 4-point Likert-type scale reflecting frequency of use: Never (0), Rarely (1), Often (2), and Very Often (3). A total of thirteen climate-smart practices were considered, covering crop management, soil conservation, and water management strategies.

Measurement of CSAP intensity

To quantify the level of engagement with climate-smart practices, a composite CSAP intensity index was constructed. This was obtained by aggregating the scores assigned to each of the thirteen practices for individual farmers. The index represents the cumulative frequency of use and serves as a proxy for the intensity of CSAP application.

Higher index values indicate greater integration of climate-smart practices into farming activities, while lower values reflect minimal or inconsistent usage.

Analytical techniques

Descriptive statistics, including means, frequencies, and percentages, were used to summarize the socio-economic characteristics of respondents and assess the distribution of CSAP usage intensity.

To examine the determinants of CSAP intensity, a Tobit regression model was employed. The Tobit model is appropriate for analyzing dependent variables that are continuous but censored, as is the case with the CSAP intensity index, which is bounded within a specific range.

Model Specification

The Tobit regression model is specified as follows:

$$Y_i^* = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ik} + \varepsilon_i$$

$$Y_i^* = 0, \text{ if } Y_i^* \leq 0$$

$$Y_i^*, \text{ if } 0 < Y_i^* < \alpha$$

$$\alpha, \text{ if } Y_i^* \geq \alpha$$

Where:

Y_i^* = Latent variable representing the unobserved propensity for CSAP usage intensity

Y_i = Observed CSAP intensity index

β_0 = Intercept

$\beta_1 \dots \beta_k$ = Coefficients of explanatory variables

$X_1 \dots X_k$ = Socio-economic and institutional variables

α = Upper censoring limit of the index

E_i = Error term

Explanatory variables

The explanatory variables included in the model are:

Age (years)

Household size (number of persons)

Level of education (years of schooling)

Farm size (hectares)

Household income (MAD)

Farming experience (years)

Access to credit (1 = yes, 0 = otherwise)

Extension contact (1 = yes, 0 = otherwise)

Membership of farmer organization (1 = yes, 0 = otherwise)

RESULTS AND DISCUSSION

The socio-economic characteristics of smallholder millet farmers presented in Table 1 provide important insights into factors influencing the intensity of Climate-Smart Agricultural Practices (CSAPs) in the study area. The result shows that a larger proportion (43.9%) of the farmers were within the age bracket of 33–47 years, with a mean age of 41 years. This suggests that millet farming is dominated by economically active individuals who are capable of adopting and intensifying the use of climate-smart practices. This finding agrees with Ojoko (2021) and Orifah et al. (2024), who reported that middle-aged farmers are more likely to engage in improved agricultural practices.

The gender distribution reveals that all (100%) respondents were male, indicating that millet production in the study area is male-dominated. This may be attributed to prevailing socio-cultural and religious norms that restrict women's participation in certain agricultural activities. Similar findings were reported by Salisu (2022), who emphasized gender-based disparities in access to agricultural resources.

In terms of marital status, the majority (71.0%) were married, suggesting that most farmers have family responsibilities that may encourage them to intensify the use of CSAPs to ensure household welfare. This aligns with Bello et al. (2018), who found that married farmers are more likely to adopt agricultural innovations.

Educational status shows that 59.9% of the respondents had formal education, while 40.1% had informal education. Education enhances farmers' ability to understand and apply agricultural innovations, although its influence may depend on other institutional factors. This finding is consistent with Ogunniyi et al. (2021).

Household size distribution indicates that most respondents (35.1%) had between 6–10 members, with a mean of 8 persons. Larger household sizes imply the availability of family labour, which is essential for implementing labour-intensive CSAPs. This supports Njuguna et al. (2015), who highlighted the role of household labour in agricultural intensification.

The results in Table 2 reveal that farm sizes are generally small, with 71.8% of respondents cultivating between 0.5–1.5 hectares, and a mean farm size of 1.07 hectares. This reflects the dominance of smallholder farming systems, which may influence the level and intensity of CSAP application. Similar findings were reported by Partey et al. (2018).

In terms of institutional characteristics, 68.7% of farmers belonged to farmer-based organizations, which can enhance access to information and improve the intensity of CSAP use. However, access to credit remains limited, with a significant number of farmers relying on informal sources. This limits their ability to invest in improved agricultural practices. Furthermore, only 51.9% of respondents had access to extension services, indicating gaps in agricultural advisory systems. This supports findings by Mutengwa et al. (2023), who emphasized the importance of extension services in promoting climate-smart agriculture.

