# Socioeconomic analysis of drought adaptation strategies among maize farmers' in Sudan savanna region of Kano state, Nigeria

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**Abstract**
This study analysed socio-economic determinants of smallholder maize 'farmers' drought adaptation strategies in the Sudan Savanna Regions of Kano State, Nigeria. Using multistage sampling procedure, data were collected from 373 smallholder farmers via a survey with structured questionnaires. Data collected was analysed using Descriptive Statistics and Multivariate probit regression model (MVP). Results indicated that maize is produced predominantly by married and average-aged and male farmers with an average age of 43 years. The average household size is 11 people, with a mean farming experience of 19 years and a land size of 1.68 hectares. Multivariate probit results showed that household size ($p<0.03$), maize farm income ($p < 0.001$), maize farm yield ($p < 0.000$), total off-farm income ($p<0.000$) and gender ($p<0.018$) significantly influenced adoption of ex-post drought adaptation strategies. In contrast, age ($p<0.002$) was found to negatively influence adoption of ex-post drought adaptation strategies. For ex-ante, cooperative membership ($p<0.019$), household size ($p<0.006$), and land ownership ($p<0.029$), had positive significance influence while contact with extension agents ($p=0.031$), age ($p<0.004$), off-farm income ($p<0.000$) and maize farm yield ($p<0.000$) had negative significant effect on adoption of ex-post drought adaptation strategies. Taking into account the socio-economic background of the farmers in the dissemination of knowledge on drought strategies and providing institutional support can improve resilience, which will subsequently ensure sustainable maize production in the region.
**Keywords:** drought, adaptation, maize, strategies, Sudan savannah, farmers

## Introduction

The future of global agriculture is hinged on how successful the existing farming systems can adopt improved practices to address the significant challenges facing farmers, their farmlands, and produce [1, 2]. In order to guarantee food security with the growing global population, there is need for increased sustainable food and agricultural production. However, agricultural farming faces a great deal of difficulty due to climate change, which is characterised by erratic rainfall patterns, and rising temperatures, especially in dry and semi-arid regions [3]. Drought stress adversely affects crops by reducing turgor pressure, gas exchange, and water content, thus impacting crop production, quality, and photosynthetic activity [4, 5]. Drought is a global concern with more than half of the ' 'world's population affected by drought [6]. Drought affects the livelihood of the developing world's farmers and economies, where an estimated 166 billion USD loss was recorded from three-quarters of the global cropped area of 454 million hectares. Globally averaged, one drought event decreases agricultural gross domestic production by 0.8%, with varying magnitudes by country [7]. Each time drought occurs in Nigeria, the area that usually receives very severe impacts includes all areas north of $11^0$N parallel (i.e mainly around Kano Katsina, Jigawa, Yobe, Sokoto, Zamfara, and Borno States) [8].

Maize (Zea mays) is one of the most important crops in the world, and is particularly sensitive to drought stress. Severe drought can reduce maize yield or even fail to harvest [9, 10]. Drought can cause a maize yield loss by 41 % and a higher risk of drought in the mid-latitudes under 1.5 °C global warming from 2021 to 2055 [11]. Just like in other countries of Sub-Saharan Africa (SSA), maize is an important crop in Nigeria, where it is largely cultivated by smallholder farmers over 6.5 million hectares of land across diverse agro-ecological zones of the country [12, 13, 14]. It is by far the largest cereal crop in terms of area and production volume and is the most consumed staple food in Nigeria [12]. While Nigeria is the second largest maize producer in Africa, the ' 'country's export capacity for the agricultural product is abysmally low. Maize yield in Nigeria stands at less than two tonnes per hectare (t/ha) relative to 4.9 t/ha due to continued usage of none drought tolerant open pollinated variety (OPV) rather than improved hybrid seeds by the ' 'country's maize farmers. As a result, production is low and could barely satisfy the huge maize demand estimated at 12 – 15 MMT thereby creating a maize supply gap of nearly 4 MMT per annum [15].

Despite its high yield potential, maize production in Nigeria is constrained by socio-demographic factors, institutional factors, and locational factors that often reduce actual maize yield in the country [16]. Increased crop yield is required to meet the needs of future population growth, but drought causes significant yield reductions for rain-fed and irrigated crops [17]. Small-scale farmers are more vulnerable to drought than other categories of farmers [18]. Under drought conditions, the incomes of small-scale farmers fall drastically because of their reliance to rain-fed agriculture with low yields [19]. Small-scale farmers from developing countries have less access to financial adaptation strategies such as credit, insurance, savings, among others, because of the lack of collateral and the reduced level of development of financial markets in less developed economies [20, 21, 22]. Maize has become one of the most important staple food crop in Kano State and is grown by both large and small-scale farmers in the state, where it is frequently grown in sole and mixed systems with other crops such as legumes or even other cereals under traditional practice [23]. The climate of the area is the tropical dry and wet, strongly associated with the movement of the Inter-Tropical Discontinuity (ITD). The wet season lasts from May to mid-October with a peak in August while the dry season extends from mid-October of one calendar year to mid-May of the next [24]. The mean annual rainfall is between 800mm to 900mm, and the mean annual temperature is about 260C. The farmers in the Sudan savannah region of the state annually experience a drought spell between the months of June-July which is the mid of the crop growing period thereby affecting crop productivity, especially maize.

