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AN ESTIMATION OF RAINFALL SEASONALITY INDEX OF YOLA SOUTH LGA AND ITS EFFECTS ON AGRICULTURE AND ENVIRONMENT

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ABSTRACT: *The study saddled to estimate rainfall seasonality index of Yola South LGA, and its effects on agriculture and environment. Fifty (50) years rainfall data from 1969-2018 were computed using proposed formular of Walsh & Lawler (1981). The result revealed that of all the years estimated were classified as markedly seasonal with a long drier season except in the year 1971 and 2016 classified as seasonal and 1991, 2003, 2009 and 2012 were rated with most rain in 3 months or less. Similarly, for the decade's results it was revealed that all the four decades (1969-2008) were classified as markedly seasonal with a long drier season with estimated mean SI value ranged from 0.884-0.933 except in the last decade (2009-2018) which was rated as seasonal with mean SI values of 0.756 having short dry season respectively. In addition, the cumulative result for the fifty (50) years of study shows that the mean SI value of 0.882 classified as markedly seasonal with a long drier season having average rainfall amount of 126.66 mm. Due to the seasonal variability of rainfall distribution imposed negative effects of floods and droughts scenarios on agriculture and environment in the area. Floods scenarios had affected farmlands, cropping system and the entire livelihood system and droughts conditions also damaged crop growth and productivity, loss of vegetation, soil erosion and desertification. It is therefore recommending that the farmer should adopt the use of early matured crops with high drought resistivity, farming and buildings along flood prone should be avoided for sustainable development.*

KEYWORDS: Agriculture, Estimation, Environment, Index, Rainfall, Seasonality, Yola.

INTRODUCTION

Rainfall is an important climatic variable that is affected by both droughts and floods (Hasanain, 2017). This might be due to its apparent seasonal distribution and variability within a given geographical area. Conventionally, decrease of precipitation is considered as the origin of drought which is leads to a reduction of storage volumes and fluxes involved in the hydrological cycle. (Nalbantis, 2008). To understand the characteristics of temporal and spatial of rainfall, many researchers interest about planning of water resources and management, hydrological modeling, flood frequency analysis, flood hazard mapping, agricultural planning, climate change impacts, water resource assessments, and other environmental assessments through seasonality index analysis. (Hasanain, 2017). Thus, there are numerous indicators based on rainfall that are being used for drought monitoring (Smakhtin and Hughes, 2007).

Many studies deal with rainfall seasonal index that helps researchers to describe the features of precipitation distribution and estimation of future. Although, Ramage (1971), Jackson

(1977) and Nieuwolt (1977) characterize seasonality of rainfall in qualitative terms, the estimation by Walsh and Lawler (1981) of Seasonality Rainfall Index is a basic of most studies. The Rainfall Seasonality Index(RSI) is used to study the spatial and temporal change in rainfall behavior which contributes in improvement of water and management plans of water resources systems and agriculture in a certain region especially during dry seasons (Hasanain, 2017). A period of at least 30 years of rainfall data are required to describe the prevailing rainfall seasonality index of an area. The higher the seasonality index of a region the greater the water resources variability and scarcity in time, the more vulnerable the area to desertification (Patil, 2015). It is a known fact that rainfall seasonality is a complicated notion which integrates a numeral of independent components (Walsh and Lawler 1981). Seasonality estimates the seasonal variances of rainfall amounts, and not wetness or dryness in an absolute sense (Livada and Asimakopoulos, 2005). The aims of seasonality index are description characterize the distribution of precipitation of selected year or period and classification of climate of an area in relation to water availability. For example, the climate of an area can be characterized as rather seasonal with a short dry season or marked seasonal with a long dry season, depending on the distribution of rainfall during the year. (Patil, 2015). Yola South LGA, is among the prone areas which had experienced resources of flood and drought events over a long climatic period as a result of seasonal variability and distribution of rainfall in the areas which imposed a serious negative impact on agriculture and the environment settings in the area.

