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Farmers' Perceptions of Drought and Adaptation Strategies in Mashi Local Government Area, Katsina State, Nigeria

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ABSTRACT
In spite of drought's long history in northern Nigeria and approaches to drought mitigation, losses from it have continued to rise. This study assessed farmers' perceptions of drought and adaptation strategies employed in combating the impacts of drought in Mashi Local Government Area of Katsina State. Rainfall data spanning a period of 60 years (1961-2020) was used in the study. A total of 384 copies of a questionnaire were administered to farmers in selected communities of the study area. A second order polynomial curve fitting, 5-year moving average, and standard deviation were used in determining trends and variability of the rainfall while Rainfall Anomaly Index was used in depicting periods of different drought intensities in the area. A five-point Likert Scale was then used to assess the impact of drought on agriculture and drought adaptation strategies. The results from the second order polynomial curve fitting, the 5-year moving average and the standard deviation indicated an increasing rainfall trend in recent years. The Rainfall Anomaly Index revealed that the area has experienced different droughts intensities in the 1970s, 1980s and 1990s while normal to very wet conditions dominated in the 2000s and 2010s. Findings also revealed that the most significant impacts of drought were decline in crop yields with a mean score ($\bar{x}$) of 4.06 an increase in the cost of food crops ($\bar{x}$ = 4.04) among others. Further findings revealed that praying for God to intervene ($\bar{x}$ = 4.46) and planting crops with early maturity ($\bar{x}$ = 4.33) among others were the most significant drought adaptation strategies. Conclusively, this study revealed that the area has been experiencing a decreasing number of droughts in recent years. It is recommended that extension workers should be trained in climate change science to enable them to pass adequate information on climate related issues and appropriate drought adaptation measures to farmers, and strategies for combating droughts should consider the traditional and religious beliefs of the people.

Keywords: communities, crops, impacts, rainfall, severe drought.

1.0 INTRODUCTION

Hydrological extremes, especially droughts and floods, are mostly responsible for the loss of lives and destruction of property. Drought is a complex phenomenon that is associated with a lack of moisture or inadequate supply of rainfall for certain times. It occurs in virtually all the climatic zones of the world, but varies in terms of its onset, magnitude, severity and duration from country to country and region to region (Henchiri *et al.*, 2021; Ayugi *et al.*, 2022). Drought is one of the most calamitous natural climatic catastrophes that affect life, the economy and society. Over-exploitation of the natural resources and climate change are mostly responsible for the occurrence of drought in any given environment (Abaje *et al.*, 2013; Abara *et al.*, 2020).

African countries are identified as having the highest vulnerability to drought, especially those whose economies are highly dependent on natural resources that are sensitive to climate such as rain-fed agriculture (Ayugi *et al.*, 2022). Reports by the University of Gothenburg and Jennifer Nnopuechi (2021) indicated that cases of drought in Africa have severely affected over 15 million people with over 680,000 people dead as a result of severe drought from 1975 to 2020. Sub-Saharan Africa witnessed very severe famines associated with the famous drought of 1980s that hit the region, causing many casualties and loss of lives and assets (Abaje *et al*., 2013). However, it is very important to note that drought is not the only cause of famine and food insecurity in Africa. For instance, countries like Somalia, Sudan, Chad and Angola have experienced severe famine in the 1980s as a result of the civil war and conflict going on as at that time alongside the drought (University of Gothenburg and Jennifer Nnopuechi, 2021).

Rainfall is critical to life and livelihood in Nigeria, as well as the economy of the country. Agriculture, which provides employment and means of livelihood for a large percentage of the Nigerian population and contribute significantly to Nigeria's Gross Domestic Product (GDP) is predominantly rain-fed. Excess rainfall could lead to varying degrees of flooding while rainfall deficit could lead to droughts and may have negative impacts on the people, economy, and ecosystems (Nigerian Meteorological Agency (NiMet), 2021). Large areas of northern Nigeria falling within the Sahel and Sudan ecological zones are prone to recurrent droughts. The area is estimated to be about

38% of the total land area of Nigeria and it is the grain basket of the country populated by small scale subsistence farmers and nomadic livestock herders (Oladipo, 1993a; Abubakar and Yamusa, 2013). These farmers and herders depend largely on rain-fed agriculture and the exploitation of rangelands by it livestock. Hence, any variations in the timing or amount of rainfall can cause serious problems for crop and livestock productions (Abaje *et al*, 2013).

Drought adaptation refers to the strategies which are developed or implemented to enhance a system's ability to adjust to the changing climate (for example, drought) and its effects by avoiding potential damages and losses, and taking advantage of the opportunities or coping with the consequences (Economic and Social Commission for Asia and the Pacific, ESCAP, 2020; IPCC, 2022). A recent global review on droughts indicated that large-scale droughts have frequently occurred during the past 1000 years across the globe (Masih *et al.*, 2014).

Studies dealing with drought in various parts of Northern Nigeria have been carried out by Oladipo (1993b), Abaje *et al*. (2013), Achugbu and Anugwo (2016), Eze (2018), Abubakar *et al.* (2019), Adejuwon and Dada (2021), Yakubu *et al*. (2021) and Ati *et al.* (2022) amongst others. Most of these studies concentrated on the extent of drought and its impact on agriculture and water resources. For examples, Oladipo (1993b) investigated some aspects of the spatial characteristics of drought in northern Nigeria and found out that severe and persistent droughts were the features of the 1980s and according to Abaje *et al.* (2013), the drought of the year 1987, in particular, was more severe than the driest year (1973) of the Great Sahelian Droughts of 1968-1973. Eze (2018) stated that the occurrence of droughts in Yobe State has a negatively impact on the environment and livelihood assets, and agriculture is the most affected sector by the frequent occurrence of drought in the State. Similarly, Abubakar *et al.* (2019) in their study of drought and coping strategies in Babura community of Jigawa State also found out that agricultural production as well as the socio-economic status of the farmers have been significantly affected by drought. Furthermore, Adejuwon and Dada (2021) examined the temporal characteristics of drought in the tropical semi-arid zone of Nigeria and their findings revealed that mild drought prevails in most of the region while extreme drought was not frequent and drought frequency was lowest in the northwest and highest in the northeastern part of the country. In Katsina State, Ati *et al.* (2022) observed that mild, moderate and severe droughts were experienced in the 1970s, 1980s and 1990s. But in the 2000s and 2010s, the State generally experienced normal to very wet conditions with just some isolated mild and moderate droughts.