Though the impact of drought on maize yield and agriculture is widely studied, ranking it the second most quantitatively and thoroughly studied topic [25], studies surrounding drought adaptation impacts on smallholder farming households have not received as much significant research attention in Kano state, Nigeria, as is needed to ensure consistent food security and resilience. Studies on drought have primarily focused on characteristic rainfall and drought trends/intensities over time such as [26] who studied """"Farmers' perceptions of ex ante and ex post adaptations to drought: Empirical evidence from maize farmers in China"""; [27] evaluates Growing Season Rainfall Trends and Drought Intensities in the Sudano-Sahelian Region of Nigeria and [28] on fluctuations in drought occurrence and perceptions of its positive consequences in the Savanna Region of Nigeria. However, there is a gap in drought studies that focuses on understanding the adoption of different adaptation strategies and how ex-ante and ex-post drought adaptation strategies affect maize yield in the Sudan Savanna of Kano. Additionally, there is limited literature and knowledge on how socio-economic factors interact with these adaptation strategies in the unique context of the Sudan Savanna Region. This study therefore, attempted to fill this gap in research by analysing the socioeconomic factors affecting the drought adaptation strategies by smallholder maize farmers in the study area

## Materials and Methods

### Description of the Study Area

This study was carried out in Kano State, Nigeria. Kano has expanded over the years to become the third largest conurbation in Nigeria. The total land area of the state is 20,760 square kilometres and has a projected population of 13,076,892 by 2021, but currently above 9.4 million (National Population Commission, 2020). The temperature of Kano usually ranges between a maximum of $33^0$C and a minimum of $15.85^0$C, although sometimes during the harmattan it falls to as low as $10^0$C, and annual rainfall ranges between 787 and 960mm. Rainfall may not be enough to sustain farming, but is supplementary with a local and semi-modern irrigation system [29].
Some of the food crops cultivated are maize, millet, cowpeas, sorghum, and rice for local consumption while groundnuts and cotton are produced for export and industrial purposes. Other farm produce found in the study area includes sesame, soybean,

cotton, garlic, gum arabic and chili pepper [30]. Maize has become one of the most important staple food crops in Kano and is grown by both large and small-scale farmers in the state, where it is frequently grown in sole and mixed systems with other crops such as legumes or even other cereals under traditional practice [23].

The climate of the area is the tropical dry and wet strongly associated with the movement of the Intertropical Discontinuity (ITD). The wet season lasts from May to mid-October with a peak in August, while the dry season extends from mid-October of one calendar year to mid-May of the next [24]. The mean annual rainfall is between 800mm to 900mm, and the mean annual temperature is about 260C.

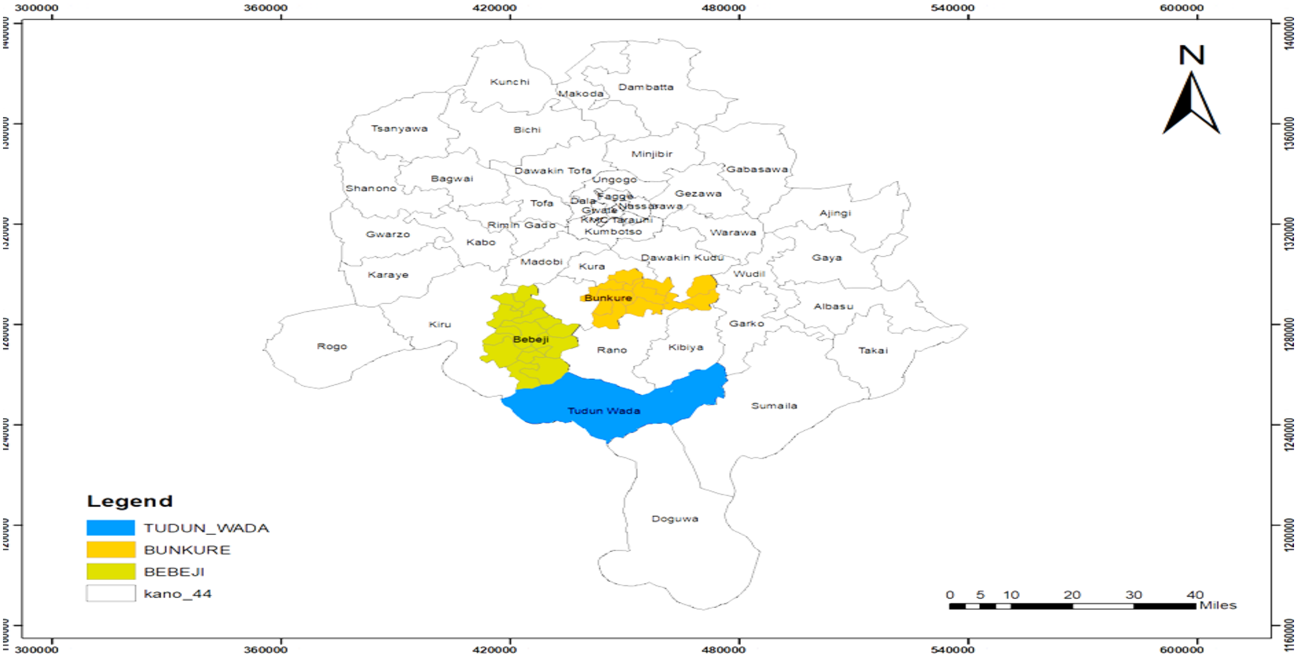


**Figure (1):** Map of Kano Showing the Study Area
Source: GIS Lab, Centre for Dryland Agriculture

**Source and Methods of Data Collection**

The study was conducted using primary data. Primary data was collected using a semi-structured questionnaire administered to maize smallholder farmers in the sampled Local Government Areas (LGAs) in Kano State, Nigeria. The information required and acquired was on socioeconomic characteristics of maize smallholder farmers, different drought adaptation strategies adopted by maize smallholder farmers, determinants of drought adaptation choice of smallholder maize farmers, drought adaptation choice, impact of drought adaptation strategies on household food security, and the profitability of smallholder maize farming in the study area.