Therefore, there is indeed an ardent need for the farmers, dwellers and decision makers in the area to acquire adequate information on the seasonal variability and distribution of rainfall and its effects on agriculture and environment through scientific research for better agronomic practices, disaster management and water resource management and planning respectively. Thus, this paper is an estimation of rainfall seasonality index of Yola South LGA and its effects on agriculture and environment

METHODOLOGY

The hydro-meteorological data of monthly and annual rainfall data for the period of fifty years (50 years) from 1969-2017 were obtained from the agro-meteorological station, Upper Benue River Basin Development Authority, (UBRBDA) Yola. In order to define the seasonal contrasts, the seasonality index (*SI*) (Walsh and Lawer 1981), which is a function of mean monthly and annual rainfall, was computed using the formula:

$$\overline{\boldsymbol{SI}} = \frac{1}{\overline{R}} \sum_{n-1}^{n-12} \overline{X}_n - \frac{\overline{R}}{12}$$

The $\overline{\boldsymbol{SI}}$ is defined as the sum of the absolute deviation of mean monthly rainfall from the overall monthly mean divided by the mean annual rainfall.

where $\overline{\boldsymbol{X}}_{\boldsymbol{n}}$ = indicates the mean rainfall of month $\boldsymbol{n}$

and $\overline{\boldsymbol{R}}$ = the mean annual rainfall.

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Table 1. Classification of Seasonality Index (SI) According to Walsh & Lawler (1981).

S/N	Rainfall regime	SI
1	Very equable	≤ 0.19
2	Equable with a definite wetter season	0.20–0.39
3	Rather seasonal with a short drier season	0.4–0.59
4	Seasonal	0.60–0.79
5	Markedly seasonal with a long drier season	0.80–0.99
6	Most rain in 3 months or less	1.00–1.19
7	Extreme, almost all rain in 1 to 2 months	≥1.20

Source: (Walsh and Lawler, 1981).
NOTE; the index varies from zero (when all months share the same amount of rainfall), to 1.83 (when all rainfall incidences occur in a single month).

Study Area

The study was conducted in Yola South LGA and Environs of Adamawa State, Nigeria which lies on latitude 090 14’N and 090 20’N of the equator and longitude 120 25’E and 120 28’E of the Greenwich meridian with an average annual rainfall of 850 mm-1000 mm with over 41% of rain falling in August and September. Temperature also has a significant temporal variation in the study area; with an average maximum temperature of 42 ^{0}C with an average relative humidity of about 29% (Adebayo, 1999; Upper Benue River Basin Authority, Yola, Nigeria. 2018).