In spite of drought's long history in northern Nigeria and approaches to drought adaptation and mitigation, losses from it has continued to rise. Containing losses due to drought requires rigorous planning and widespread application of techniques and strategies for mitigating its impacts, especially at the local level. It is in view of the above facts that this research seeks to assess farmers' perception on drought and the adaptation strategies adopted by the people, based on locally available resources, in some selected communities in Mashi Local Government Area (LGA) of Katsina State.

2.0 STUDY AREA

Mashi LGA (Figure 1) is located at the extreme northern part of Katsina State. It lies between Latitudes 12°50′N to 13°10′N and Longitudes 7°47′E to 8°00′E. It has a tropical continental climate, that is, the wet/dry type of climate classified as Köppen's Aw (Köppen, 1936). The rainy season starts from May to September and the average annual rainfall is about 500 mm. The dry season is from October to May. The climate is dominated by the influence of the Tropical Maritime (mT) air mass and the Tropical Continental (cT) air mass. The mT air mass which is relatively warm and moist originates from the Atlantic Ocean and is associated with Southwest winds in Nigeria. The cT air mass on the other hand is relatively cool and dry and originates from the Sahara Desert. It is associated with the dry, cool and dusty Northeast Trades Winds known as the Harmattan. These two air masses meet along a slanting surface known as the Inter-tropical Discontinuity (ITD). The movement of the ITD determines the seasons. The mT air mass controls the area during the wet season (May to September) while the cT air mass prevails during the dry season (October to April) (Abaje and Ogoh, 2018; .Abaje and Oladipo 2019; Adejuwon and Dada, 2021).

The geographical location of Mashi LGA in relation to the distance in which the mT air mass has to travel before reaching the area and also its proximity to the Sahara desert makes this area one of the driest part of the country (FRN, 2018). The highest air temperatures are always recorded in the month of April while the lowest temperatures are recorded in the months of December/January. The highest amount of evapotranspiration occurs during the dry season (Ati *et al.*, 2022). The soil is the tropical ferruginous type while Sahel vegetation characterized the area. The vegetation consists of trees that grow long tap roots and thick barks that make it possible for them to withstand the long dry season and bush fires. The predominant trees species are acacia and baobab (Dogonyaro *et al.*, 2022).

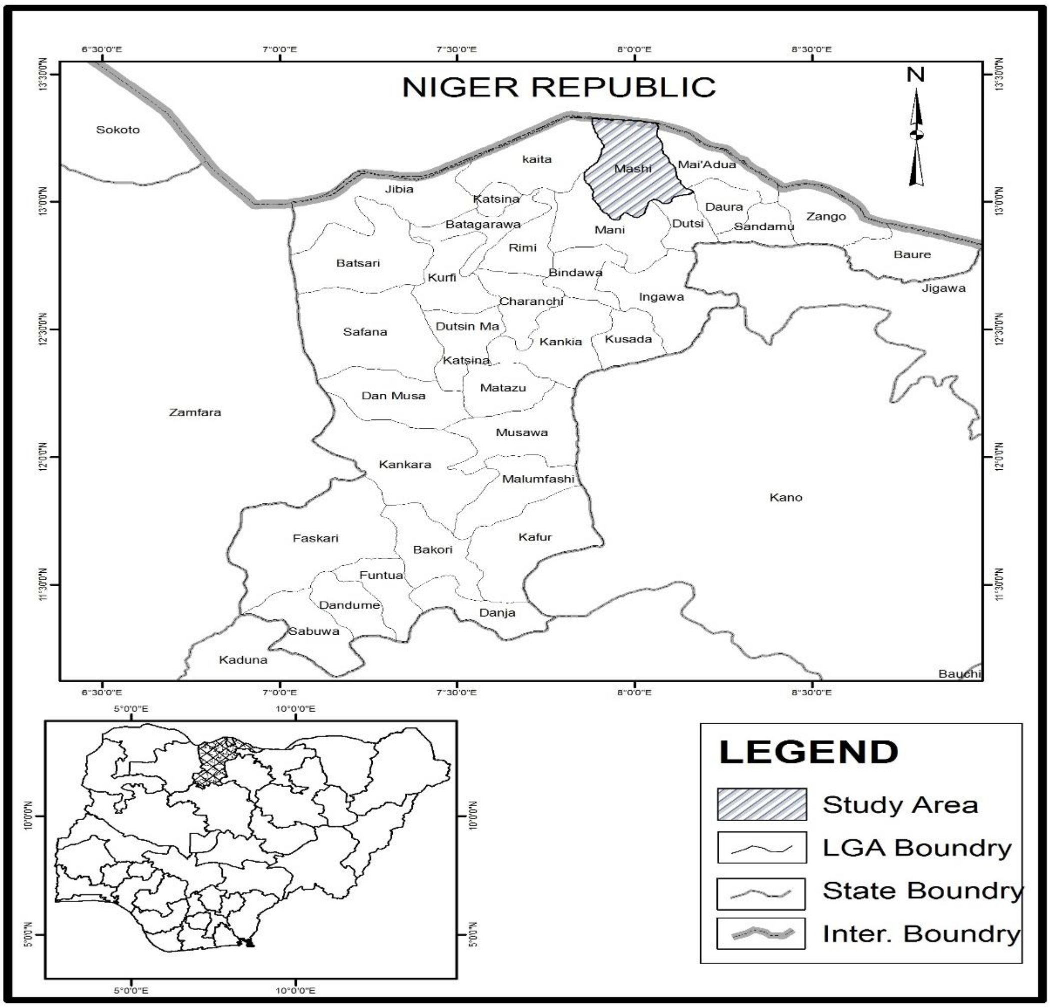

Figure 1: Mashi Local Government Area
Source: Adapted from Abaje and Ogoh (2018)

3.0 MATERIALS AND METHODS

3.1 Data Collection

This study was effectively achieved by the use of both primary and secondary data. The major primary data instruments used were structured questionnaire and one Focus Group Discussion (FGD). Copies of the structured questionnaire were distributed to literate farmers while illiterate farmers were interviewed using the same instruments with the help of research assistants that understood the local dialect of the people. The secondary data were monthly rainfall data for 60 years (1961-2020) which were collected from the archive of the Nigerian Meteorological Agency, Abuja.

