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An Assessment of the Effects of Flood on Agricultural Production in Auyo Local Government Area of Jigawa State, Nigeria

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Abstract

Within the past decades, the impact of climate conditions is evident on crop productions across the Nigeria's different regions. Between the years 2021 and 2022 Nigeria witnessed one of its worst floods in the last decade as hundreds of villages and urban centres were submerged in waters, displacing over 2.4 million people. These events had negative impacts on crop yield. Crop yield is the product of both growth and development. Thus, this study attempted to investigate the effects of flood on agricultural production in Auyo Local Government Areas of Jigawa State, Nigeria spanning a period of 30 years (1993-2022), with the aimed of conducting a land-use and land-cover change of the study area; analyze the temporal trends of rainfall in the area of study; examining the yields of agricultural production in the area and to establish the relationship between agricultural yields and flood occurrence in the Auyo Local Government Area. Thus, both primary and secondary sources of data were employed in this study. In view of this, Landsat 5 Thematic Mapper (TM) of 2002 and Landsat Enhanced Thematic Mapper Plus (ETM+) data of 2022 where used. In order to examine the trend in rainfall and agricultural yields series, 5-year running mean and linear trend lines was calculated and plotted using Microsoft Excel Statistical Tool. The rainfall and agricultural yields series were also sub-divided into 5-year non-overlapping sub-periods and Cramer's test was then used to compare the means of the sub-periods (5-years) with the mean of the whole record period (30 years). The relationship between the flood and agricultural yields were tested using R statistical analysis. The study revealed that built-up increased from 14% in 2002 to 19% in 2022. Bare lands occupied about 50km2 of the total area examined in 2002, but decreased to about 44km2 in 2022. In addition, the water body decreased from about 172km2 in 2002 to 155km2 in 2022. Besides, the positive nature of relationships between rice yields and flood occurrences indicated a significant degree of relationship at 95% confidence level. In view of this, it was recommended among other measures, the need for the development of a Response Farming Technique and longitudinal approach for comprehensive measures to address the shock and destruction that comes with re-occurrence of flood.

Keywords: Agricultural, Flooding, Landsat, Production, Auyo

1. Introduction

The antithesis of drought is flood, and both are as disastrous as they can be properly ameliorated or managed (Murtala, et al. 2018). Flood, or flooding, refers to the general or temporary conditions of partial or complete inundation of normally dry land areas from the overflow of inland or tidal water or of surface water runoff from any source (Florida Division of Emergency

Management, 2018). Flooding is often thought of as a result of heavy rainfall, but floods can arise in a number of ways that are not directly related to ongoing weather events. Thus, a complete description of flooding must include processes that may have little or nothing to do with meteorological events. Nevertheless, it is clear that in some ultimate sense, the water that is involved in flooding has fallen as precipitation at some time, perhaps long ago.

The origins of flooding, therefore, ultimately lie in atmospheric processes creating precipitation, no matter what specific event causes the flooding (Temi & Tor, 2016). Agricultural produce in Nigeria is mostly rain fed. Unpredictable rainfall variation makes it difficult for farmers to plan their operations (Anabaraonye et al., 2019). The high vulnerability of states in the north to flood poses a serious threat to food security throughout the country (Madu, 2016). Extreme weather events can greatly undermine economic growth.

The 2012 floods experienced in Nigeria affected several sectors of the economy. The overall impact of the flood on real GDP growth in 2012 was estimated at 1.4 percent, stemming from production losses and from extraordinary spending in most sectors of the economy as a result of the floods (Federal Government of Nigeria, 2013). Consequently, Studies have shown that agricultural synthetically loss model shows in any water depth of flooding above 1.5 Meter on farmland could lead to One hundred percent loss rate of the agricultural yields (100%). In recent years (2022 in particular), Nigeria experienced her worst flooding in over (forty years).

It is evident from literatures of flood occurrences across the six geographical zones of Nigeria that the North-West zone had the highest frequency of flooding with 31 instances, followed by the North-Central and North-East zones with 20 and 19 instances, respectively (Research on the Epidemiology of Disasters, 2022). The challenges associated with climate change are not the same across the country. Vulnerability analysis demonstrates that states in the north experience higher degrees of vulnerability to climate change than those in the south (Federal Ministry of Environment, 2014). This shows Northwest zone of the country is the most vulnerable.

Existing studies on floods in Nigeria, particularly those that have looked at vulnerabilities and flood disaster risk management efforts, include impacts and institutional responses (Olorunfemi, 2011), factors responsible for reoccurrence of floods in some Nigerian cities and flood effects on human activities (Aderogba, 2012), gender as well as urban or rural differentials from flood losses (Adeagbo et al., 2016) and factors influencing households' and individuals' adaptive capacity to flood disasters (Daramola et al., 2016). Some other studies on flood management and risk response in Nigeria have recommended the need for building flood resilient infrastructure through restructuring our cities and the need for different stakeholders to participate (Barau et al., 2015).