RESULTS

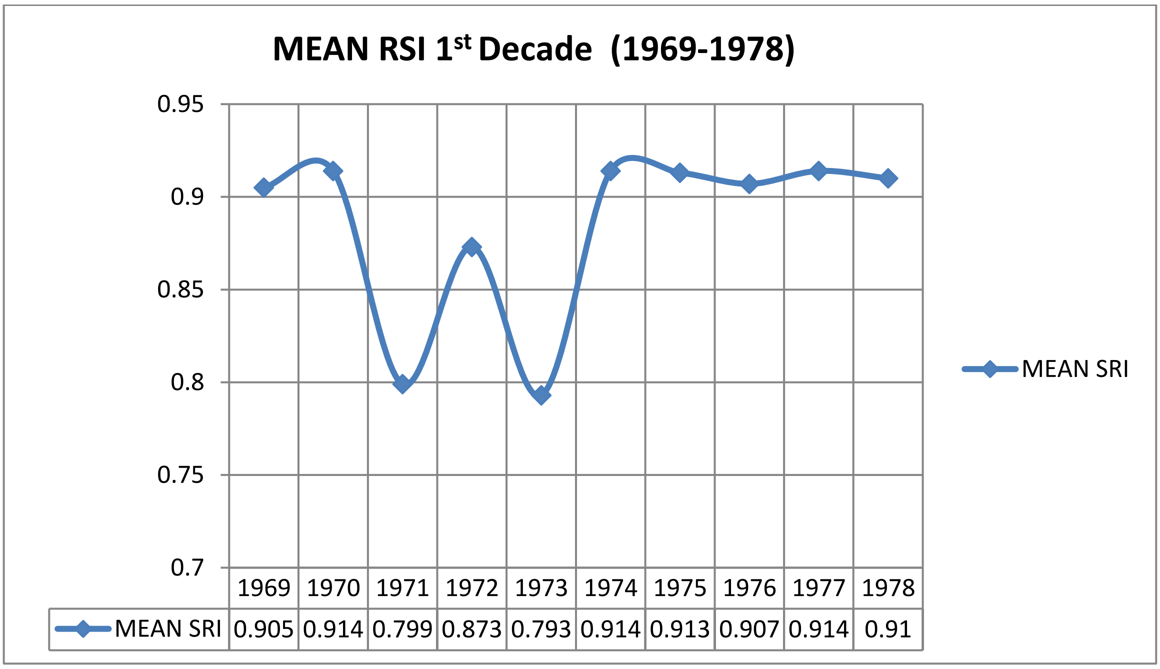

Figure 1: Shows the Mean Rainfall Seasonality Values from 1969-1978

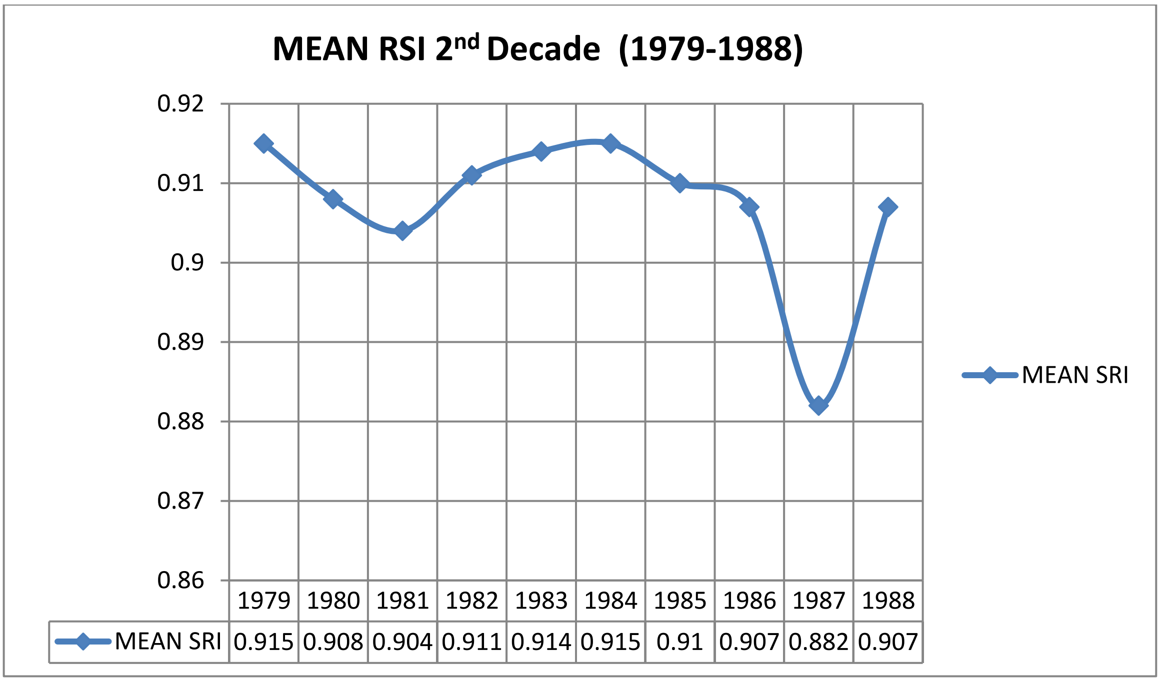

Figure 2: Shows the Mean Rainfall Seasonality Values from 1979-1988