3.1.1 Sample Size and Sampling Techniques

The 1991 national census was used for the purpose of this study. The basis for using the 1991 census instead of 2006 was that the 2006 population census' document has no locality population (FRN, 2010). Mashi LGA, during the 1991 census had a population of 137,555 people with an annual growth rate of 2.8% (FRN, 1991). This figure was projected to the year 2020 for the purpose of this study using the method of Mehta (2004). The method is determined as:

$$P_n = P_o (1 + R/100)^n \quad (1)$$

where: Pn = population in the current year

Po = population in the base year.

R = annual growth rate.

n = number of intermediary years.

Based on the above method, the projected population of the study area for the year 2020 is 306,392 people. However, to determine the sample size, Krejcie and Morgan (1970) method was employed. The formula is given as:

$$s = \frac{X^2 NP(1-P)}{d^2 (N-1) + X^2 P(1-P)} \quad (2)$$

where: s = sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be 0.50 since this would provide the maximum sample size.

d = the degree of accuracy expressed as a proportion (0.05)

Based on this method, the sample size used for this research was 384. Mashi LGA has 126 local communities based on the 1991 census. Due to the homogenous nature of the population of this area in terms of livelihoods, religion, cultural background, among others, thirteen (13) local communities were then sampled using systematic sampling techniques (see Table 1). Simple random sampling was then used to sample the farmers from each of the selected community. In addition, the study also utilized snowball sampling technique in sampling the farmers. This sampling technique was based on previously identified farmers that have experienced drought over the years to recommend others who have or share the same characteristics as the respondents already in place. This technique really helped in gathering information from hidden respondents that have experienced drought and were difficult for the researchers to access.

3.1.2 Questionnaire Administration

The questionnaires were purposively administered to farmers who are 40 years and above, based on simple proportion, and must have been residing in the area for at least 30 years. The basis for this was to gather information from respondents who have had experiences in drought over the years. Only respondents who were willing and interested on the subject matter were purposively administered questionnaires. The respondents were mostly interviewed in their nearby farms, and at home around 2-8 pm for those whose farms were far away from their houses. Regular supervision exercises were carried out by the researchers to ensure effective questionnaire administration and collation. In addition, Focus Group Discussions (FGD) of thirteen 13 people (one participant from each of the selected communities) was also held in Mashi town in order to obtain in-depth information on the recent changes in rainfall, occurrences of drought and adaptation strategies adopted by the farmers in their various communities.

Table 1: Sampled Communities and Sampled Size

S/NO	Local Communities	Population (1991)	Projected Population (2020)	Number of Respondent
1.	Birnin-kuka	2,159	4,809	64
2.	Dantankan-Gabas	1,677	3,735	50
3.	Kamarawa-Nakaye	1,427	3,179	42
4.	Doguru	1,317	2,934	39
5.	Kukar-Gata	1,138	2,535	34
6.	Badauri-C	998	2,223	29
7.	Kogo-Yamma	886	1,973	26
8.	Buluwa	794	1,769	23
9.	Ilalla	697	1,553	21
10.	Bunawa	593	1,321	17
11.	Hamis-Zanguwa	554	1,234	16
12.	Duma	495	1,103	15
13.	Chidawa	143	319	8
	Total	**12,878**	**28,685**	**384**

Source: Field survey, 2021.

Data Analysis

The standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) statistics as defined by Brazel and Balling (1986) were used to test for the normality in the rainfall series for the study area. The standardized coefficient of Skewness (Z_1) was calculated as:

$$Z_1 = \left[\left(\sum_{i=1}^{N} (x_i - \bar{x})^3 / N \right) \Big/ \left(\sum_{i=1}^{N} (x_i - \bar{x})^2 / N \right)^{3/2} \right] \Big/ \left(6/N \right)^{1/2} \quad (3)$$

and the standardized coefficient of Kurtosis (Z_2) was determined as:

$$Z_2 = \left[\left(\sum_{i=1}^{N} (x_i - \bar{x})^4 / N \right) \Big/ \left(\sum_{i=1}^{N} (x_i - \bar{x})^2 / N \right)^{2} \right] - 3 \Big/ \left(24/N \right)^{1/2} \quad (4)$$

where $\bar{x}$ is the long term mean of x_i values, and N is the number of years in the sample. These statistics were used to test the null hypothesis that the individual temporal samples came from a population with a normal (Gaussian) distribution. If the absolute value of Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at the 95% confidence level.

To examine the nature of the rainfall trend, second order polynomial curve fitting was used to determine the non-linear trend of the rainfall. The equation is of the form:

$$y = a + b_1 x + b_2 x^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

To evaluate the three unknowns (a, b_1, b_2), the normal equations become a set of 3 simultaneous equations:

$$\sum y = na + b_1\left(\sum x\right) + b_2\left(\sum x^2\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\sum xy = a\left(\sum x\right) + b_1\left(\sum x^2\right) + b_2\left(\sum x^3\right) \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$\sum x^2 y = a\left(\sum x^2\right) + b_1\left(\sum x^3\right) + b_2\left(\sum x^4\right) \ldots\ldots\ldots\ldots\ldots (8)$$

Here $\sum xy$ is the sum of the products obtained by multiplying each value of x by the corresponding value of y, $\sum x^2 y$ is the sum of the products obtained by multiplying the square of each value of x by the corresponding value of y, and $\sum x^2$, $\sum x^3$, and $\sum x^4$ are the sums of the second, third, and fourth powers of the x's respectively.