Thus, summary of number of flood occurrences by states in Nigeria between 2011 to 2022 shows Jigawa has the highest cases of flood in the whole country (Research on The Epidemiology of Disasters, 2022). Flooding has an adverse impact on the Nigerian society and economy in many ways with Jigawa State in particular, notably agriculture, food production, water resources, health, energy, human settlement and societal relations (Abdulmalik et al., 2021). The present study attempts to assess the effects of flood on agricultural production in Auyo Local Government Area of Jigawa State. This is the thrust of this research proposal.

2. Aim and Objectives

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i. to conduct a land-use and land-cover change of Auyo Local Government Area.
ii. to analyze the temporal trends of rainfall in Auyo Local Government Area;
iii. to examine the yields of agricultural production in Auyo Local Government Area.
iv. to establish the relationship between agricultural yields and flood occurrence in the Auyo Local Government Area.

3. Scope of The Study

This study is designed to cover Auyo Local Government Area of Jigawa State. The content scope of the study is assessing the effects of flood on agricultural yield. It must however be emphasized here that before ascribing annual variation of a particular crop to flood, it must be assumed that some other climatic and biophysical factors remain constant.

Thus, a study of this magnitude is expected to cover the entire Agricultural yields in Auyo. However, the study focused only on rice yield due to its dominance and wide acceptability by farmers in the study area (Questionnare, 2023). Similarly, rainfall data for the period under study was limited to a length of data of about 30years of record. This arises from the fact that rice yield records available in the study area does not extend beyond this period.

4. Study Area

Auyo is one of the twenty-seven LGAs of Jigawa State, with an area coverage of about 512 km2 (Abubakar, Kutama & Sulaiman, 2016) The area lies between Latitudes 12°21'6.457"N to 12°6'7.808"N and Longitudes 9°28'0.944"E to 10°15'28.924"E. It is bounded by Bauchi State in the east, Kafin-Hausa and Jahun LGAs in the south. In the northeast by Hadejia, Malam-Madori and Kirikasamma LGAs, in the north it is bounded by Kaugama LGA. In the northwest it is bounded by Taura and some part of Jahun LGA respectively (Fig. 1).

The climate of the area is semi-arid. However, the micro-climate is modified by the local effect of the Hadejia River system. The mean annual temperature is about 25°C. The total annual rainfall ranges from 600mm to 762mm (Kaugama & Ahmed, 2014). The study area is part of an extensive downstream of floodplain created by the Hadejia River. It comprises of permanent lakes and seasonally flooded pools connected by a network of channels (Abubakar et al., 2016). The LGAS have a total population figure of 260,692 (NPC, 2009), to about 371,684 as at the year 2020.

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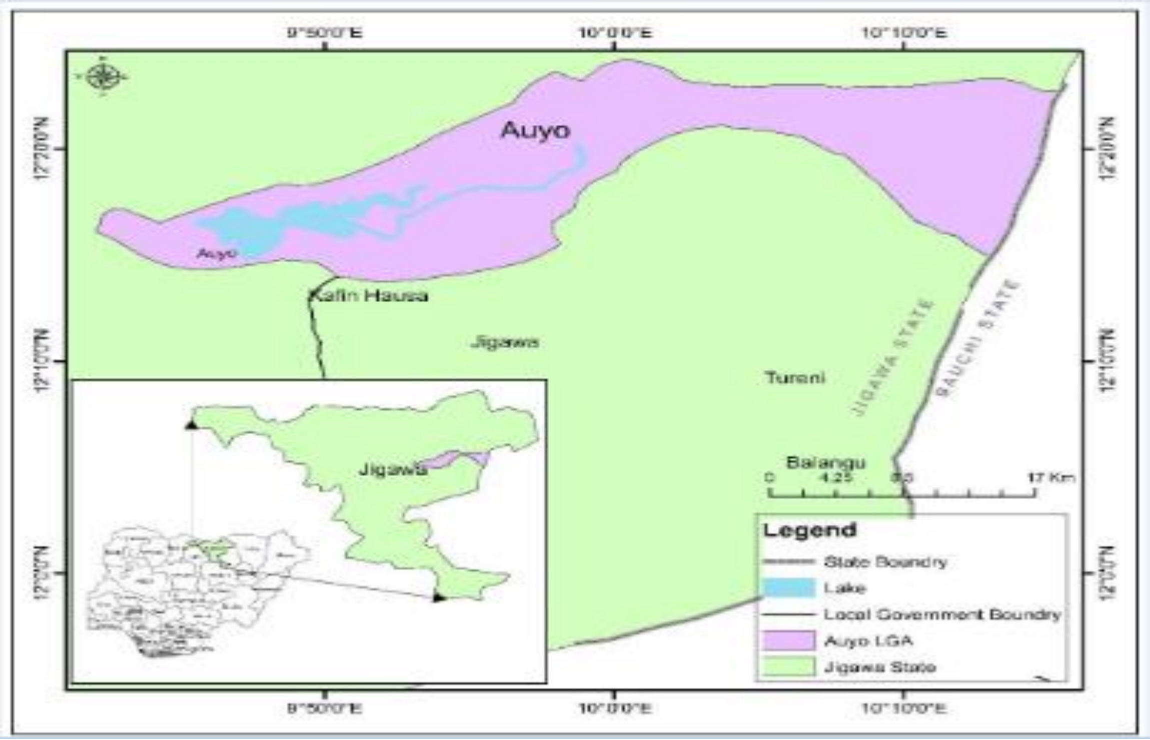