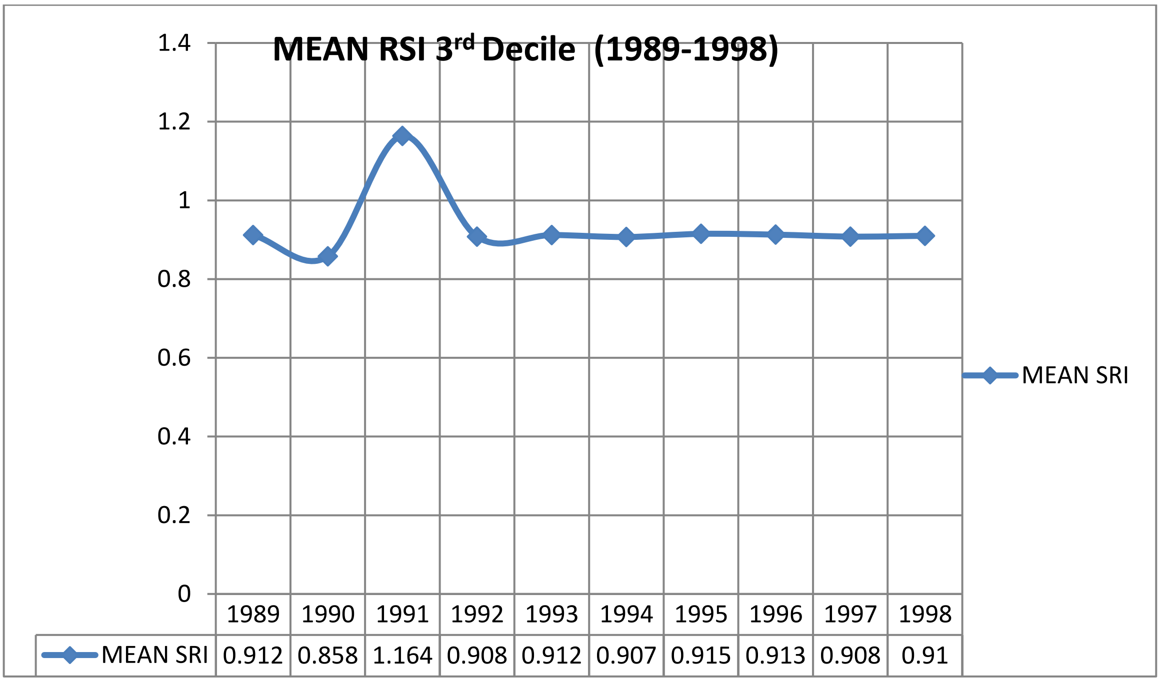

Figure 3: Shows the Mean Rainfall Seasonality Values from 1989-1998

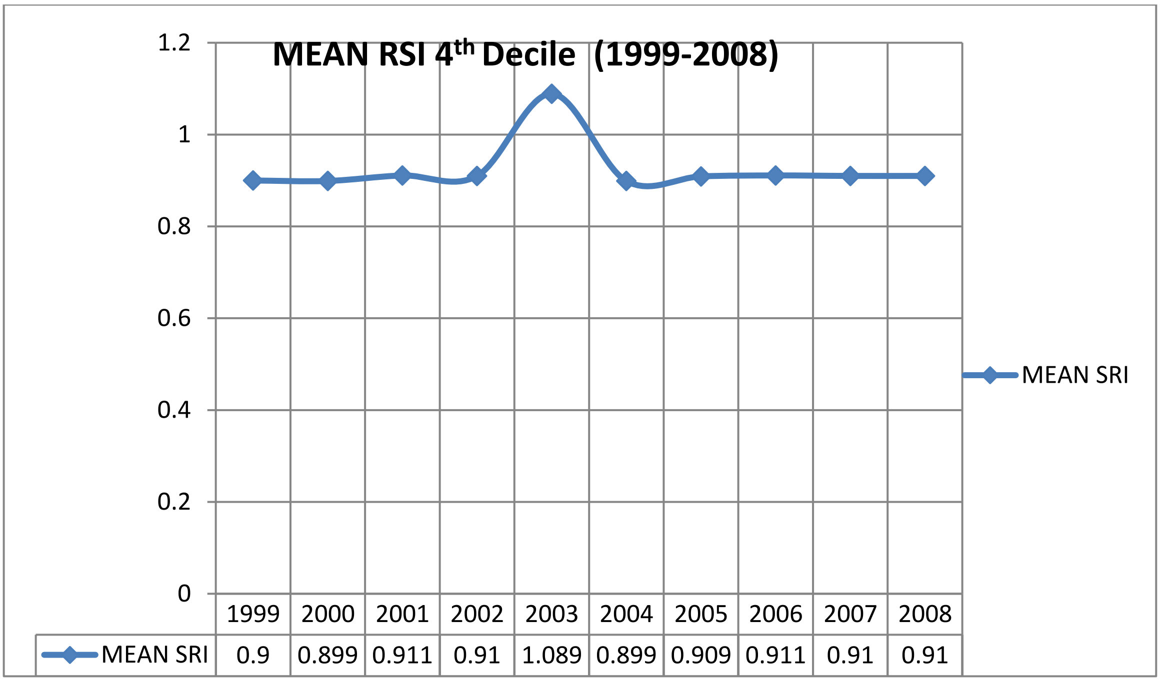

Figure 4: Shows the Mean Rainfall Seasonality Values from 1999-2008