Level of intensity of CSAP usage

The result in Table 3 shows that the majority (71.8%) of the farmers were medium users of CSAPs, while 25.6% were high users and only 2.7% were low users. This indicates that although most farmers have adopted CSAPs, their level of usage remains moderate.

The dominance of medium users suggests partial and inconsistent application of climate-smart practices, which may limit their effectiveness. This finding agrees with Khatri-Chhetri et al. (2017), who emphasized that the benefits of CSA are maximized when practices are applied consistently and intensively.

Determinants of CSAP intensity

The regression results in Table 4 show that age had a positive and significant effect ($\beta = 0.068$, $p = 0.013$), indicating that older farmers are more likely to intensify CSAP usage. This may be due to accumulated farming experience and better risk perception. This finding is consistent with Oyinbo et al. (2019) and Adebisi et al. (2022), who reported that age positively influences the use of improved agricultural practices in Nigeria.

Total income was found to be positive and highly significant ($\beta = 4.017\text{E-}6$, $p = 0.000$), suggesting that farmers with higher income are more capable of investing in climate-smart practices. This

aligns with Ogunniyi et al. (2021), who found that income significantly enhances adoption and intensity of CSA technologies.

However, income from millet had a negative and significant effect ($\beta = -3.910\text{E-}6$, $p = 0.010$), indicating that reliance on millet income alone may limit farmers' capacity to intensify CSAP usage. This supports Oyinbo et al. (2019), who noted that low profitability of staple crops can constrain reinvestment in improved technologies.

Household size was positive and significant ($\beta = 0.140$, $p = 0.035$), suggesting that larger households provide labour needed for implementing CSAPs. This is in agreement with Ojo and Baiyegunhi (2020), who found that labour availability enhances agricultural intensification.

Farm size also had a positive and significant effect ($\beta = 1.220$, $p = 0.025$), indicating that farmers with larger landholdings are more likely to intensify CSAP usage. This finding is consistent with Liverpool-Tasie et al. (2017), who reported that farm size positively influences technology adoption and use intensity.

Access to credit showed a negative and significant effect ($\beta = -1.258$, $p = 0.022$), suggesting possible inefficiencies in credit utilization. This supports Oyinbo et al. (2019), who observed that access to credit does not always translate into increased agricultural investment due to diversion of funds.

Similarly, extension visits had a negative and highly significant effect ($\beta = -2.457$, $p = 0.000$), indicating that extension services may not be effectively promoting CSAPs. This aligns with Bello et al. (2021), who highlighted the poor quality and irregularity of extension services in Nigeria as a major constraint to agricultural innovation.

Education and farming experience were not statistically significant, suggesting that institutional support and economic capacity may be more critical determinants of CSAP intensity. This finding is supported by Adenle et al. (2017), who emphasized that access to resources and institutional support often outweigh formal education in influencing agricultural technology use.

CONCLUSION

The study concludes that the use of Climate-Smart Agricultural Practices (CSAPs) among smallholder millet farmers in Jigawa State is generally at a moderate level, indicating that while awareness and adoption exist, the intensity of usage remains limited and inconsistent. The findings revealed that socio-economic factors such as age, total income, household size, and farm size significantly and positively influenced the intensity of CSAP usage, suggesting that farmers with greater economic capacity, labour availability, and production scale are more likely to apply climate-smart practices more consistently.

However, income from millet, access to credit, and extension visits were found to have negative and significant effects on CSAP intensity. These results highlight underlying challenges such as low profitability of millet production, inefficient utilization of credit facilities, and ineffective extension service delivery. Despite moderate levels of CSAP usage, the full benefits of these practices are yet to be realized due to institutional and resource-related constraints.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

- Farmers should be encouraged to intensify the use of climate-smart agricultural practices through continuous application rather than partial adoption, particularly those practices that are

compatible with their farming systems and resource capacity.

- Government and relevant stakeholders should strengthen extension service delivery by focusing on practical, location-specific training and regular field demonstrations to improve farmers' understanding and effective use of CSAPs.
- Financial institutions and policymakers should improve access to agricultural credit while ensuring proper monitoring and guidance on its utilization, so that funds are directed toward productive investments in climate-smart practices.
- Efforts should be made to improve farmers' overall income through better market access, value chain development, and support for diversified livelihood activities, as higher income significantly enhances the intensity of CSAP usage.
- Policies that promote access to land and efficient land utilization should be encouraged, as larger farm sizes were found to significantly increase the level of CSAP application among farmers.

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