**Sampling Techniques and Sampling Size**

The maize production environment in the state was broadly categorised into three administrative zones. The highest proportion of maize area is estimated to fall under zones one and three [29]. Multistage sampling was used, and in the first stage, three (3) LGAs from Sudan Savanna were purposively selected (Tudun Wada, Bunkure, and Bebeji LGAs) based on drought occurrence, availability of maize smallholder farmers, and large maize cultivation volumes. In the second stage, four (4) farming communities were purposively sampled from each LGA. Finally, as shown in Table 1, 373 respondents were randomly selected from chosen communities proportionate to the size as determined using Raosoft's sample size calculator at 5% confidence level.

**Table (1):** Summary of Sampling Frame and Size

| Selected LGAs | Communities | Sampling Frame | Sample size |
|---|---|---|---|
| Tudun Wada | Tudun Wada | 1,110 | 52 |
| | Yarysa | 1,300 | 63 |
| | Faska Wambai | 1,000 | 50 |
| | Ruwa Tabo | 1,000 | 50 |
| Bunkure | Bunkure | 330 | 19 |
| | Gurjiya | 315 | 16 |
| | Barkum | 325 | 16 |
| | Kumurya | 335 | 19 |
| Bebeji | Bebeji | 416 | 22 |
| | Tiga | 420 | 21 |
| | Kofa | 460 | 23 |
| | Gwarmai | 420 | 22 |
| Total | 12 | 7431 | 373 |

Source: KNARDA/Preliminary survey, 2022

**Methods of Data Analysis**

MS Excel was used to enter data and then exported to SPSS for analysis. For this study, data were analysed using both descriptive and inferential statistics as well as econometric analysis methods: descriptive statistics such as percentage, frequency, arithmetic means, and standard deviation were used to achieve objectives i and ii. At the same time, Multivariate Probit Regression Model was used to achieve objective iii.

**Descriptive statistics**

Descriptive statistics was used to achieve one (i) and objective two (ii). Descriptive statistics are concerned with scientific methods for summarizing, presenting, and analysing data as well as drawing valid conclusion and making reasonable decisions based on such analysis [31]. For this study, descriptive statistic such as mean, minimum, maximum, standard error, standard deviation, percentage, and frequency distribution were used to achieve objective 1 and 2. The descriptive approach is briefly explained as follows:

**Arithmetic mean:** this is the set of scores divided by the total number of the observations. Mean is written mathematically as:

$$X = \frac{\sum Xi}{N} = X1, X2, X3 \ldots\ldots..Xn/N \quad \ldots\ldots (1)$$

Where:
X= Arithmetic mean
∑= Summation
$X_i$= Individual observation
I= 1, 2, 3………………..n

**Percentage:** this would be employed in the research to determine the population of respondents to a particular response. Percentage is written mathematically as:

$$Percentage\ (\%) = X/N \times 100 \quad \text{(2)}$$

Where:
% = percentage
X = Individual observation
N = Total observation

**Multivariate Probit Model (MVP)**

MVP was used to achieve objective three (iii). Since the majority of farmers in all research locations have used several adaptation techniques, the best way to assess the factors influencing the decision to use multiple adaptation strategies is via a multivariate probit model. Because of the possibility of dependency and the simultaneity of adaptation decisions, it is not advised to use univariate logit and probit techniques for each type of adaptation strategy. This can result in skewed estimates [32]. The decision to adopt one adaptation technique may influence the adoption of other strategies since multiple adaptation strategies might be used concurrently. This study generates efficient and unbiased estimates by using a multivariate probit model to identify the possible link among unobserved random error factors across these equations and the interdependence between choices [32].

The two adaptation strategies (ex-ante and ex-post) are modelled as:

$$Y_i\, 1^* = X_i\beta_1 + \epsilon_i 1 \quad \text{(3)}$$

$$Y_i\, 2^* = X_i\beta_2 + \epsilon_i 2 \quad \text{(4)}$$

Where: $Y_i\, 1^*$As the latent variable representing the utility or propensity of farmer i to adopt an ex ante adaptation strategy.
$Y_i\, 2^*$as the latent variable representing the utility or propensity of farmer i to adopt an ex-post adaptation strategy.
The socio-economic factors determine these latent variables $X_i$ and the observed binary outcomes for each strategy are denoted as:
$Y_i 1 = if\ Y_i\, 1^* > 0$ (farmer $i$ adopts an ex-ante adaptation strategy) and 0 otherwise.
$Y_i 2 = Y_i\, 2^* > 0$ (farmer $i$ adopts an ex-post adaptation strategy) and 0 otherwise.
$X_i$ is a vector of socioeconomic factors (such as age, education, household size, in-

come, access to credit, farm size, etc.) for farmer $i$. $\beta_1$ and $\beta_2$ are vectors of coefficients for the ex-ante and ex-post adaptation strategies, respectively. $\epsilon_i 1$ and $\epsilon_i 2$ are error terms that are assumed to follow a bivariate normal distribution:

$$\begin{pmatrix}\epsilon_i 1\\ \epsilon_i 2\end{pmatrix} \sim N\left(\begin{pmatrix}0\\0\end{pmatrix}\right), \begin{pmatrix}1 & \rho_{12}\\ \rho_{12} & 1\end{pmatrix}$$

