RAINFALL VARIABILITY OVER GUSAU AND ENVIRONS, ZAMFARA STATE, NIGERIA

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ABSTRACT: This study aims to determine trends in long-term monthly rainfall using nonparametric methods (i.e. the Mann–Kendall and Sen's T tests) in Gusau North-Western Nigeria. Monthly rainfall records of Gusau synoptic stations for a period 60 years (1953-2012), were acquired from the Nigerian Meteorological Agency. The result revealed that the monthly rainfall recorded downward trend in the months of April, June, July, August and September within 1953-2012. While an upward trend in May, and October was recorded but they were not significance at 95% confidence level. The s Sen's slope estimator revealed that of the seven (7) rainy months considered (April, May June, July, August, September and October) only two months May and October showed upward trends with rainfall of 0.028mm and 0.182mm as obtained by Sen's slope estimator, while from of month of June, July August and September there were downward trends of -0.492mm, 0.580mm, -0.069mm and -0.716mm. The implication of the findings i that the area experience some basic indices of climate change.

Keywords: *Rainfall, Trends, Climate, environment, variability*

1. Introduction

Yavuz and Erdoğan (2012) confirmed that global warming and climate change is significantly altering various environmental variables in many countries around the world. It has been documented severally that the Earth's climate has been changing notably at a fast pace since the last century and the changes are expected to continue (Huang, *et al.* 2014). Rainfall being one of the important climatic elements i found to be changing on both the global (Dore, 2005) and the regional scales (Kayano and Sans´ıgolo, 2008). It is understood that projected global climate changes have the potential to alter precipitation patterns. Changes in precipitation patterns is believed to directly affect hydrology, agriculture, ecosystems and water resources management. It i argued that to meet the futur

development and sustainable management of water resources of a given region especially within the context of global warming, water and energy cycles and the increasing demand of water for domestic, agricultural and industrial need, knowledge of trends and variations of hydro-climatological element is relevant (Shamsuddin, 2010).

Wang, *et al.* (2011) assed that temporal and spatial variability in precipitation around the world are receiving increasing attention as the information about changing patterns of precipitation is the starting point for accurate assessment of water resources, flood and drought control, understanding climate change and efficient water management. Rainfall trends studies in Nigeria have shown contrasting result. It is based on this Bigg, (1991) noted that a complete description of intraregional rainfall variability and changes is of great interest, especially in areas with strongly contrasting rainfall regimes and with associated environmental problems. Nigeria still remains largely an agriculture-based country where more than 65% of population are directly or indirectly engaged in a wide range of agricultural activities. Rainfall is the most important natural factor that determines the agricultural production in Nigeria. The variability in rainfall is therefore very important for the economy of the country. This study aimed to determine long-term rainfall trend in Gusau North-Western Nigeria with a view of identifying the impact of the rainfall variability in agricultural planning.

2. The Study Area

The study area is Gusau and its environs. It on Sudano ecological zones of Nigeria Longitudes 6.70° East and Latitudes 12.17° North.

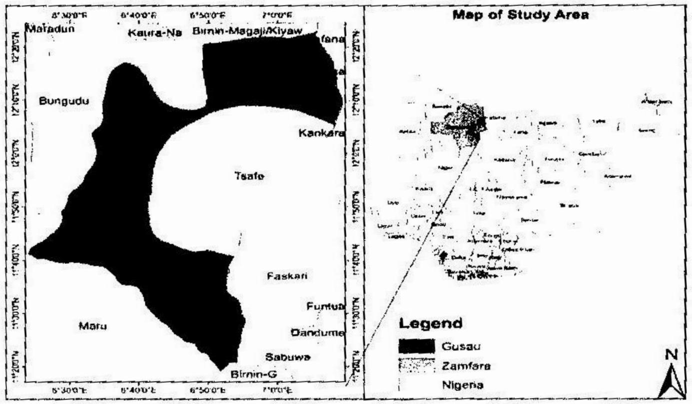

Figure 1: The Study Area (Gusau and Environs, Zamfara State Nigeria)

The climate is dominated by Tropical Maritime (mT) air mass, and the Tropical Continental (cT) air mass. The rainy season in this region is associated with late onset and earlier cessation. The onset and cessation are also characterized by destructive storms which destroy life and property (AbdulKadir, *et al*., 2013). The seasonal and latitudinal variations are understood to affect diurnal and seasonal temperature ranges. The highest maximum air temperature is recorded in the northern part usually areas north of latitude 9° and occur in March /April and minimum temperatures are recorded in December/January North of latitude 9°N (AbdulKadir *et al*, 2013).