A 5-year moving average was calculated and plotted using Microsoft Excel 2013 in order to smoothen the time series, thereby reducing the irregular fluctuations and highlighting those that were regular. Given a set of numbers y_1, y_2, y_3, - - - y_n, a moving average of order n is defined by the sequence of arithmetic means:

$$\frac{y_1 + y_2 + --- + y_n}{n}, \frac{y_2 + y_3 + --- + y_n + 1}{n}, \frac{y_3 + y_4 + --- + y_n + 2}{n}, e.t.c. \quad \ldots \text{ eq. 9}$$

The sum in the numerators of equation 9 are called moving totals of order n. Here the order is 5.

Furthermore, the standard deviation which provides the deviation from normal was equally determined and plotted using Microsoft Excel 2013. This was done in order to find out the nature of the trend and measurement of variability of the rainfall. From the plotted charts, extreme conditions were then detected. The standard deviation (δ) is computed as:

$$\delta = \sqrt{\frac{\sum (x - \bar{x})^2}{n}} \quad \text{……..……………….…… eq. 10}$$

Where: x = value of rainfall or temperature observations. $\bar{x}$ = mean value of rainfall or temperature observations.

n = number of rainfall observations of sample.

Rainfall Anomaly Index (RAI) as developed by van Rooy (1965) was used in depicting drought intensities and years of occurrences in the study area. The method was chosen due to the fact that it is only rainfall records that are mostly available for the study area. The equation is given as:

$$RAI = 3[(p - \bar{p})/(\bar{m} - \bar{p})] \quad \text{…………..…………………….. (11)}$$

for positive anomalies and

$$RAI = -3[(p - \bar{p})/(\bar{x} - \bar{p})] \quad \text{…..…………..……………….. (12)}$$

for negative anomalies, where p is the actual rainfall, $\bar{p}$ is the long-term average rainfall, $\bar{m}$ is the mean of the ten highest values of p on record and $\bar{x}$ is the mean of the ten lowest value of p on record. The arbitrary threshold values of +3 and – 3 have been assigned to the mean of the ten most extreme positive and negative anomalies respectively. There are nine abnormality classes in this technique, ranging from extremely wet to extremely dry (Table 2).

These nine classes of van Rooy (1965) were modified and seven abnormality classes, ranging from very wet to severe drought conditions, were adopted in this study (Table 3). This modified technique was tested and found to be suitable in depicting periods of different drought intensities in northern Nigeria and the country at large.

Table 2: RAI Classification Values

Index	Character of the Weather
≥ 3.00	Extremely wet
2.00 to 2.99	Very wet
1.00 to 1.99	Moderately wet
0.50 to 0.99	Slightly wet
-0.49 to 0.49	Near normal
-0.99 to -0.50	Slightly dry
-1.99 to -1.00	Moderate dry
-2.99 to -2.00	Severe dry
≤ -3.00	Extremely dry

Source: van Rooy (1965)

Table 3: Modified RAI Classification Values

Index	Character of the Weather
≥ 3.00	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
-0.99 to 0.99	Normal
-1.99 to -1.00	Mild drought
-2.99 to -2.00	Moderate drought
≤ -3.00	Severe drought

The primary data obtained were analyzed based on descriptive statistics and the use of a five points Likert Scale (LS) as follows: SA=Strongly Agree, A=Agree, UD=Undecided, DA=Disagree, and SD=Strongly Disagree. Values assigned to these options were 5, 4, 3, 2 and 1 respectively. The mean score of the respondents is computed as:

$$\bar{x} = \frac{\sum fx}{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(13)}$$

where: $\bar{x}$ = mean
fx = frequency of x
N = number of occurrences.

Based on the calculated five points LS, the mean score of the respondents is 3. Therefore, factors with mean scores less than 3.0 connote not significant while those with mean score above 3.0 connote significant factors. A mean score of exactly 3 indicates undecided on the level of significance impacts of drought and adaptation strategies employed to combat drought in the study area.

4.0 RESULTS AND DISCUSSION

4.1 Socioeconomic Characteristics of Respondents

The socioeconomics characteristics of the respondents in the study area are presented in Table 4. The results of the findings show that majority of the respondents were males (87%) while only 13% were females. This is in agreement with other related studies. For examples, Ishaya and Abaje (2008) and Abaje *et al* (2014) observed that most of the activities related to agriculture, especially farming, were dominated by males. One other reason for this lopsidedness of the result has to do with the culture and religion of the people where women are always restricted from some certain activities or confined inside their houses. However, in cases of death of husband or divorce, the woman takes over the responsibility of taking care of the household by engaging in the tedious agricultural activities or leasing land, and other petty trading.

Table 4: Socio-economics Characteristics of the Respondents

Household Characteristics		Frequency	Percentage	Average
Gender	Male	334	87.0	
	Female	50	13.0	
Age Bracket	40 – 44	162	42.1	47
	45 – 49	63	16.3	
	50 – 54	108	28.1	
	55 – 59	35	9.0	
	≥ 60	16	4.5	
Marital Status	Married	342	89.1	
	Divorced	20	5.2	
	Widowed	16	4.2	
	Single	6	1.5	
Educational Level	No formal education	23	5.9	
	Islamiyya	195	50.8	
	Primary	81	21.1	
	Secondary	66	17.1	
	Tertiary	20	5.1	
Farming Practice	Rain fed	287	74.7	
	Irrigation	45	11.8	
	Both	52	13.5	
Farming Experience	≤ 10 Years	85	22.1	17
	11 – 20	185	48.2	
	21 – 30	82	21.3	
	≥ 31	32	8.4	
Major Occupation	Civil servants	63	16.3	
	Business	40	10.4	
	Farming	264	68.9	
	Others	17	4.5	
Household Size	≤ 5	108	28.0	10
	6 – 10	156	40.7	
	11 – 15	65	16.8	
	16 – 20	33	8.7	
	≥ 21	22	5.8	
Cultivated Crops	Millet	147	38.2	
	Sorghum	85	22.2	
	Peanut	70	18.3	
	Sesame	44	11.5	
	Others	38	9.8	
Types of Farming	Commercial	132	34.3	
	Subsistence	140	36.4	
	Both	113	29.3	
Farm Size (Hectares)	≤ 5	78	20.2	10
	6 – 10	147	38.2	
	11 – 15	94	24.6	
	16 -20	35	9.0	
	≥ 21	28	7.2	