Assumptions**:**

1. The error terms $\epsilon_i 1$ and $\epsilon_i 2$ are jointly distributed with a correlation coefficient$\rho_{12}$, capturing the interdependence between the two adaptation decisions. 2. $\rho_{12} \neq 0$ indicates that the adoption of one adaptation strategy is correlated with the adoption of the other.

The model is estimated using the maximum likelihood method, taking into account the potential correlation between the error terms. The estimates of $\beta_1$and $\beta_2$ andprovide the marginal effects of socioeconomic factors on the likelihood of adopting each adaptation strategy. The significance and sign of $\rho_{12}$ will indicate whether the decisions to adopt ex-ante and ex-post strategies are complementary, substitutes, or independent.

**Results and Discussion**

**Socio Economic Characteristics of Maize Farmers in the Study Area**

Socioeconomic characteristics significantly influence the success of farmers, and these characteristics are helpful in acquiring a better understanding of their activities and providing clues that can be utilised to explain their attitudes, ultimately leading to their productivity [33]._Results in Table 2 showed that the mean age of the smallholder maize farmers is approximately 43 years, suggesting that the majority of the farmers were within the economically active and productive age category [34]. In support of this research finding, [35] noted that respondents within this age bracket (45years) are innovative and motivated individuals who can cope with challenges that may emanate from farming activities. This Result also aligned with the research outcomes of [36]. The study results in Table 2 also revealed that the farmers had households ranging from 1 to as large as 25 individuals, with an average household size of approximately 11 persons. This indicates a considerable range in household size within the population and suggests a higher contribution of family labour for maize production. This is in line with the mean household size of 6 members reported by [37]

Moreover, results in Table 2 showed that farming experience ranges from 3 to 55 years, with an average of 19 years of farming experience and a standard deviation of 10. This suggests a significant variation in the level of experience among the surveyed farmers. This is similar to findings [37] Gender or Sex is an important consideration in household socioeconomic dynamics. The Result in Table 2 indicated that the surveyed group is predominantly male, with 84.18% of the respondents being male farmers, while 15.82% were female farmers. This distribution by sex suggests a gender imbalance in maize farming in the surveyed area, with a significantly higher representation of male. This Result is in line with the findings of [38] who reported the majority of maize farmers in their study. It is further revealed from the results in Table 2 that 46.11% of the surveyed farmers had access to credit, while 53.89% do not. Access to credit is crucial for agricultural activities as it can facilitate investment in inputs, technology, and expansion of farming operations. The fact that nearly half of the respondents had access to credit implies that a significant portion of maize farmers in the survey area can potentially invest in their farming activities and improve their productivity. This finding aligns with the assertion from [39] that the majority of respondents did not have access to credit.

**Table (2):** Distribution of Quantitative Socioeconomic Variables (n=373)

| Variable | Freq. | Percent% | Mini; | Maxi | Mean | SD |
|---|---|---|---|---|---|---|
| Age (years) | | | | | | |
| 21-29 | 43 | 11.53 | 21 | 75 | 43 | 9.42 |
| 31-39 | 88 | 23.59 | | | | |
| 40-48 | 137 | 36.73 | | | | |
| 49-57 | 79 | 21.18 | | | | |
| 58-66 | 23 | 6.17 | | | | |
| 67-75 | 3 | 0.80 | | | | |
| Gender | | | | | | |
| Male | 314 | 84.18 | | | | |
| Female | 59 | 15.82 | | | | |
| Household Size (persons) | | | 1 | 25 | 11 | 6 |
| 1-5 | 84 | 22.52 | | | | |
| 6-10 | 95 | 25.47 | | | | |
| 11-15 | 120 | 32.17 | | | | |
| 16-20 | 47 | 12.60 | | | | |
| 21-25 | 27 | 7.24 | | | | |
| Farming Experience(years) | | | 3 | 55 | 19 | 10 |
| 3-18 | 84 | 35.92 | | | | |
| 19-34 | 57 | 35.12 | | | | |
| 35-50 | 20 | 19.30 | | | | |
| 51-66 | 1 | 9.11 | | | | |
| Farm size (ha) | | | | | | |
| 0.4-1.32 | 158 | 42.36 | 0.4 | 5.0 | 1.66 | 0.944 |
| 1.33-2.24 | 154 | 41.29 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.25-3.16 | 41 | 10.99 | | | | |
| 3.17-4.08 | 16 | 4.9 | | | | |
| 4.09-5.0 | 4 | 1.07 | | | | |
| Access to Credit | | | | | | |
| Access | 172 | 46.11 | | | | |
| No access | 201 | 53.89 | | | | |
| Rented | 72 | 19.30 | | | | |
| Purchased | 32 | 8.58 | | | | |
| Inherited | 78 | 20.91 | | | | |
| Purchased + Rented | 27 | 7.24 | | | | |
| Inherited + Rented | 19 | 5.09 | | | | |
| Inherited + Purchased | 78 | 20.91 | | | | |
| Inherited + Borrowed + Rented | 49 | 13.14 | | | | |
| Inherited + Borrowed | 10 | 2.68 | | | | |
| Borrowed + Rented | 8 | 2.14 | | | | |