3 Materials and Methods

3.1 Data

Monthly rainfall records of Gusau synoptic stations for a period 60 years (1953-2012), is acquired. The data were collected from the Nigerian Meteorological Agency

3.2 Trend Analysis

In this research, trend detection is carried out by the Mann-Kendall test and Sen's slope estimator analysis .The detailed explanations of these methods are:

3.3 Mann-Kendall test

Mann-Kendall test (Mann, 1945; Kendall, 1975) is applied to detect the trend in rainfall time series. Confidence levels of 95% is taken as thresholds to classify the significance of positive and negative trends. The Mann–Kendall (MK) test is a non-parametric test, commonly used to detect significant trends in hydrological and meteorological time series (example Tabari and Hosseinzadeh Talaee, 2011). The MK test is given as:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sign}(x_j - x_k) \qquad (1)$$

$$\text{Where: } \text{sign}(x_j - x_k) = \begin{cases} 1 \text{ if } (x_j - x_k) > 0 \\ 0 \text{ if } (x_j - x_k) = 0 \\ -1 \text{ if } (x_j - x_k) < 0 \end{cases} \qquad (2)$$

$$\text{VAR}(S) = \frac{[n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i - 1)(2t_i + 5)}{18} \qquad (3)$$

Where:

n = the number of data points t_i = the number of ties for the i value and m= the number of tied values (a tied group is a set of sample data having the same value)

Then Equation 2 and 3 is used to compute the test statistic Z from the following equation:

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & \text{if } S < 0 \end{cases} \qquad (4)$$

A positive value of Z will indicates that there is an increasing trend and a negative value indicates a decreasing trend while zero value indicates no trends.

2.3.2 Magnitude of Rainfall Trend Changes

It is observed that some trends may not be evaluated to be statistically significant while they might be of practical interest (Basistha, *et al*, 2007). In the instance where climate change component is present, it may not be detected by statistical tests at a satisfactory significance level (Radziejewski and Kundzewicz, 2004). To overcome this challenge, linear trend analysis will be carried out and the magnitude (change per unit time) will be estimated by using a non-parametric procedure developed by Sen (1968). The Sen's slope approach is adjudge to gives a robust estimate of the magnitude of a trend (Yue, Pilon, Phinney, Cavadias 2002) and for this reason, it has been preferred above the regression slope approach in recent hydrologic studies (Huang et al. 2014; Zhang, Zheng, Wang, Yao 2015). The trend magnitude by this method is computed as follows:

$$Q = \frac{x_j - x_k}{j - k} \qquad (5)$$

$Q_{med} = \frac{Q(N+1)}{2}$ and if N is even, Sen's estimator is computed by $= \frac{[QN/_2 - Q(N+2/_2]}{2}$

Where:

Q = slope between data points x_j and x_k, x_j, x_k = data values at times j and k j>k respectively

N is the number of calculated slopes

4.0 Results and Discussion

The Mann Kendall trends test for monthly rainfall is shown in table 1. The result revealed that the monthly rainfall recorded downward trend in the months of April, June, July, August and September within the study period. The above months all showed a negative sign. While an upward trend in May and October was recorded. The month of May and October revealed a positive sign. The result however show no significance at 95% confidence level.

Table 1 Trends in Monthly Rainfall over Gusau and Environs

Time Series	First Year	Last Year	n	Test Z
April	1953	2012	60	-0.73
May	1953	2012	60	0.10
June	1953	2012	60	-1.38
July	1953	2012	60	-1.19
August	1953	2012	60	-0.11
September	1953	2012	60	-1.35
October	1953	2012	60	1.17

The trend slope, which is the reduction of rainfall is shown in table 2. The month of May and October recorded upward increase in rainfall of 0.028mm/month and 0.182mm/month. The above months showed a minimal increase in monthly rainfall. The month of June, July, August and September recorded downward of -0.492mm/month, -0.580mm/month, -0.069mm/month and -0.716mm/month. The result revealed a minimal reduction of monthly rainfall. The month of April however exhibit no changes.

Table 2 Magnitude Change in Monthly Rainfall over Gusau and Environs

Time Series	First Year	Last Year	n	Sen's Slope Estimate Q
April	1953	2012	60	0.000
May	1953	2012	60	0.028
June	1953	2012	60	-0.492
July	1953	2012	60	-0.580
August	1953	2012	60	-0.069
September	1953	2012	60	-0.716
October	1953	2012	60	0.182

The graphical distribution of the trends and the trend slope for the months under consideration are illustrated from Figure 2 to 8.

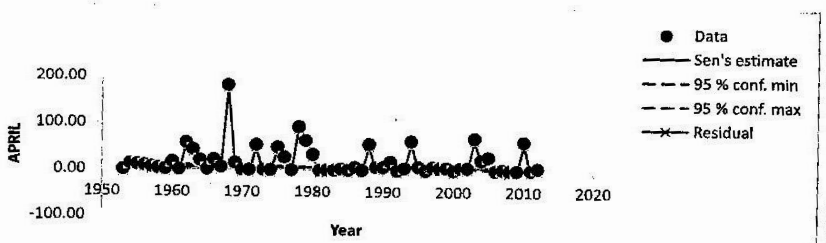

Figure 2. Trends and Magnitude Change in Monthly Rainfall of April over Gusau and Environs (1953-2012)

