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APPRAISAL OF METEOROLOGICAL FLOODS EVENTS OVER YOBE STATE, NORTHEAST, NIGERIA (1965-2015).

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ABSTRACT

This paper seeks to examine floods occurrence along with its frequency, duration, and magnitude in Yobe State, Northeast, Nigeria for the period of fifty (50) years. Rainfall pattern was thoroughly inspected in the light of trend so as to ascertain its effect on the occurrence of flood over the study area. Scatter plot and its line of best fits and simple linear regression statistics were used to understand the trend in the rainfall series. Standardize Precipitation Index (SPI) was employed for the comprehensive quantification of three important properties of flood namely frequency, duration, and magnitude on twelve (12) months scale. Annual rainfall spanning a period of fifty (50) climatological years was obtained from the Nigerian Meteorological Agency (NIMET) Oshodi, Lagos and was subjected to SPI model to reveal the occurrences of floods over the years under study. The results of trend analysis revealed positive trend over the two stations but statistically not significant at 95% confidence level. The increasing rainfall trend has a repercussion on the incidence of flood. While findings of SPI analysis explicitly revealed that the study area is generally replete with all categories of floods ranging from mild, moderate, severe and extreme. The findings could be helpful to agencies like state emergency management agency (SEMA) on purposeful developmental planning process, decision-making and proactive management of the flood disaster. The research concludes that flood occurs variably time by time in specific periods.

keywords: Flood, SPI, Frequency, Trend, Magnitude

INTRODUCTION

Climate Change and its attendant problems such as drought, flood, desertification, and famine are things of concern to researchers all over the globe (Yiman & Mohammed, 2016; Adam, 2015). It has been in the public domain and discourse both locally and globally for some decades now. One of the unequivocal indicators of climate change is change in rainfall pattern-given some places little rain while other places too much rain. Areas that received little rainfall have the tendency of drought occurrence. While areas that received too much rainfall has the possibility of flood occurrence. Meteorological flood is a typology of flood that occurs due to the occurrence of excessively anomalous rainfall. The anomaly is the departure of rainfall from the long-term mean called normal (Ayoade, 2015). Yobe state suffered from different types of flood. For instances, in 2022 alone 83 people died of flood of different intensities and 37,485 household were affected by the flood (SEMA, 2022). Hence, this paper seeks to appraise floods that occurred in the state due to rainfall anomaly (excessive rainfall).



MATERIALS AND METHODS

Study Area

Yobe is one of the states in the north-eastern zone of the country. It is located at the latitude 12°00'N and longitude 11°30'E. The state has a total estimated population of 2,321,591 people. Physiographically, the southern part is rocky terrain consisting of volcanic rock at the fringes of the border with Biu, Borno state, and sedimentary formation around Potiskum and Fika. The northern flank is generally flat with a deposit of sand dunes in Machina, Yunusari, Tulotulo, Kaska, etc. This section of the state is seriously experiencing desertification (Naibbi *et al.*, 2014). Odiogor (2010) quoted the incumbent governor, Alhaji Ibrahim Geidam, emphasizing that the sand dunes are encroaching at a rate of 0.3 km² annually taking over villages.

The climate is characteristically marked by two seasons namely: dry and wet season. The rainy season starts in May or June in the southern part and June or July in the northern flank and peaks in August and finishes quite rapidly in September or October. The rainfall in the state is mostly influenced by the migration of the Inter-Tropical Discontinuity (ITD). The ITD oscillates south to north and back and so modulates the pressure system of the West African Monsoon. The pressure system of the monsoon is controlled by the moisture laden southwesterly winds and the dry continental airmass known as the North-east trade winds. The areas located south of the ITD are dominated by southwesterly winds which blow moist air from the Gulf of Guinea onto the continent. Whereas the region north of the ITD is influenced by northeasterly winds known as the Harmattan. The Harmattan brings in dry and dusty winds from the Sahara between November and March. According to Iloeje (2004), the northern corner of the study area is one of the places in the country with the least rainfall, longest dry season, lowest relative humidity and severest harmattan. Temperature is high reaching its peak at about 44⁰ c in May.