Source: Field Survey,

The results in Table 2 further showed that a considerable proportion of the surveyed farmers do not own the land they cultivate. About 19.30% of maize farmers indicated that they "rented" the land they use for maize farming. On the other hand, a smaller portion (8.58%) of maize farmers reported "purchased" land ownership. This suggests that some farmers have invested in acquiring land, potentially indicating a more secure and long-term commitment to agriculture. However, the relatively low percentage of purchased landowners indicates that land acquisition through purchase may not be a prevalent practice among the surveyed farmers. This is contrary to the findings of [40].

One of the most common forms of land ownership identified in the study is inherited land, which is reported by 20.91% of maize farmers. This implies that a significant portion of maize farmers in the surveyed area have gained access to land through generational transfer, often within families. Additionally, the results showed that some farmers combine different forms of land ownership. For instance, "purchased + rented" (7.24%) and "inherited + rented" (5.09%) categories indicate that some farmers may own a portion of their land while renting additional parcels. Similarly, "inherited + purchased" (20.91%) ownership implies a mix of land acquisition methods. These combinations suggest that farmers may employ diverse strategies to secure the land they need for their farming activities, adapting to their specific circumstances and needs. Lastly, the presence of "inherited + borrowed + rented" (13.14%) and "inherited + borrowed" (2.68%) categories signifies that a subset of farmers relies on borrowed land in addition to other ownership types. According to [40] rented land and inherited land are the most used by smallholder maize farmers, which does not exactly align with the findings from this study.

Concerning Farm Size of the respondents. The Result in table 2 further showed a minimum farm size was 0.4 ha, and the maximum was 5.0 ha. The average farm size was approximately found to be 1.66 ha, with a standard deviation of 0.944. These land sizes conform with the smallholder definition by international standards as reported by [41]. Results for Farm Income (NGN) was however shown in Table 3. Findings revealed that the range of income varies from NGN 0 to NGN 1.750,000. However the average income is NGN 447,562, with a standard deviation of NGN 268,330. This Result is contrary to the findings of [42], who reported about twice the average farm revenue. A notable proportion of maize farmers (24.13%) reported minimal income (NGN250, 000). A lower percentage (2.52%) of maize farmers reported larger farm incomes over N 1,000,000. This suggests that smallholder farmers still earn low income from farming in the study area. In addition, the Result in Table 3 also revealed that the range of income of maize farmers varies from NGN 1 to NGN 1,500,000 from off-farm activities. The mean total off-farm income was approximately NGN 221,116, with a standard deviation of NGN 249,848. This finding varies with the findings from [37], who reported an average farm income of NGN 50.745.32.

**Table (3):** Distribution of 'Farmers' Farm and Off-farm Income (n=373)

| Variable | Freq. | Percent% | Min | Max | Mean | SD |
|---|---|---|---|---|---|---|
| Farm income (NGN) | | | 1 | 1,610,000 | 447,562 | 268,330 |
| 1-250,000 | 90 | 24.13 | | | | |
| 250,001-500,000 | 149 | 39.95 | | | | |
| 500,001-750,000 | 89 | 23.86 | | | | |
| 750,001-1,000,000 | 36 | 9.65 | | | | |
| 1,000,001-1,250,000 | 5 | 1.34 | | | | |
| 1,250,001-1,500,000<br>1,500,001-1,750,000 | 2<br>2 | 0.54<br>0.54 | | | | |
| Total Off-Farm (NGN) | | | 1 | 1,500,000 | 221,116 | 249,848 |
| 1-250,000 | 278 | 74.66 | | | | |
| 250,001-500,000 | 52 | 14.05 | | | | |
| 500,001-750,000 | 24 | 6.49 | | | | |
| 750,001-1,000,000 | 11 | 2.97 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1,000,001-1,250,000 | 3 | 0.81 | | | | |
| 1,250,001 – 1,500,000 | 2 | 0.54 | | | | |

Source: Field Survey, 2022

**Socioeconomic Factors Influencing Drought Adaptation Strategies**

This section presents the findings from the Multivariate Probit Regression analysis, conducted to explore the effect of socioeconomic variables on the adoption of various adaptation strategies by smallholder maize farmers. The regression model accounts for the interdependence between these strategies, acknowledging that farmers often adopt multiple approaches simultaneously in response to environmental and economic pressures. The results provide insights into the drivers of adaptation choices and their statistical significance, allowing for a deeper understanding of the patterns in decision-making and policy implications.