Figure1: Study Area (Auyo Local Government Area)

5. Literature Review

Flooding is a crucial component in the climate system, with unparalleled historical occurrences. This has sparked significant discussion among economies affected by climate change, which encompasses over 70 million people annually. The effective management of flood risk has been a decisive issue over the years because of several environmental and climatic changes such as increasing levels of rainfall and rapidly growing populations, among others. There are also economic implications of flood occurrences (EMDAT, 2015) indicating that flood disasters have cost billions of dollars over the past decades while also resulting in several hundreds of thousands of deaths, psychological issues and several degrees of injuries among others in flood prone areas of Asia (Tapsell &Tunstall, 2008).

However, in some Sub-Saharan African countries such as Nigeria, flood disasters have resulted in dislodgments of several houses and properties (Obeta, 2014). As a result, Nigeria's losses have amounted to billions of dollars (NEMA 2013). The impacts of these disasters may include death, substantial injuries, homelessness, transmission of widespread infections and diseases, and famine (Ogunbodede & Sunmola, 2014). These disasters are commonly connected to global climate change as well as inadequate regional planning of susceptible flood areas (Action Aid, 2016).

Nigeria had a bitter flooding incident in 2012 that affected approximately 32 states and was the worst on record with several days of heavy down-pour in some of these states (NEMA, 2013). The floods extended from July to October that year and affected 7.7 million people, more than 2 million of which were recorded as internally displaced persons (IDPs). More than 5000 people were physically injured and over 5900 houses were destroyed. In the past, flooding in Nigeria was typically fluvial, coastal, and pluvial in nature and had mostly affected rural areas and country sides (Bashir et al., 2012). The fluvial floods would usually result from the major

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flood pressure witnessed in areas with major rivers that cuts across the North-western, Middle belt and South-south regions of the country (Iloje, 2004).

The durations and intensities of rainfall have increased in the last three decades, producing large runoffs and flooding in many places (Enete, 2014). Rising sea level and ocean surge in Southern Nigeria has submerged villages in Lagos and some places in the Niger Delta (Anabaraonye et al., 2019). Severe nationwide floods in 2012 resulted in unprecedented damage and losses to human settlements located downstream (Akande et al., 2017).

6. Materials and Methods

6.1 Methods of Data Collection

6.1.1 Reconnaissance Survey

A reconnaissance survey was undertaken, in order to familiarize the researcher with the study area. Auyo Local Government was also visited and information on flooding was gotten from the officials. The types of data used for this research is shown in Table 1.

Table 1: Primary Data

S/N	Data Type Source Date Acquired
1.	Rice yields data (sourced from Jigawa State Agricultural and Rural Development Agency (JARDA) AND Hadejia Jam'are River Basin Development Authority (HJRBDA) 2023.
2.	Rainfall data (sourced from Jigawa State Agricultural and Rural Development Agency (JARDA).

Source: Authors Analysis (2023)

6.1.2 Data Processing

Table 2: Classification Scheme

	Land use categories D Description
1.	Built-up Land used for residential and transportation/communication purposes (i.e. settlements and roads, high residential area, industry and administrative block)
2.	.Bare surface Exposed soils, lands devoid of vegetation cover.
3.	Vegetation Land covered with natural forest and natural vegetation that is predominantly grasses, shrubs and grass-like plants.
4.	Water body Areas covered by body of water e.g. dam, lake and rivers.

Source*: Modified from Anderson, Hardley, Roach and Wtmer, (1976)*

In examining the changes that occurred on the land use/land cover in Auyo Local Government from 2002 to 2022, the land uses were grouped into four (4) different land use/land cover features: vegetation, build-up areas, bare lands and water bodies using the Landsat images for the study years, showing the spatial differences of all the land use/land cover features in the area. In examining the spatial extent of changes 2002 to 2022, the satellite images were classified for each year, showing the spatial changes on land use/land cover over the years in the study area.