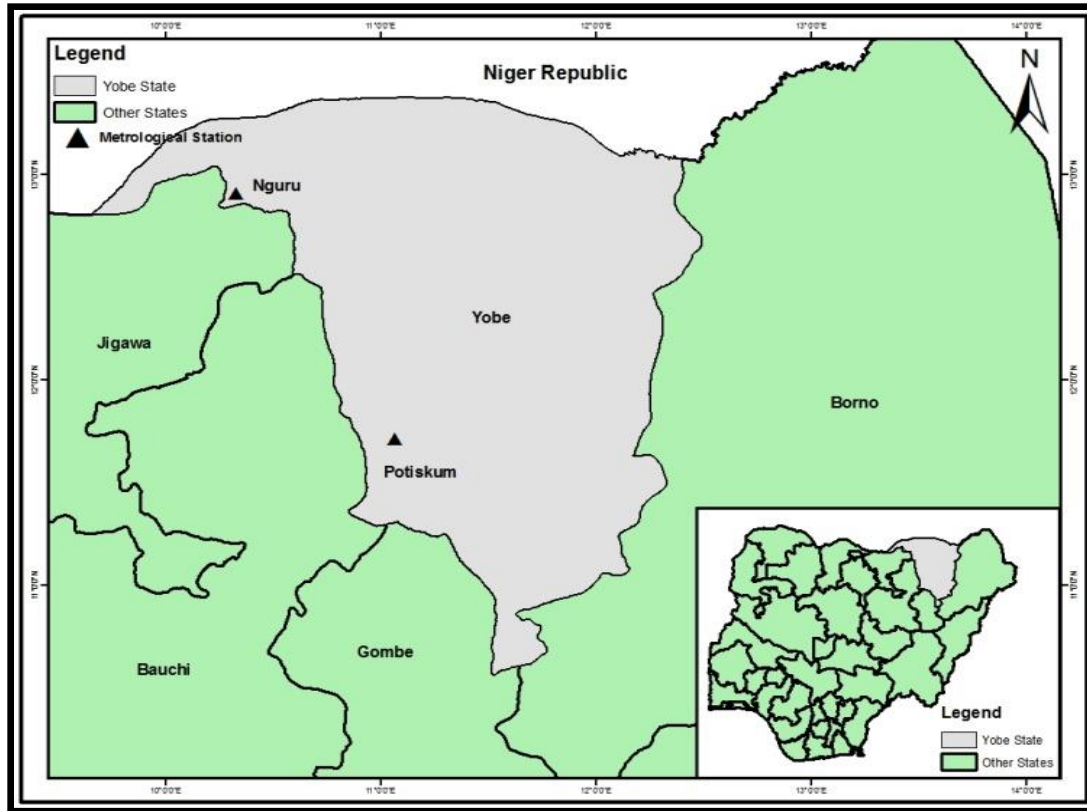


Fig. 1: Map of Yobe showing stations' location

Source: FUG GIS Lab., 2023.

Yobe state is covered by two vegetation zones; Sahel Savanna to the north and Sudan Savanna to the south (Naibbi *et al.*, 2014). The Sahelian vegetation is typified by grasses, open thorn scrub, and scattered thorny trees, shrubs interspersed with occasional trees, patches of woodlands and short scattered grasses. The trees are short with hard corky bark ranging in height between 2 to 7 meters. They shade their leaves in a withering-like manner during the dry season and sprout at the onset of rainy season. Savanna is a grassland area characterized by a varying degree of woody trees and shrubs in a fairly close number.

METHODOLOGY

Rainfall as a meteorological parameter was used solely for this study. Annual rainfall records spanning a period of fifty (50) climatological years from two (2) stations were sourced from the data bank of Nigerian Meteorological Agency (NIMET) Oshodi, Lagos and fully utilized for trend and drought analyses. The stations are Nguru and Potiskum. Figure 1 above shows the spatial position of stations used in the study area.



i. Rainfall Trend Analysis

Simple linear regression analysis was used to spot the trend in the rainfall series. The rainfall values in the time series were regressed on time (years). The simple linear regression formula is expressed as $Y = a + bx$, $a = \bar{y} - b\bar{x}$ and $b = \frac{\sum(x-\bar{x})(y-\bar{y})}{(x-\bar{x})^2}$. Where

a = is the intercept of the line on the y -axis,

b = is the regression coefficient representing the slope of the line,

y = is the dependent variable (the rainfall) and x = is the independent variable (the year).

ii. Flood Indexing.

Floods as well as drought conditions are often quantified by indices which measure the departure of rainfall variables from their normal conditions according to their corresponding historical distributions. They often serve as a link between the data, the public, and decision-makers to understand, assess, and act in response to drought events (He *et al.*, 2017). Examples are Standardized Precipitation Index (SPI), Percentage Deviation Below Mean Index (PDBM), Rainfall Anomaly Index (RAI) and the host of others.

SPI Index

SPI model is propounded by McKee *et al.*, 1993 was used for the detection of flood events of varying categories. It is robust and reliable. It uses rainfall only and has ease of calculation (WMO, 2012). An SPI value is computed using the formula below;

$$SPI = \frac{x_{ik} - \bar{x}}{\delta_i}$$

Where x_{ik} = Observed rainfall for the station,

\bar{x} = Mean rainfall and δ_i = Standard deviation.

Flood occurs when SPI value reads positive and negative value connotes zero floods.