**Table (4):** Effect of Socio-Economic Variables on Ex-ante Drought Adaptation Strategies

| Dependent Variables | Independent Variables | Coefficients | SE | t-values | p-values P>t |
|---|---|---|---|---|---|
| Changing Crop Variety | Cooperative Membership | 0.054 | 0.129 | 2.370 | 0.019** |
| | Gender | 0.056 | 0.048 | 1.160 | 0.247 |
| | EA Contacts | -0.831 | 0.203 | -4.090 | 0.000*** |
| | Access to credit | 0.000 | 0.037 | 0.000 | 0.998 |
| | Household size | -0.001 | 0.003 | -0.250 | 0.802 |
| | Landownership | -0.006 | 0.007 | -0.850 | 0.396 |
| | Farm size | -0.000 | 0.000 | -0.200 | 0.842 |
| | Total off-farm income | -0.000 | 0.000 | -0.200 | 0.843 |
| | Farm yield | -0.000 | 0.000 | -0.170 | 0.867 |
| Planting HYMV | Cooperative membership | 0.034 | 0.058 | 0.590 | 0.558 |
| | Gender | -0.004 | 0.052 | -0.080 | 0.9836 |
| | EA Contacts | 0.346 | 0.218 | 1.590 | 0.113 |
| | Access to credit | 0.003 | 0.039 | 0.080 | 0.934 |
| | Household size | 0.006 | 0.004 | 1.780 | 0.075* |
| | landownership | 0.029 | 0.007 | 4.050 | 0.000*** |
| | Age | -0.004 | 0,002 | -1.720 | 0.087* |
| | Farm size | -0.000 | 0.000 | -0.170 | 0.867 |
| | Total off-farm income | -0.000 | 0.000 | -0.380 | 0.707 |
| | Farm yield | -0.000 | 0.000 | -1.030 | 0.304 |

| | | | | | |
|---|---|---|---|---|---|
| Income Diversification | Cooperative membership | -0011 | 0.086 | -0.130 | 0.900 |
| | Gender | 0.031 | 0.076 | 0.410 | 0.681 |
| | EA Contacts | -0.362 | 0.320 | -1.130 | 0.259 |
| | Access to credit | 0.067 | 0.058 | 1.160 | 0.247 |
| | Household size | -0.000 | 0.005 | -0.010 | -0.010 |
| | Landownership | -0.005 | 0.011 | -0.500 | 0.620 |
| | Age | -0.000 | 0.000 | 0.930 | 0.356 |
| | Farm size | 0.000 | 0.000 | 0.930 | 0.356 |
| | Total off-farm income | 0.000 | 0.000 | 1.260 | 0.208 |
| | Farm yield | 0.000 | 0.000 | 0.540 | 0.587 |
| Crop Diversification | Cooperative membership | 0.013 | 0.023 | 0.570 | 0.566 |
| | Gender | -0.001 | 0.021 | -0.050 | 0.959 |
| | EA Contacts | -0.007 | 0.088 | -0.080 | 0.937 |
| | Access to credit | 0.005 | 0.016 | 0.340 | 0.737 |
| | Household size | -0.001 | 0.001 | -0.880 | 0.379 |
| | Landownership | 0.005 | 0.016 | 0.340 | 0.737 |
| | Age | -0.000 | 0.001 | -0.180 | 0.860 |
| | Farm size | 0.000 | 0.000 | 0.070 | 0.944 |
| | Total off-farm income | -0.000 | 0.000 | -1.900 | 0.059** |
| | Farm yield | 0.000 | 0.000 | 0.120 | 0.905 |
| Planting pest and disease resistant seeds | Cooperative membership | | | | |
| | Gender | -0.004 | 0.052 | -0.080 | 0.936 |
| | EA Contacts | 0.346 | 0.218 | 1.590 | 0.113 |
| | Access to credit | 0.003 | 0.039 | 0.080 | 0.934 |
| | Household size | 0.006 | 0.004 | 1.780 | 0.076* |
| | Landownership | 0.029 | 0.007 | 4.050 | 0.000*** |
| | Age | -0.004 | 0.002 | -1.720 | 0.087* |
| | Farm size | -0.000 | 0.000 | -0.200 | 0.845 |
| | Total off-farm income | -0.000 | 0.000 | -0.310 | 0.758 |
| | Farm yield | -0.000 | 0.000 | -2.440 | 0.015** |
| Model Fit | R-Square | 0.014 | | | |
| | F | 1.071 | | | |
| | Akaike crit. (AIC) | 10200.95 | | | |
| | SD dependent var | 208512.70 | | | |

| | | | | | |
|---|---|---|---|---|---|
| | Prob > F | 0.376 | | | |
| | Bayesian crit. (BIC) | 10224.478 | | | |
| | Number of obs | 373 | | | |

***Significant at 1% ($p<0.01$), ** at 5%($p<0.05$), * at 10% ($p<0.10$).
Source: Field Survey, 2022

The multivariate probit regression model presents an R-squared (0.014), which is quite low, meaning the model explains only about 1.4% of the variation in the dependent variable. The chosen independent variables in this case explain just a small portion of the change in the dependent variable. This is mainly due to the absence of drought variables in the model. Also, F-test (p-value = 0.376) suggests that the overall model is not statistically significant, implying that the explanatory power of the included variables is weak.

**Changing Crop Variety**

The results in Table 4 showed that cooperative membership with the coefficient is 0.054 at 5% level of significance, indicating that cooperative membership positively influences the adoption of crop variety change strategy. This suggests that cooperatives might play a critical role in disseminating information or providing support for adopting new crop varieties. The findings are consistent with studies such as [43], which show that farmer cooperatives are essential for adopting agricultural innovations to combat drought.