Source: Field Survey, 2021

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The results from the 384 respondents had 50.8% of the respondents attended *Islamiyya* and 5.1% went to tertiary institutions, 17.1% possess secondary school education, 21.1% primary education and only 5.9% had no formal education (Table 4). This shows that majority of the farmers are literate since the least can communicate in Hausa and Arabic (*Ajami*). One of the major reasons most of the respondents attended *Islamiyya* is not unconnected with the fact that Islam is the major religion of the people in the study area. This findings is in line with the work of Abaje *et al.* (2016) in Safana LGA of Katsina State where 38% of the farmers attended Qur'anic (*Islamiyya*) education. The literacy level of the respondents is very important because an educated farmer is considered to be in a better position to make informed decisions on drought adaptation and mitigation strategies that will reduce the impact and vulnerability on the people. The average age of the respondents is 47 years. Age is an important factor in terms of drought adaptation strategies in the area. This is because the younger ones that are still active and agile commit more of their energy in crop production and are conscious about the impacts of drought on their livelihood and the environment while the older ones have had experiences in adaptation strategies to drought over the years.

The major occupation of the respondents is farming and about 89.1% are married with an average household size of 10 persons. This findings concurs with the investigation of Tarfa *et al.* (2019) on farmers' perception of climate change and adaptation strategies in Nasarawa State, Nigeria in which the average household size was 10 persons. The large household size according to a participant of the FGD is believed to provide cheap labor that would assist in cultivating vast lands. This will lessen the impacts of drought in the community. Some of the children may travel to cities in search of income-producing labor in order to buy food for the family as stated in Oladipo (1993a). The major type of farming practiced in the area is rain-fed. This is because of the absence of rivers and artificial dams that can support irrigation farming in the area. Millet is the major cultivated crop in the area. This is because it is very resistant to drought and it matures early with high yield when compared with other crops. In terms of farming experience, majority (48.2%) of the farmers have farming experience between 11 and 20 years and only 8.4% have over 30 years' experience. This may not be unconnected with old age and less burden as they mostly depend on their children. The major farming type is subsistence. However, since agriculture is the mainstay of the communities, majority of the people depend on it for income generation.

4.2 Rainfall Trend and Fluctuation

The mean ($\overline{x}$), standard deviation (δ), minimum and maximum values, range, standardized coefficients of skewness (Z_1) and Kurtosis (Z_2) of the annual rainfall for the station are presented in Table 5.

The results of the standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) show that the annual rainfall was accepted as indicative of normality at 95% confidence level, and therefore, no transformation was done to the data. The mean annual rainfall for the study period is 588.7 mm with a standard deviation of 160.3 mm.

The graphical presentation of the annual rainfall (mm) against the years of record in the study area smoothened out with the 5-year running average is shown in Figure 2. The figure shows that the lowest annual rainfall of about 262 mm was experienced in 1993 while the highest annual rainfall of about 979 mm was experienced in 1964. The plotted standard deviation in Figure 2 has 18 anomaly years. 6 years were wetter than the normal condition while the other 12 years were drier than the normal condition. All the 12 years that were drier than the normal condition are found between 1972 and 1999. This period corresponds with the Great Sahelian Droughts of the 1970s and the droughts of the 1980s that ravaged the northern part of the country (Oladipo, 1993b; Abaje *et al*., 2013). Conversely, out of the 6 years that were wetter than the normal condition, 2 cases are found in 2010 and 2018 signifying increasing rainfall trend in recent years. This finding agrees with that of Ati *et al.* (2022) that the area is becoming wetter in recent years.

Table 5: Descriptive Statistics of Annual Rainfall (mm) (1961-2020)

Statistics	Values
Mean ($\bar{x}$)	585.0
Standard deviation(δ)	156.4
Minimum	262.0
Maximum	979.0
Range	717.0
Skewness (Z_1)	0.035
Kurtosis (Z_2)	-0.227

Source: Authors' Analysis (2021)

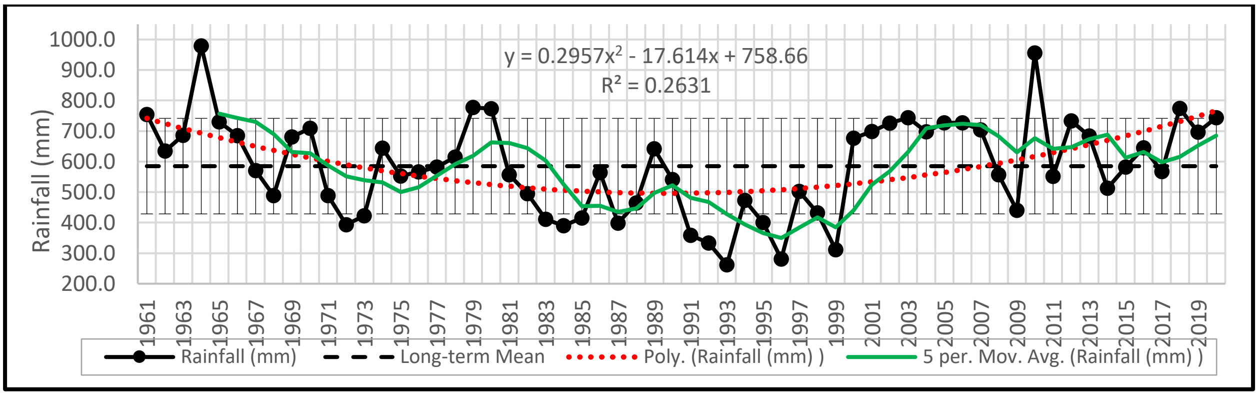

Figure 2: Annual Rainfall Trend and Fluctuation (1961 – 2020)