After the computation of the SPI values, the derived positive SPI values were then compared with the SPI threshold values for the categorization and classification of the flood in terms their magnitude, frequency, and duration. A 12-month SPI time scale is adopted here because of its suitability for meteorological flood investigation (Umar, 2013). See Table 1 for the constant flood SPI Severity threshold values.

Merits of SPI Model of Flood Detection

1. It uses rainfall climatic element as a sole climatological input.
2. The index is ascertained as a good flood indicator on varying time scales inter alia: 3 months, 6 months, 12 months and 24 months etc.
3. It can be used to monitor anomalously wet (Flood) as well as dry periods (Droughts).
4. It facilitates the identification of different flood typologies.
5. It displays a statistical consistency.
6. It is used in delineating flood spatial extent.
7. It helps in monitoring flood pattern over space and time
8. It is known for computational simplicity.



9. Less complicated than other indices like PDSI.
10. The model is adaptable to all regions.
11. It also allows comparisons of flood events across different geographical areas.

Demerits of SPI Model of Flood Detection

- i. Applicable only to long-term rainfall records (of at least 30 years)
- ii. It does not take into account other climatic variables that are contributory to flood like high wind.
- iii. Time scales of analysis are hard-coded into the program and cannot be changed (Praveen & Ramachandran, 2015; Wambua, *et al.*, 2015; Brencic, 2016; Guo *et al.*, 2016; Masih *et al.*, 2017).

Table 1. SPI Severity Threshold (After McKee *et al.*, (1993).

SPI VALUES	FLOOD CATEGORY
0 to to 0.99	Mild Flood
1.00 to 1.49	Moderate Flood
1.5 to 1.99	Severe Flood
2.00 or more	Extreme Flood

RESULTS AND DISCUSSIONS

Rainfall Trend Over Nguru Station

Figure 2 shows the observed annual rainfall trend of Nguru station. Estimation of changes in annual values of rainfall expressed in mm for the period of study 1956-2015 exhibited an annual rise at the rate of 4.335 mm per annum and 216.75 mm annual totals for the 50 years period of the study. See table 2 for the summary of linear trend line equation variables. This finding corroborate with the work of (Lennaret 2008) that Sahel is greening due to increasing rainfall trend.

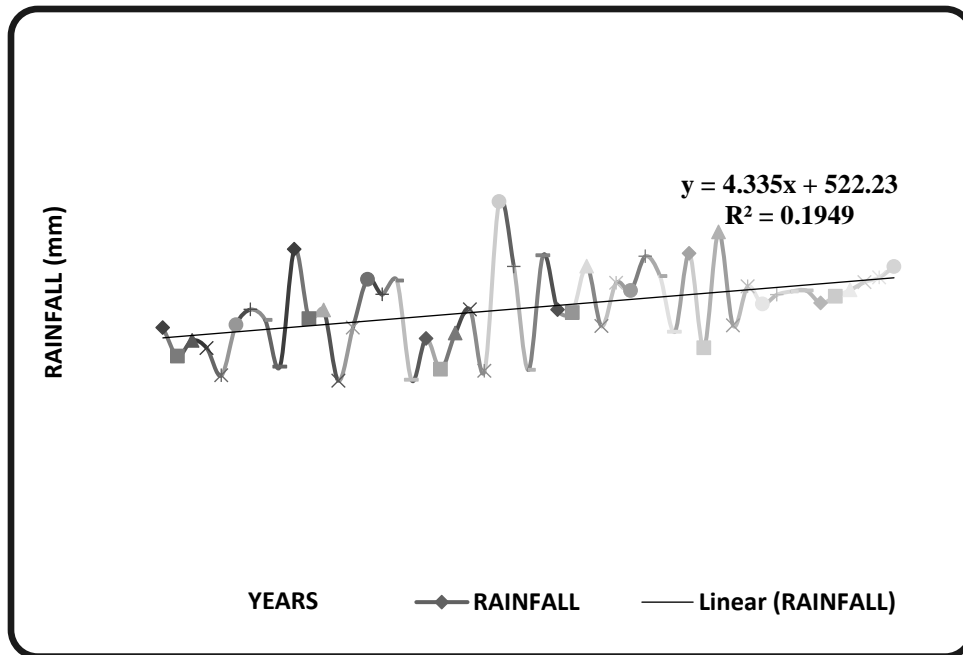


Fig. 2: Rainfall Trend for Nguru Station. (1965-2015)

Source: Authors' Computation, 2023.

Rainfall Trend Over Potiskum Station.