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6.1.3. Population of the Study

The population of the study will comprise selected farmers and Auyo Local Government staff, (particularly those over-seeing Agricultural activities). Auyo Local Government Area has a population of 132,001 (NPC, 2009) with 10 administrative wards (which include: Auyo, Auyokayi, Ayama, Ayan, Gatafa, Gamafoi, Gamsarka, Kafur, Tsidir, and Unik). A sample of 0.4% of the total population of the study was taken, and distributed equally among the 10 administrative wards.

6.1.4. Sample and Sampling Technique

A purposive random sampling technique was used to select farmers from each ward of Auyo Local Government. Fifty-three farmers from each ward will be selected using systematic random sampling.

6.1.5. Sample size

Fifty-three farmers was selected from each ward both purposive and systematic random sampling. The total sample size was 553.

6.2 Data Analysis

Objective i:

6.2.1. Land-use/Land-cover change: land-use/land-cover changes, as well as spatial extent of changes were generated from Satellite Imageries.

Objective ii & iii:

6.2.2. Trend of Rainfall and Rice Yields

Linear regression was used to determine the linear trends of rainfall and rice yields of the study area. It was computed by using:

$$y = a + bx \quad \text{……………………………..eq…. 1}$$

Where the intercept of the regression line on the y-axis; is the slope of the regression line. The values of and was obtained from the following equations:

$$a = \frac{\sum y - b(\sum x)}{n} \quad \text{……………………………….……… eq……. 2}$$

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \quad \text{……………………..…. ...eq…… 3}$$

In applying Cramer's test, the mean ( ), and the standard deviation ( ), was calculated for the station in the study area for the total number of years (N). The purpose of this statistic was to measure the difference in terms of a moving t-statistic, between the mean ( ), successive n-year period and the mean ( ) for the entire period. The t-statistic was computed as:

$$t_k = \left(\frac{n(N-2)}{N - n(1+\tau_k^2)} \right)^{1/2} \tau_k \quad \text{...................................... eq. 4}$$

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Where τ_k is a standardized measure of the difference between means given as:

$$\tau_k = \frac{\bar{x}k - \bar{x}}{\delta} \text{ ……………………………..….. eq. 5}$$

Where, k is the mean of the sub-period of n–years. and are the mean and standard deviation, and tk is the value of the student t–distribution with N–2 degrees of freedom. This was tested against the "students" t distribution table at 95% confidence level appropriate to a two-tailed form of test. When tk is outside the bounds of the two-tailed probability of the Gaussian distribution (equal to 1.96 at 95% confidence level), a significant shift from the mean was assumed.

Objective vi: To establish the relationship between flood occurrence and rice yields in the study area.

The relationship between flood and crop yield has been a subject of longstanding interest (Gote, Khodiar, Sadhu and Shekhar, 2010). Thus, the relationships between the rainfall value and the yield of rice in the study area were tested using bivariate correlation analysis. This is represented as:

$$r = \frac{\Sigma\,(x-x)(y-y)}{\sqrt{\Sigma(x-x)^2(y-y)^2}} \text{ ----------------------------eq. 6}$$

r = Correlation coefficient

Where *x* and *y* = individual observations of dependent and independent variables respectively

$\bar{x}$ and $\bar{y}$ = Mean of dependent *(x)* and independent *(y)* variables respectively

The rice yields value was used as dependent variables and rainfall value as the independent variable. This has been used in similar studies on the relationship between drought and agricultural yields Ananthoju and Rajini (2014)

7. Results and Discussions

7.1 Landuse/Landcover changes

The results of Landuse and Landcover Changes analysis for the periods between 2002 and 2022 were presented in Table 3 and Figure 2.

Table 3: Result of land use/land cover changes of 2002 and 2022

	Square Kilometer	
Landuse Categories	**2002**	**2022**
Barren Area	49.70789887	44.592947
Built Up Area	74.64462952	102.3875835
Vegetation	215.5471662	209.9622932
Waterbody	172.1003054	155.0571763
Total	**512**	**512**

Source: Authors Analysis (2023)

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As shown in Table 3 and Table 4, the built-up area occupied about 74.6 km2 (14%) in 2002 but increased to 102. km2 (19%) in 2022. Bare lands decreased from 9.71% in 2002 decreased to about 8.71% in 2022. The vegetation also decreased from about 215km2% in 2002 to 209km2 in 2022. The decrease in bare land and vegetation throughout the study period might have been caused by the increase in the built-up areas as supported by Weng and Yang (2014).