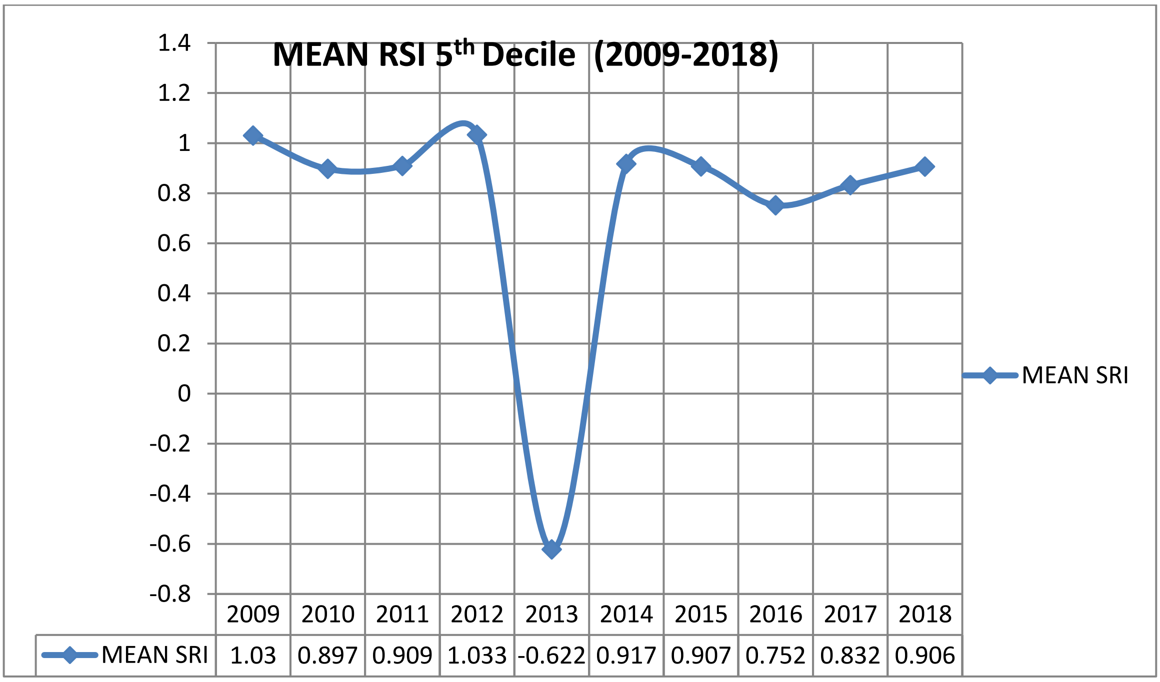

Figure 5: Shows the Mean Rainfall Seasonality Values from 2009-2018

Table 2: Shows the Classification of SRI for the First Decade (1969-1978)