It could be observed that from figure 3 annual rainfall pattern exhibited an upward trend over the period of the study. The trend shows a systematic pattern of increase at the rate of 0.671 mm per year, amounting to 33.55 mm annual total for the 50 years period of record. The increasing trend in both the two stations indicates increasing rainfall hence good tendency for meteorological flood occurrence (Umar, 2013)

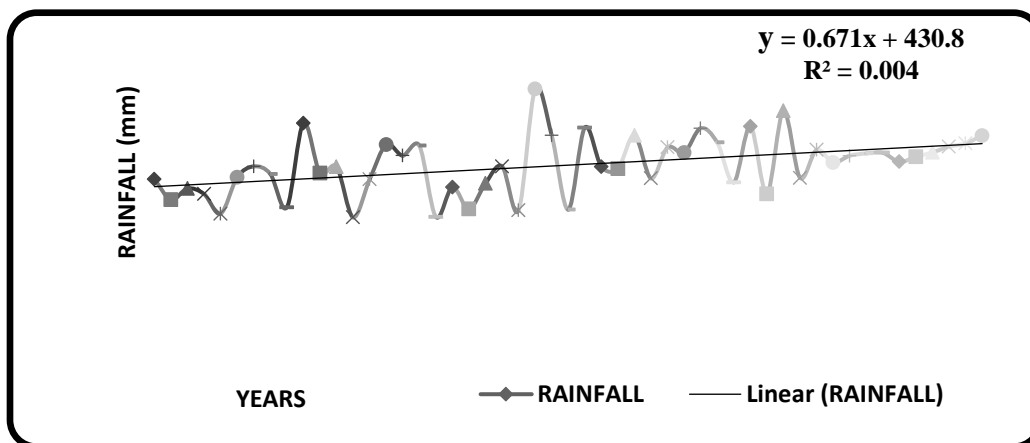


Fig. 3: Rainfall trend for Potiskum station, (1965-2015)

Source: Authors' Computation, 2023.

Table 3: Results of linear trend line equations variables

S/N	STATION	Duration of Rainfall Record	Equation on Chart Y=	R- Squared value on Chart	Trend
1	NGURU	50 Years	4.335x	0.194	Increase
2	POTISKUM	50 Years	0.671x	0.004	Increase

Flood Frequency-Duration- Magnitude-Analysis Over Nguru station Using SPI.

The outcome of flood occurrence analysis in Nguru station showed that from 1965 to 1968 mild to moderate droughts occurred in the station. The year 1973 and 2003 were the episode of severe floods that affected the state. However, moderate floods occurred in multiple of about 9 times. However, the flood of severe magnitude affected the station occurring in 1973 and 2003. Flood duration analysis revealed the detection of 6 cases of single year short-term flood, 3 and 3 cases of 2-year and 3-year duration. The highest duration flood is that of above 5years duration that occurred once.

Table 4: Flood episodes detected across the study area based on SPI Index

S/N	STATION	MILD FLOOD	MODERATE FLOOD	SEVERE FLOOD	EXTREME FLOOD	TOTAL FLOOD
1	NGURU	17	07	02	--	26
2	POTISKUM	19	03	01	02	25
	TOTAL	36(54.3%)	10(19.6%)	03(5.9%)	02(3.9%)	51(100%)

Flood Frequency-Duration- Magnitude-Analysis Over Potiskum station Using SPI.

The result of the SPI analysis revealed that mild flood occurring nineteen times. Moderate flood category occurs three times with severe and extreme flood occurring once and twice respectively. The results of the analysis further revealed that the station is wetly in condition, a clear indication of more humid condition and a testimony of the fact that there exists an intra-zonal difference in the amount of rainfall by the Sudan and Sahelian zone of the study area. The Sudan zone received more rain and fewer variables than the Sahelian. The occurrence of severe and extreme flood in the station can further be attributed to the increasing rate of rainfall as shown in the rising trends. For details on the frequency of various flood conditions characterized using the SPI for both the station see table 4. As can be visualized in table 5 below.

Flood duration results indicate that there is 5 cases of 1 year flood duration, 6 cases of 6year duration, 2 and 1 cases of 3 and 4 year duration respectively.

Table 5: Summary of Flood duration over Yobe State based on SPI Index

S/N	STATION	1-YEAR	2-YEAR	3-YEAR	4-YEAR	5-YEAR	ABOVE 5-YEAR
1.	NGURU	06	03	03	0	0	01
2.	POTISKUM	05	06	02	1	0	0
	TOTAL	11	9	05	1	0	01



CONCLUSION.

The results obtained unraveled series of different categories of flood besetting the Yobe state. However, more extreme flood episode was obtained in the southern flank and the reason is attributable to high rainfall and the rising trend. Therefore, the paper concludes that meteorological floods is a looming natural hazard in the state and its occurrence is codependent on rainfall condition.

RECOMMENDATION.

The study recommends the followings; The development of early warning system which is instrumental in alerting the farmers, government and other stakeholders to the impending flood. The study further recommends to researchers to incorporate and integrate the use of space-based remote sensing models in order to verify, support and complement the findings made from the in situ ground-based approach i.e the SPI Model. Government at all level should assist the victims of flood to cushion the impact of the phenomenon

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