Percentages

Landuse Categories	2002 in %	2022 in %
Barren Area	9.708573999	8.709559961
Built Up Area	14.5790292	19.9975749
Vegetation	42.09905589	41.00826038
Waterbody	33.61334091	30.28460475
Total	**100**	**100**

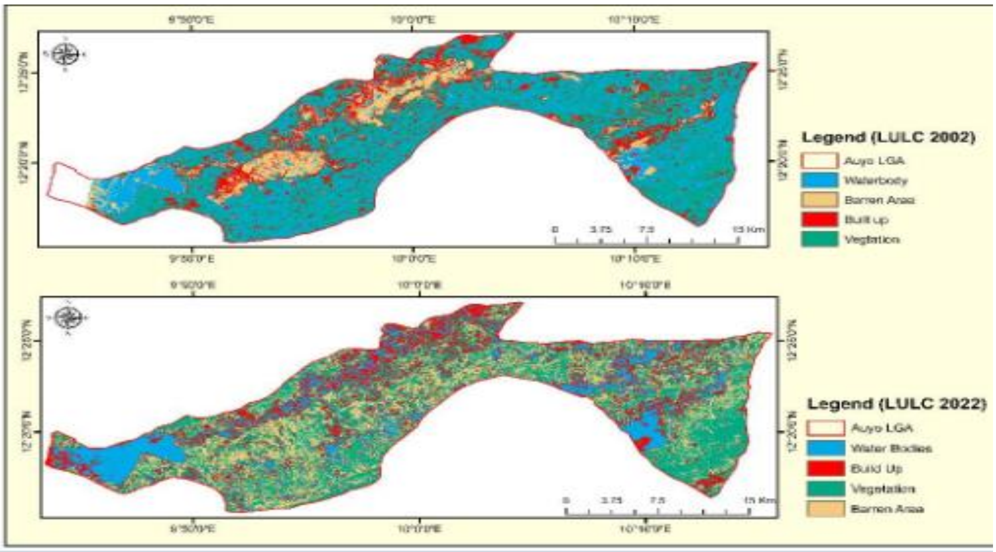

Figure 2: Spatial Extent of Landuse/Landcover changes in 2002 and 2022

More so, Figure 2 shows changes in the spatial extent of individual Landuse/Landcover classes (Bare surfaces; Vegetation; Water bodies and Built up areas) in Auyo Local Government Areas from 2002 and 2022.

7.2 Annual Rainfall

Rainfall varies substantially yearly and over decades. Not only the amount but also the trends of rainfall can change and affect the environment and society. Thus, the annual rainfall and rice yield trends for Auyo were analyzed to reveal their temporal patterns for the period under study (1993 – 2022). Figure 3(a-c) shows the graphical presentation of the annual rainfall trends for the station smoothened out with 5-years Running Means. In view of this, the variability in 5years Running Means for the study area indicated a normal condition. The linear trend lines for the study area showed an increasing trend (y=5.694x+828.1). It is therefore clear from the results of the variability in 5-year Running Means and the linear trend line that the rainfall has been increasing in recent years at the rate of 0.062% percent per annum (in Auyo).

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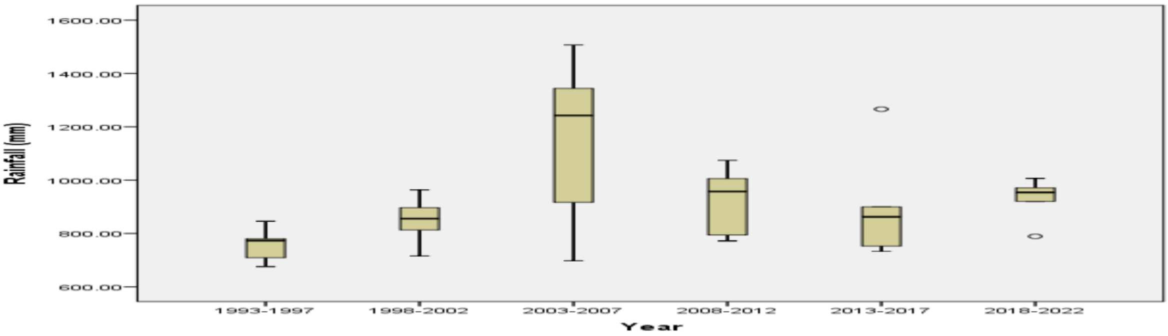