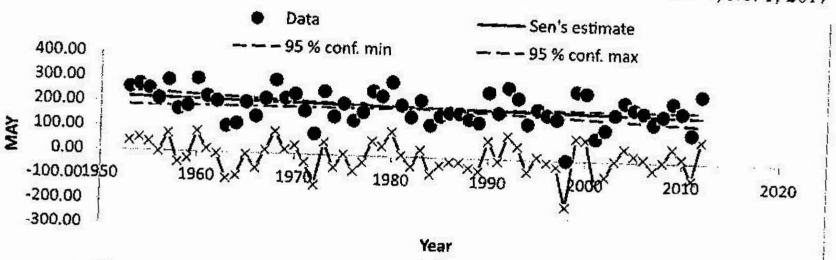

Figure 3. Trends and Magnitude Change in Monthly Rainfall of May over Gusau and Environs (1953-2012)

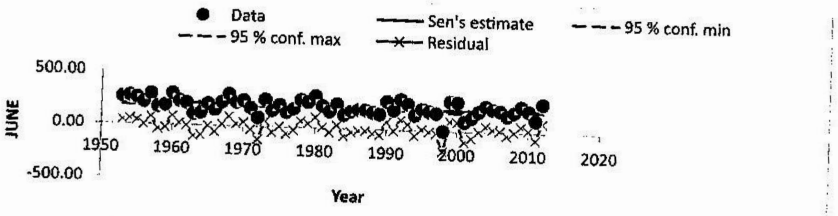

Figure 4. Trends and Magnitude Change in Monthly Rainfall of June over Gusau and Environs (1953-2012)

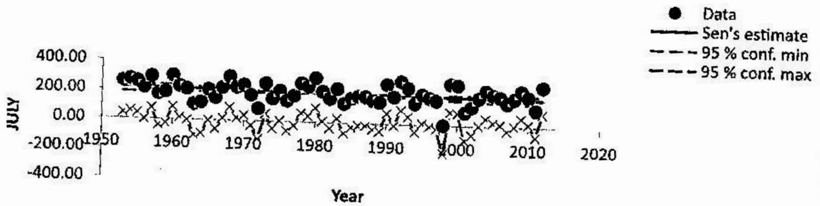

Figure 5. Trends and Magnitude Change in Monthly Rainfall of July over Gusau and Environs (1953-2012)

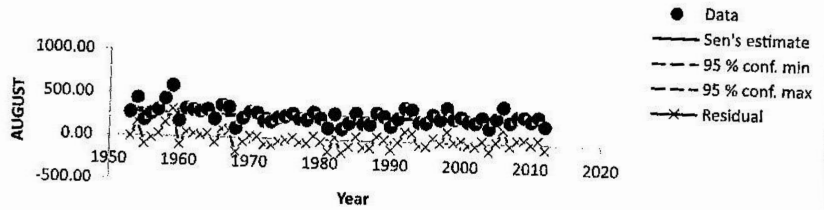

Figure 6. Trends and Magnitude Change in Monthly Rainfall of August over Gusau and Environs (1953-2012)

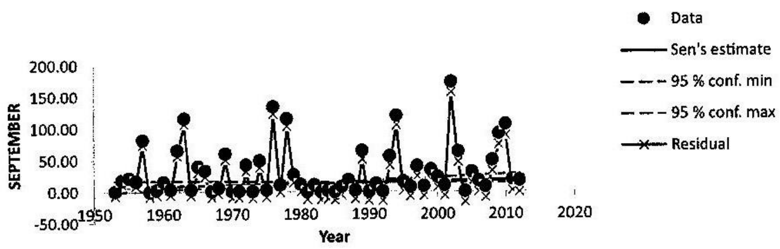

Figure 7. Trends and Magnitude Change in Monthly Rainfall of September over Gusau and Environs (1953-2012)

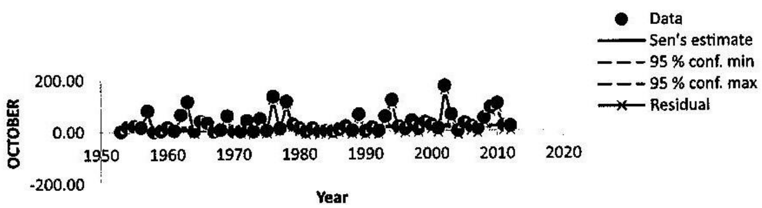

Figure 8. Trends and Magnitude Change in Monthly Rainfall of October over Gusau and Environs (1953-2012)

5 Conclusion and Recommendation

The study revealed that of the seven (7) rainy months considered in this study (April, May. June, July, August, September and October within 1953-2012) only two months May and October showed upward trends with the rainfall of 0.028mm and 0.182mm as obtained by Sen's slope estimator, while from of June, July, August and September there were downward trends of -0.492mm/month, -0.580mm mm/month, -0.069mm mm/month and -0.716mm mm/month. The month of April showed no changes. The implication of this is that the area experience some basic indices of climate change. There rain fed farmer are to take note of these fluctuation in order to take advantage of those months with increased rainfall.

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