From the beginning of the data studied to 1971, the 5-year running mean and the second order polynomial curve fitting for the station show that the annual rainfall was above the long-term mean. From that point up to 2002, both the running mean and the second order polynomial curve fitting show that the annual rainfall was below the long-term mean. This period coincided with the period of the great droughts of the 1970s, 1980s and 1990s that ravaged the northern part of the country as described by Oladipo (1993b), Abaje *et al*, (2013) and Ati *et al.* 2022). From 2002 afterwards, the annual rainfall was above the long-term mean as indicated by the 5-year running mean and the second order polynomial curve fitting. This finding is in agreement with the observation made by Abaje *et al* (2012, 2013) and Ati *et al* (2022) that the Sudano-Sahelian Ecological Zone of Nigeria has been experiencing decreasing number of drought occurrences over the recent years and increasing wetness.

4.3 Drought Intensity and Years of Occurrence

The results of the analysis of Rainfall Anomaly Index (RAI) in the study area is presented graphically in Figure 3, while the intensity and years of occurrence of drought in the area are presented in Table 6. The results revealed that the area has experienced mild, moderate and severe droughts during the study period. All previously identified drought episodes in northern Nigeria by other researchers such as Oladipo (1993b), Abaje *et al*. (2013), Adejuwon and Dada (2021) and Ati *et al*. (2022) among others were captured by this drought index. For example, the well-known Great Sahelian Droughts that started in the northern part of West African Sahel in 1968 and retreated southwards until 1973 when the whole region, including northern Nigeria, was affected by severe drought and then moderate to severe droughts between 1982 and 1988 as described by Oladipo (1993b), Abaje *et al* (2013) and Ati *et al*. (2022) among others. After the droughts of the 1970s and 1980s, the whole of the 1990s was severely hit by drought (see Table 6). This was the decade in which severe drought became more extensive in Mashi LGA. Mild drought affected the area in 1994 and 1997, moderate drought in 1995 and 1998 while severe drought affected the area in 1991, 1992, 1993, 1996 and 1999. This findings corresponds with the investigation of Ati *et al.* (2022) on the occurrence of meteorological drought in the Sudano-Sahelian Ecological Zone of Nigeria in which they found out that the whole of the 1990s was affected by different drought intensities in Katsina State. From the 2000s to the end of the study period (2020), the LGA generally experienced normal to very wet conditions with only moderate and mild droughts that affected the area in 2009 and 2014 respectively.

A general observation of Table 6 shows that the total number of years affected by different drought intensities during the study period were 21 which represents about 35% of the study period (60 years). The most dominant drought intensity in this area were moderate droughts with 9 years of occurrence followed by mild drought (7 years) and then severe drought (5 years). This result agrees with Atedhor (2014) and Ati *et al.* (2022) that mild and moderate drought intensities are much more dominant in northern Nigeria than severe droughts.

4.4 Farmers' Perceptions on Rainfall Pattern and Drought

Figure 4 represents respondents' perceptions on rainfall variability and drought occurrences in the study area for the past 3 decades (1991-2020). Significant number of the respondents (42.9%) agreed that rainfall has been increasing for the past three decades, 36.7% disagreed while the remaining 20.4% were neutral. The increase in annual rainfall amount in recent years in the area as perceived by the farmers is in line with the observed data. It also agrees with recent related researches in the study area such as Abaje *et al* (2012, 2013) and Ati *et al* (2022).

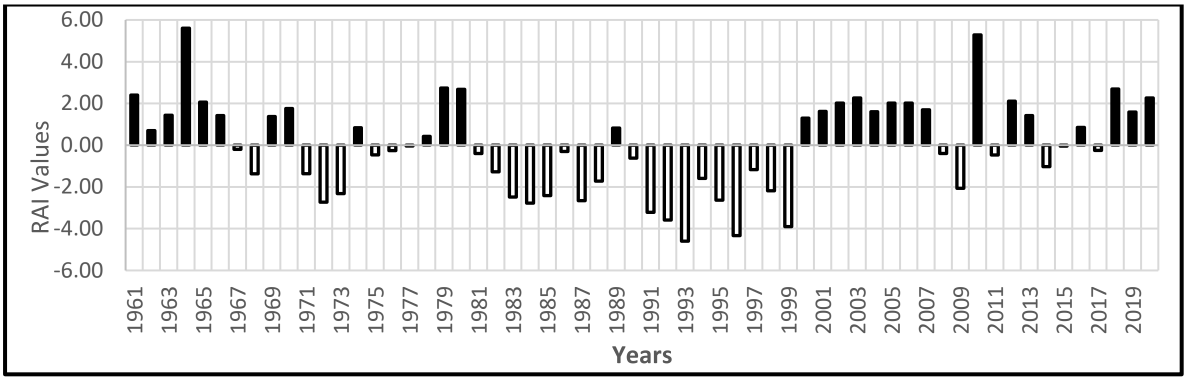

Figure 3: Rainfall Anomaly Index

Table 6: Intensities of Wet/Drought and Years of Occurrences

Intensity	Frequency
Very Wet	1964 and 2010 (**2 Years**).
Moderately Wet	1961, 1965, 1979, 1980, 2002, 2003, 2005, 2006, 2012, 2018, 2020 (**11 Years**).
Slightly Wet	1963, 1966, 1969, 1970, 2000, 2001, 2004, 2007, 2013, 2019 (**10 Years**).
Normal	1962, 1967, 1974, 1975, 1976, 1977, 1978, 1981, 1986, 1989, 1990, 2008, 2011, 2015, 2016, 2017 (**16 Years**).
Mild Drought	1968, 1971, 1982, 1988, 1994, 1997, 2014 (**7 Years**).
Moderate Drought	1972, 1973, 1983, 1984, 1985, 1987, 1995, 1998, 2009 (**9 Years**).
Severe Drought	1991, 1992, 1993, 1996, 1999 (**5 Years**).