Figure 3a: Annual Rainfall Trend in Auyo from 1993-2022

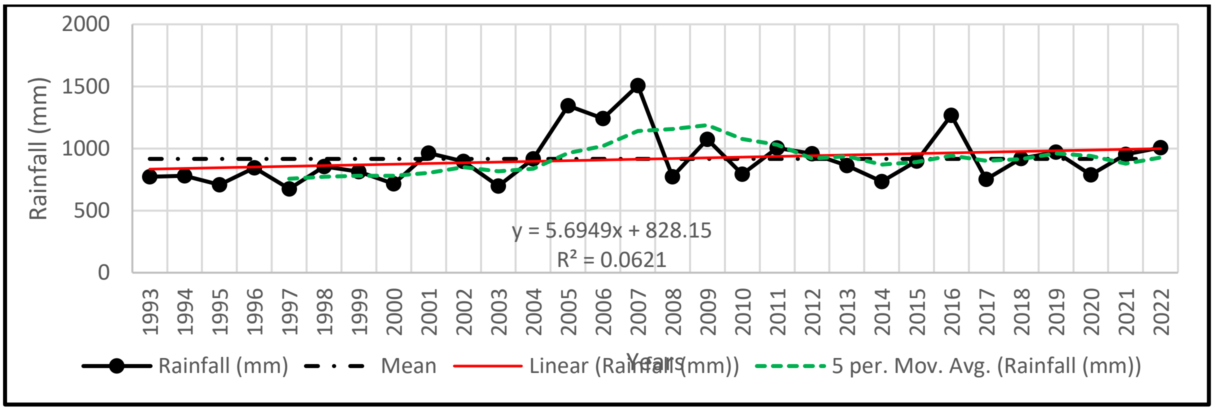

Figure 3b: Annual Rainfall Trend in Auyo from 1993-2022

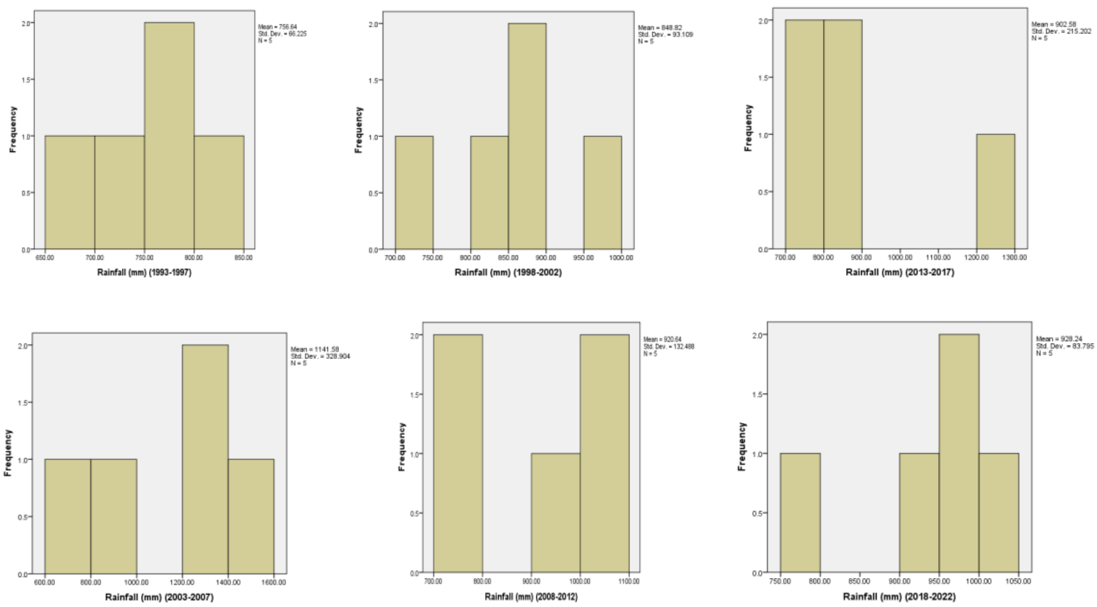

Figure 3c: 5-Years Rainfall Series in Auyo from 1993-2022

The results in Figure 3 (a-c) shows in reality the actual annual values fluctuate around the mean to which the rainfall series had been fitted from 1993 to 2007, there was a steep increase within this period. Similarly, from 2008-2022 there was a steep decline in rainfall. It could therefore be seen that 2007 was the wettest year in Auyo and 1997 was the driest year. This period coincided with the floods in the study area.

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7.3 Trends of Rice Yields

Auyo was prominent among producers of rice in Jigawa State. However, there has been upward and downward trends in recent years. Figure 4 (a-c) shows the results of 5-year non-overlapping sub-period analysis of rice yields and trends in the study area. In view of this, the variability in 5years Running Means for the study area indicated a negative condition. The linear trend lines for the study area showed decreasing trend (y=-226.9x+27195). It is therefore clear from the results of the variability in 5-year Running Means and the linear trend line that the yields has been decreasing in recent years at the rate 0.035% percent per annum (in Auyo).