The Result in Table 4 also showed that contact with extension agents (EA) (-0.831), at 1% level of significance, indicating that more frequent contacts with extension agents negatively affect the likelihood of adopting this strategy. This unexpected Result might suggest that the advice provided by extension services could be inadequate or misaligned with the farmers' needs in this region, possibly corroborating findings by [44] who highlight the gap between farmer needs and the services provided by agricultural extension in some developing regions.

Planting High-Yielding Maize Variety (HYMV)

The coefficient of Household Size is 0.006, and at 10% level of significance, indicating a marginally significant positive effect. Larger households are more likely to adopt high-yield maize, likely due to greater labour availability. This aligns with the findings of [45] who argue that household labour availability is a key factor in the adoption of agricultural technologies.

Landownership was also significant with a coefficient of 0.029 and a highly significant at 1%, land ownership plays a major role in influencing the adoption of high-yield varieties. This Result is in line with literature, such as that by [46], which indicates that secure land tenure encourages investment in improved agricultural practices.

Furthermore, age was also significant with a coefficient of -0.004, and 10% level of significance, indicating that older farmers are less likely to adopt high-yield maize varieties. This reflects the findings of [47], who noted that younger farmers are more open to adopting innovative practices in the face of climate change.

### Income Diversification

Though results in Table 4 indicated that that EA Contacts had no statistically significant effect on income diversification strategies, this finding aligned with literature suggesting that the focus of extension services is often on farm-level productivity rather than off-farm diversification strategies [48]. Conversely, with access to credit, its non-significant effect on income diversification contradicts studies like [49], which found that access to credit positively influences farmers' ability to diversify their income.

### Crop Diversification

Results on total off-farm income (-0.000) at 1% in Table 4 indicated a marginally significant adverse effect. This implies that farmers with higher off-farm income are less likely to diversify their crops. This may be because they rely more on off-farm income for financial security rather than diversifying their agricultural production, consistent with the findings of Kassie *et al*. (2017). On the contrary, access to credit and EA contacts both showed non-significant results, implying that they do not influence crop diversification. This is contrary to some studies, such as [50], which suggest that access to finance and advisory services should support broader crop choices in response to environmental risks.

### Planting Pest and Disease-Resistant Seeds

Results on planting pest and disease-resistant seeds showed that landownership (0.029) had a strong positive impact at 1% level of significance on the likelihood of adopting pest- and disease-resistant seeds. This reinforced findings from Suri [51] that suggest land tenure security promotes investment in resilient seed varieties. On the other hand, maize farm yield (-0.000) had small but significant adverse effect on the adoption of pest- and disease-resistant seeds at 5% level of significance. This could suggest that farmers who already have high yields might not see the need to invest in additional resilience measures, consistent with findings by [52].

**Table (5):** Effect of Socioeconomic Variables on Ex-Post Drought Adaptation Strategies

| Dependent Variables | Independent Variables | Coefficients | SE | t-values | p-values P>t |
|---|---|---|---|---|---|
| Changing Crop Pattern | Cooperative membership | 0.010 | 0.016 | 0.600 | 0.548 |
| | Gender | 0.005 | 0.014 | 0.350 | 0.725 |
| | EA Contacts | 0.003 | 0.060 | 0.060 | 0.955 |
| | Access to credit | -0.003 | 0.011 | -0.280 | 0.783 |

| | | | | | |
|---|---|---|---|---|---|
| | Household size | 0.003 | 0.001 | 3.470 | 0.001*** |
| | landownership | -0.001 | 0.002 | -0.510 | 0.611 |
| | Farm size | 0.000 | 0.000 | 0.280 | 0.776 |
| | Age | -0.002 | 0.001 | -3.010 | 0.003** |
| | Total off-farm income | 0.000 | 0.000 | 0.290 | 0.769 |
| | Farm yield | 0.000 | 0.000 | 0.740 | 0.459 |
| Irrigation | Cooperative membership | -0.019 | 0.017 | -1.170 | 0.243 |
| | Gender | -0.010 | 0.015 | -0.710 | 0.479 |
| | EA Contacts | 0.016 | 0.062 | 0.250 | 0.799 |
| | Access to credit | -0.007 | 0.011 | -0.590 | 0.558 |
| | Household size | -0.000 | 0.001 | -0.640 | 0.521 |
| | landownership | 0.001 | 0.002 | 0.480 | 0.629 |
| | Age | -0.000 | 0.001 | -0.640 | 0.521 |
| | Farm Size | 0.000 | 0.000 | 0.040 | 0.965 |
| | Total off-farm income | 0.000 | 0.000 | 0.690 | 0.489 |
| | Farm yield | 0.000 | 0.000 | 0.320 | 0.752 |
| Mixed Farming | Cooperative membership | 0.027 | 0.052 | 0.520 | 0.601 |
| | Gender | 0.029 | 0.046 | 0.630 | 0.528 |
| | EA Contacts | 0.226 | 0.194 | 1.160 | 0.245 |
| | Access to credit | 0.042 | 0.035 | 1.190 | 0.233 |
| | Household size | 0.002 | 0.003 | 0.480 | 0.630 |
| | Landownership | 0.010 | 0.006 | 1.490 | 0.137 |
| | Age | -0.006 | 0.002 | -3.090 | 0.002*** |
| | Farm Size | 0.001 | 0.000 | 3.390 | 0.001*** |
| | Total off-farm income | 0.000 | 0.000 | 1.990 | 0.047** |
| | Farm yield | 0.000 | 0.000 | 2.020 | 0.044** |
| Use of Minor Tillage | Cooperative membership | 0.003 | 0.010 | 0.340 | 0.737 |
| | Gender | 0.018 | 0.009 | 2.090 | 0.038** |
| | EA Contacts | -0.006 | 0.036 | -0.180 | 0.859 |
| | Access to credit | 0.005 | 0.006 | 0.750 | 0.456 |
| | Household size | 0.000 | 0.001 | 0.730 | 0.468 |
| | Landownership | 0.005 | 0.016 | 0.340 | 0.737 |
| | Age | 0.000 | 0.000 | 0.520 | 0.603 |
| | Farm size | 0.000 | 0.000 | 0.020 | 0.988 |
| | Total off-farm in- | -0.000 | 0.000 | -0.460 | 0.646 |