Source: Authors' Analysis (2021)

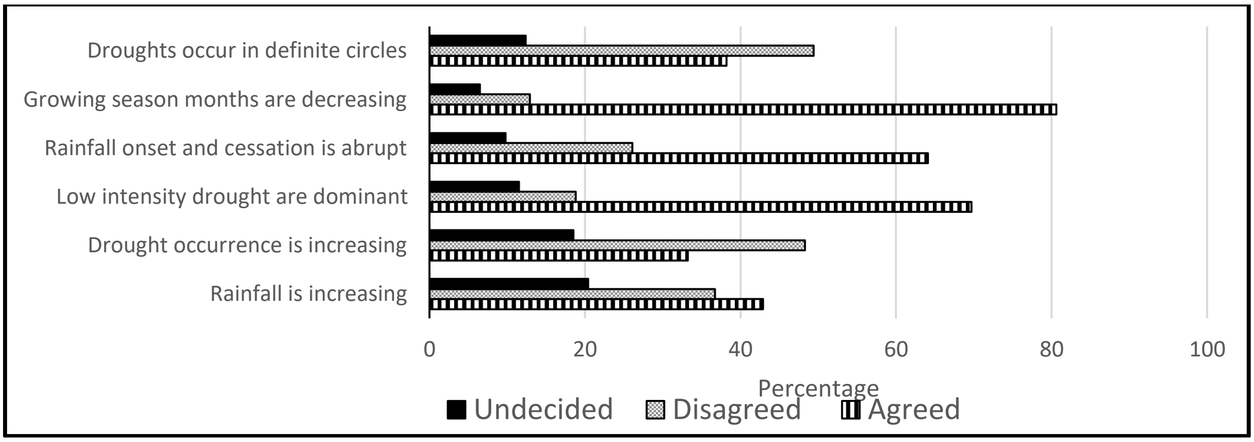

Figure 4: Farmers' Perceptions on Drought

In term of drought, majority of the farmers (48.3%) perceived those occurrences of drought are decreasing for the past three decades in the area, 33.2% of the farmers perceived that drought is increasing, while 18.5% were undecided. The decreased in drought is likely due to the reduced occurrences of dry spell during the rainy season or because of the recent increased in annual rainfall amount as perceived by the farmers. The perceptions of the respondents on the decreased number of drought occurrences in the area concurred with the observed data and recent related studies in the area. For example, the work of Abaje *et al* (2013) and Ati *et al* (2022) revealed that the late 2000s have been witnessing decreasing number of drought occurrences in the Sudano-sahelian Zone of Nigeria. In terms of drought intensity, about 69.7% of the respondents perceived that most of the droughts that occurred are of low intensity. Their perceptions is in line with the analyzed data in which moderate and mild drought dominate. This finding is also in agreement with Atedhor (2014) and Ati *et al.* (2022) that mild and moderate drought intensities are much more dominant in northern Nigeria than severe droughts. Majority (64.1%) of the respondents agreed that rainfall onset and cessation is abrupt. Some of the participants of the FGD reported that they have been observing rainfall variability in term onsets and cessation in the last 3 decades. One of the participant stated that "there have been late rainfall onsets from mid and late May to early and mid-June as well as the early cessation which now shifted from October to September". This finding is in agreement with Oruonye (2014) in which farmers in Taraba State were of the opinion that there was always a delay in the onset of the raining season while the rainfall ends earlier than usual. The rainy days (growing season) according to 80.6% of the respondents have been decreasing in the last 3 decades. This may not be unconnected with the late onset and early cessation of the rainfall in the area. Some of the participants of the FGD stated that the raining season has decreased in the area from 4 months to about 3 months. In terms of drought occurrences, 49.4% of the respondents did not believe that drought occurs in a definite cycle. The strong religion belief of the people (mostly *Islam*) seems to have influenced their response to believe that sins of mankind are a factor that is causing drought in the area. Drought is, therefore, seen by the people as a punishment from God (*Allah*) being meted out due to the several sins that the communities have committed against the environment and *Allah* who created it.

4.5 Impact of Drought on Agriculture

The impact of drought on agriculture as perceived by the farmers is shown in Table 7. The most significant impacts are decline in crop yields with a mean score ($\bar{x}$) of 4.06, increase in cost of food crops ($\bar{x}$ = 4.04), increasing in death of livestock ($\bar{x}$ = 4.39), crop infestation and diseases ($\bar{x}$ = 3.85), famine/death ($\bar{x}$ = 3.84) and effects on human health ($\bar{x}$ = 3.79).

Farmers' perceived decline in crop yields as the most significant impact is due to the fact that farming is their major occupation. This agrees with Abubakar *et al.* (2019), Orimoloye *et al.* (2022) and Ayugi *et al.* (2022) that the most immediate effect of drought on the farming sector is a fall in crop production as a result of crops withering and dying. However, the resultant effect of drought-induced decrease in crop yields is shortage of food and consequently hike in the food crops in the market due to limited supply. This also agrees with Orimoloye *et al.* (2022) that drought is the primary cause of grain output shortages relative to consumption, therefore, posing a threat to food security. The farmers also perceived that death of livestock and crop infestation and diseases are other impacts of drought on agriculture. Their perceptions are in line with the findings of other researches such as Oladipo (1993a), Abaje *et al.* (2013) and Orimoloye *et al.* (2022).