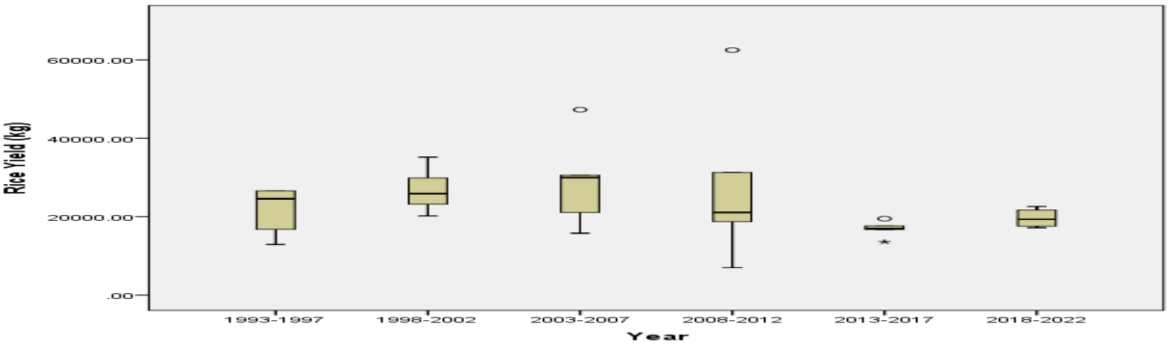


Figure 4a: Annual Rice Yield Trend in Auyo from 1993-2022

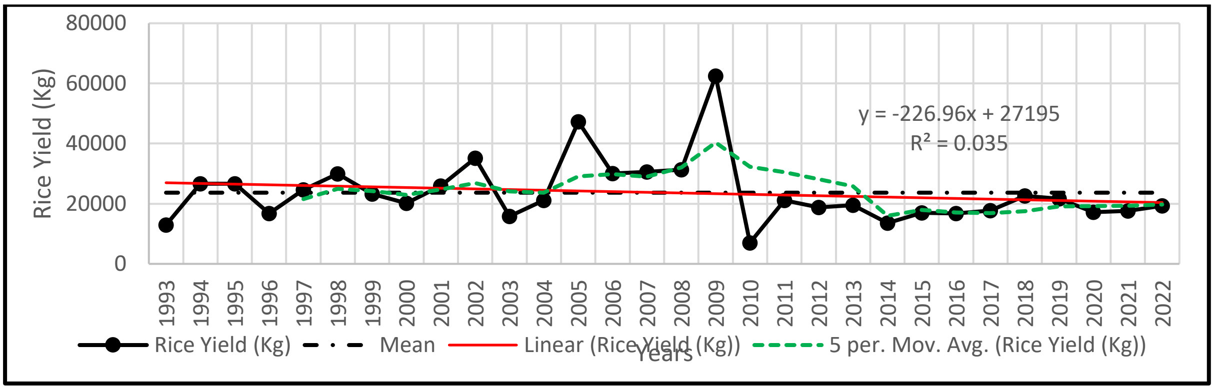
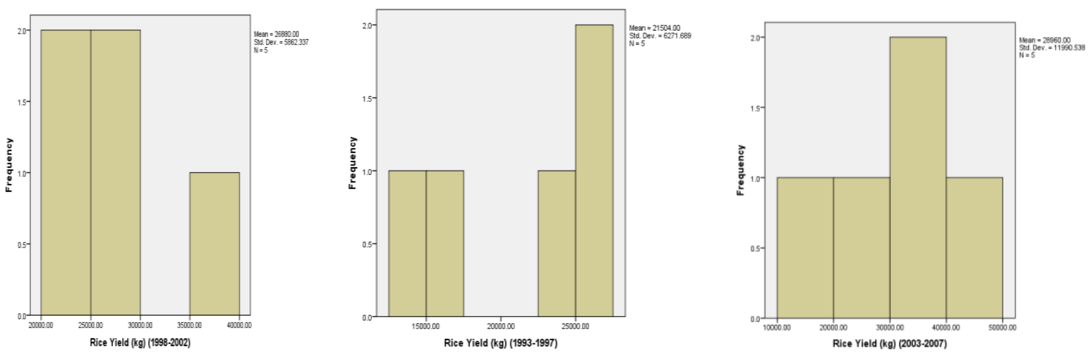


Figure 4b: Annual Rice Yield Trend in Auyo from 1993-2022



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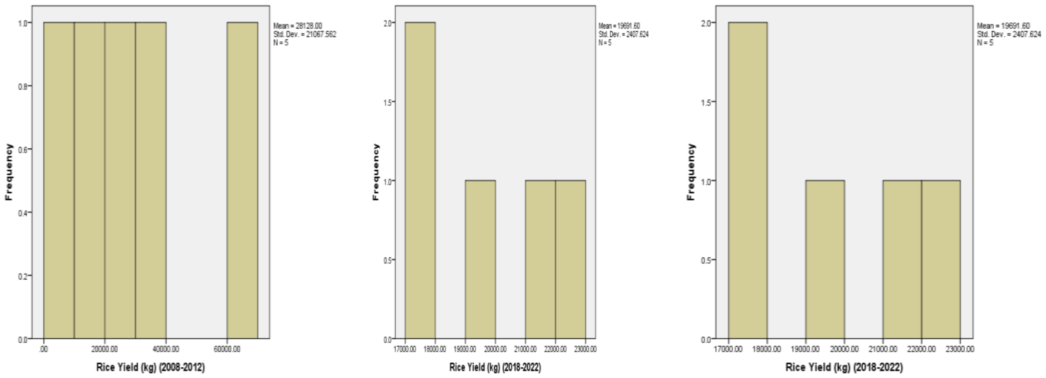

Figure 4c: 5-Years Rice Yields Series in Auyo from 1993-2022

The results in Figure 4(a-c) showed downward trends between: 2011-2022 of rice yields in the study area.