| | | | | | |
|---|---|---|---|---|---|
| | come | | | | |
| | Farm yield | -0.000 | 0.000 | -0.180 | 0.857 |
| Model Fit | Mean dependent Var | 226631.099 | | | |
| | R-Square | 0.024 | | | |
| | F – test | 1.808 | | | |
| | Akaike crit (AIC) | 10197.278 | | | |
| | SD dependent var | 208512.695 | | | |
| | Prob > F | 373 | | | |
| | Bayesian crit. (BIC | 0.110 | | | |
| | Number of obs | 10220.807 | | | |

***Significant at 1% (p<0.01), ** at 5%(p<0.05), * at 10% (p<0.10).
Source: Field Survey, 2022

The multivariate probit regression model presents with an R-squared (0.024) which is low, meaning the model explains only about 1.4% of the variation in the dependent variable. The chosen independent variables in this case explain just a small portion of change in the dependent variable. This is mainly due to the absence of drought variables in the model. Also, the F-test (p-value = 1.110) suggests that the overall model though better than ex-ante, is not statistically significant at 5%.

**Changing Crop Pattern**

The results in Table 5 showed that household size and age were significant. Household size (0.003) was highly significant at 1% indicating that larger households are more likely to adopt crop pattern changes. Larger households often have more labour available, which is critical for managing different crop patterns, particularly in labour-intensive farming. This Result is supported by [53], who found that household labour availability significantly influences adaptation decisions. Age, on the other hand, with a negative coefficient (-0.002) was also significant at 1%, suggesting that older farmers are less likely to change their crop patterns. This is consistent with the findings of [54], who noted that younger farmers tend to be more innovative and open to adopting new agricultural practices compared to older farmers.

**Irrigation**

The results in Table 5 equally revealed that all socioeconomic variables, including cooperative membership, gender, extension agent contacts, and access to credit, were found to be statistically insignificant. This may suggest that these factors do not significantly influence the adoption of irrigation practices in the study area. One possible explanation is that irrigation might be highly dependent on external infrastructure rather than household characteristics, a finding consistent with the work of [49] who highlighted the infrastructural constraints in smallholder irrigation adoption.

**Mixed Farming**

The findings in Table 5 indicated that age, farm size, maize farm yield and total off-farm income were significant. Age, with a negative coefficient (-0.006) was significant at 1%, implying that older farmers were less likely to adopt mixed farming as a drought adaptation strategy. This finding aligns with the theory that younger farmers are more willing to diversify their farming operations [44]. Conversely, maize farm size (0.001) was positively significant at 1%, showing that larger farms are more likely to adopt mixed farming strategies. Larger farm sizes provide the flexibility and resources needed to diversify farming activities, supporting findings by Suri (2011), who noted the critical role of farm size in technology and practice adoption.

Total off-farm income (0.000) was also significant at 5%, implying that higher off-farm income encourages mixed farming. This suggested that farmers with alternative income sources may have more financial resources to invesst in diversified farming systems. This finding is consistent with [52], who argued that off-farm income provides financial resilience, allowing farmers to take more risks in their agricultural choices. In the same way, maize farm yield (0.000) was significant at 5% suggesting that higher maize farm yields were associated with a greater likelihood of adopting mixed farming. This may be because farmers with higher yields have more resources or confidence to diversify their farming operations, a finding supported by [50].

**Use of Minor Tillage**

Gender was the only significant socioeconomic variable influencing the adoption of minor tillage as an adoption strategy in the study area, as seen in Table 5. The positive coefficient (0.018) at 5% level of significance indicated that male farmers are more likely to use minor tillage than female farmers. This Result highlighted potential gender disparities in access to or knowledge of tillage practices, as noted by [48], who found that men are more likely to adopt agricultural innovations due to better access to resources.

The study concludes that socio-economic factors such as household size, access to credit, education, and land ownership significantly impact the ability of farmers to adapt to drought conditions through adaptation strategies. The adoption of these strategies, including crop diversification and the use of early maturing varieties, has been shown to positively influence maize yield, underscoring the importance of targeted interventions to improve adaptive capacities. Taking in to account socio-economic background of the farmers in the dissemination of innovative drought strategies and providing institutional support can improve resilience, which will subsequently ensure sustainable maize production in the region.

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