Table 7: Impacts of Drought on Agriculture

Impacts of drought on agriculture	SA	A	UD	DA	SA	Total	Mean Scores	Rank
Drought has resulted to decline in crop yields	167	144	17	37	19	384	4.06*	1
Prizes of food crops are increasing due to drought	182	110	27	35	10	384	4.04*	2
Death of livestock is increasing during drought	112	157	75	27	13	384	3.86*	3
Drought has led to crop infestation and diseases	142	130	50	37	25	384	3.85*	4
Drought has led to famine and death	120	142	77	30	15	384	3.84*	5
Drought period affect human health	110	172	47	25	30	384	3.79*	6
Drought has led to rural-urban migration	47	95	79	110	53	384	2.93	7
Drought has led to decline in soil fertility	52	78	84	112	58	384	2.88	8
Forest resources are declining during drought	31	52	138	70	93	384	2.63	9

*Significant impacts
Source: Field Survey, 2021.

Some of the effects of drought can have an immediate and direct impact on human health as a result of severe heat waves that cause heat stroke and other health issues. According to Ayugi *et al.* (2022), drought-related health effects are strongly dependent on the severity of the drought, baseline population vulnerability, existing health facilities, and the availability of resources to migrate the affected population during drought events. Prolonged and severe drought always result to death due to famine and starvation.

4.6 Drought Adaptation Strategies

Farmers in the study area employed different on-farm and off-farm adaptation measures to combat drought. Table 8 presents farmers' adaptation strategies employed to adapt to the impacts of drought. The most significant adaptation strategies adopted by the farmers are: praying for God to intervene ($\bar{x}$ = 4.46), planting crops with early maturity ($\bar{x}$ = 4.33), and planting drought resistant crops ($\bar{x}$ = 4.1). This is followed by migration to cities or wetter areas ($\bar{x}$ = 4.07) and irrigation ($\bar{x}$ = 4.03) among others (see Table 8). Praying for *Allah* (God) to intervene was perceived as the most significant strategy because most of the farmers believed that rampant evil deeds of the communities are responsible for causing *Allah*'s punishments that come in form of drought. Findings from the studies of Abaje *et al.* (2014) and Abubakar *et al.* (2019) also revealed that majority of the respondents believed that praying to God and doing simple acts of God in the community may hamper the occurrence of drought. Planting of crops with early maturity is a sustainable strategy as perceived by the farmers because it involves the use of scientific innovation of genetically modified varieties that matured in a short period to cope with the short growing season. The farmers also practice the planting of drought tolerant crops which is also a sustainable strategy of cultivating crops with minimum moisture requirement since the rainfall is unreliable. Multiple cropping, instead of monoculture, which is a significant strategy, would help in avoiding potential economic loss due to drought. All of these strategies concur with the findings of Abaje *et al.* (2014) and Abubakar *et al.* (2019). Furthermore, planting of economic trees (afforestation) which is significant as perceived by the respondents is a sustainable adaptation strategy that helps in reducing land degradation and increases soil-water availability during drought. It also creates a carbon sink and helps in mitigating global warming. In addition, one other adaptation strategy to cope with water shortages during drought as perceived by the people is water harvesting in the form of construction of water storage structures such as ponds and tanks and rainwater harvesting. This would assist in reducing the impacts of drought in the area.

Table 8: Drought Adaptation Strategies

Adaptation Strategies	SA	A	UD	DA	SD	Total	Mean Scores	Rank
Praying for God to intervene	249	85	33	15	2	384	4.60*	1
Planting crops with early maturity	190	154	22	12	6	384	4.35*	2
Planting of drought resistant crops	135	184	37	15	13	384	4.10*	3
Migration to cities or wetter areas	137	187	50	42	30	384	4.07*	4
Irrigation farming	130	172	50	28	24	384	4.03*	5
Multiple cropping	137	162	40	30	15	384	3.98*	6
Dry planting	95	199	50	65	18	384	3.84*	7
Planting of economic trees	49	76	95	100	64	384	3.83*	8
Water harvesting	105	159	70	35	37	384	3.79*	9
Adjusting feeding habit	102	157	70	50	5	384	3.60*	10
Selling of assets	53	87	81	106	57	384	2.93	11
Application of manure and dung	56	79	87	95	67	384	2.90	12
Adjusting planting dates	55	70	96	92	71	384	2.86	13

*Significant adaptation strategies
Source: Field Survey, 2021

On the other hand, adjusting planting dates, application of manure and animal dungs, and selling of assets were not considered as significant strategies for combating the impacts of drought. This result agrees with Abaje *et al.* (2014) that selling of livestock to augment cost of crop production is not a sustainable strategy for combating the impacts of climate change, especially extreme climate events such as drought. This is because most of the local people rely on some of these livestock (cattle, camels and donkeys) as a means of transportation and a source of draught for ploughing, collection of firewood, conveyance of manure to the farms and harvested crops from the farms. However, some of the constraints identified during the FGD that have been hindering the effectiveness of the adaptation strategies employed by the farmers include poor or absence of enlightenments from extension workers and the lack of weather information from NiMet and other relevant agencies.

5.0 CONCLUSION AND POLICY RECOMMENDATIONS

This study has proven that the area has experienced persistent droughts in the 1970s, 1980s and 1990s that led to reduced yield or total crop failure in some areas. This led to hunger, famine and even death in some communities. The study also revealed that from the 2000s to the end of the study period (2020), the area generally experienced normal to very wet conditions with only moderate and mild droughts that affected it in 2009 and 2014 respectively. This means that the area has been experiencing wetter condition (decreasing number of drought occurrences) in recent years. The study also revealed that farmers' socioeconomic characteristics have serious implications for their perception on drought. Farmers' age, level of education, farming experience are some of the important socio-economic characteristics that influence their adaptation strategies.

This study recommends that strategies for combating the impacts of droughts should take into account the traditional and religious beliefs of the people; extension workers should be trained on climate change science to enable them pass adequate information to farmers on climate related issues and appropriate adaptation measures among others. Integrating drought adaptation into the existing national climate change policies is also recommended.

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