7.4 Relationship between flood Occurrence and Rice Yield in Auyo

The results of the correlation analysis of flood occurrence and yields of rice in the study area shows in Table 3 and Figure 5.

Table 3: Correlation Statistical Summary

R^2	P-Value	F	Standard Error	T-Ratio
0.177	0.010191	6.176262	0.351868	2.485209

***Significant at 95% confidence level**

Source: Fieldwork (2023)

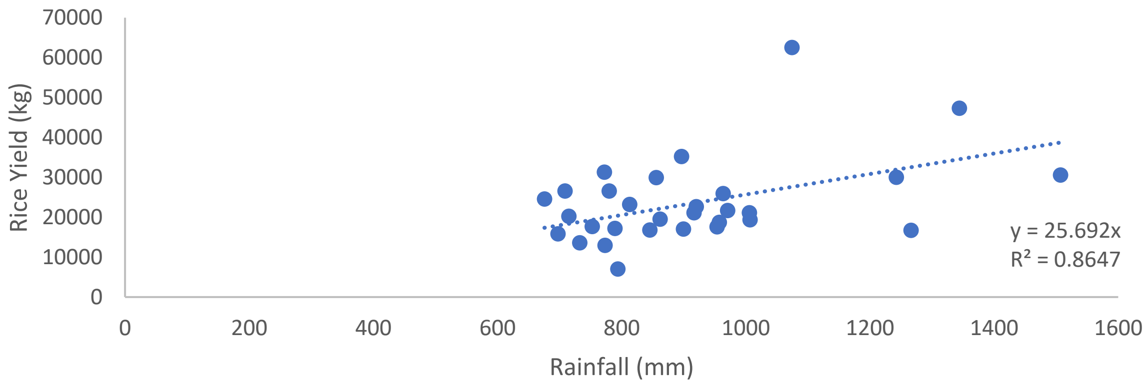

Figure 5: Relationship between Rainfall and Rice Yields in the Study Area

The correlation analysis results in Table 3 showed the value of F is 6.176262 with a P- value of 0.0119191which is not significant at the $\alpha = 0.05$. This indicates that the predictor variable is statistically significant from θ zero, and significant predictability of the flood occurrence rate by the model. Similarly, an examination of the t- ratios support this conclusion using $\alpha = 0.05$. The t- ratio for flood is 0.727572 with an associated P – value of 0.019191. This information indicates that there is significant correlation between flood occurrence and yield of rice in study area (1993 - 2022).

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Similarly, the standard error of the estimate Se = 9.080993, which indicate approximately 9% of the flood is with ± 0:09 ratio, and the R2 for this correlation analysis is 0.177 or 17.7% indicating positive relationship between flood occurrence values and rice yields in study area. This positive nature of relationship indicated that rice yield exhibited a significant degree of relationship with flood which is significant at the 0.05% level.

8. Conclusion

Based on the findings of this study, it can be deduced from landuse /land cover changes as well as spatial extent in the study area that there is a phase of massive and rapid destruction of its forest wealth. Also, the relationships rice yield and flood occurrence shows that flood exert much negative influence on rice yield. Based on the foregoing, there are grounds to conclude that before ascribing annual variations of a particular crop to rainfall, it must be assumed that some other climatic and biophysical factors remain constant (Adejuwon and Ogunkoya, 2006). In view of this, it could be concluded from these results that there are fluctuations in rice yields in the study area. To some extent, there is significant positive correlation between flood occurrence and yield of rice in study area.

Policy Recommendations

Based on the above facts of this research, it is recommended that the expected results for this research is strategize to achieve two goals.

The short-term goal will be to conduct a land-use and land-cover change; analyze the temporal trends of rainfall; examine the yields of agricultural production; establish the relationship between agricultural yields and flood occurrence.

The long-term goal will be to provide evidence-based information for the Ministries of Education, Environment and Agriculture.

In view of this, the need for the development of a Response Farming Technique and longitudinal approach for comprehensive measures to address the shock and destruction that comes with re-occurrence of flood. Therefore, based on the outcome of this research, Government policies in this area should be based on land use/land cover changes, recent rainfall trends and rice yields fluctuations.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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