S/N	Years	Classification of SI according to Walsh & Lawler (1981)
1	1969	Markedly seasonal with a long drier season
2	1970	Markedly seasonal with a long drier season
3	1971	Seasonal
4	1972	Markedly seasonal with a long drier season
5	1973	Seasonal
6	1974	Markedly seasonal with a long drier season
7	1975	Markedly seasonal with a long drier season
8	1976	Markedly seasonal with a long drier season
9	1977	Markedly seasonal with a long drier season
10	1978	Markedly seasonal with a long drier season

Table 3: Shows the Classification of SRI for the Second Decade (1979-1998)

S/N	Years	Classification of SI according to Walsh & Lawler (1981)
1	1979	Markedly seasonal with a long drier season
2	1980	Markedly seasonal with a long drier season
3	1981	Markedly seasonal with a long drier season
4	1982	Markedly seasonal with a long drier season
5	1983	Markedly seasonal with a long drier season
6	1984	Markedly seasonal with a long drier season
7	1985	Markedly seasonal with a long drier season
8	1986	Markedly seasonal with a long drier season
9	1987	Markedly seasonal with a long drier season
10	1988	Markedly seasonal with a long drier season

Table 4: Shows the Classification of SRI for the Third Decade (1989-1998)

S/N	Years	Classification of SI according to Walsh & Lawler (1981)
1	1989	Markedly seasonal with a long drier season
2	1990	Markedly seasonal with a long drier season
3	1991	Most rain in 3 months or less
4	1992	Markedly seasonal with a long drier season
5	1993	Markedly seasonal with a long drier season
6	1994	Markedly seasonal with a long drier season
7	1995	Markedly seasonal with a long drier season
8	1996	Markedly seasonal with a long drier season
9	1997	Markedly seasonal with a long drier season
10	1998	Markedly seasonal with a long drier season

Table 5: Shows the Classification of SRI for the Fourth Decade (1999-2008)

S/N	Years	Classification of SI according to Walsh & Lawler (1981)
1	1999	Markedly seasonal with a long drier season
2	2000	Markedly seasonal with a long drier season
3	2001	Markedly seasonal with a long drier season
4	2002	Markedly seasonal with a long drier season
5	2003	Most rain in 3 months or less
6	2004	Markedly seasonal with a long drier season
7	2005	Markedly seasonal with a long drier season
8	2006	Markedly seasonal with a long drier season
9	2007	Markedly seasonal with a long drier season
10	2008	Markedly seasonal with a long drier season

Table 6: Shows the Classification of SRI for the Fifth Decade (2009-2018)

S/N	Years	Classification of SI according to Walsh & Lawler (1981)
1	2009	Most rain in 3 months or less
2	2010	Markedly seasonal with a long drier season
3	2011	Markedly seasonal with a long drier season
4	2012	Most rain in 3 months or less
5	2013	Very equable
6	2014	Markedly seasonal with a long drier season
7	2015	Markedly seasonal with a long drier season
8	2016	Seasonal
9	2017	Markedly seasonal with a long drier season
10	2018	Markedly seasonal with a long drier season

Table 7: Shows the Classification of SI for the Sixth Decades Under Study According to Walsh and Lawler (1981)

S/N	Decades	Total RSI	Mean Decade RSI	RSI Decade Rating
1	1969-1978	8.842	0.884	Markedly seasonal with a long drier season
2	1979-1988	9.073	0.907	Markedly seasonal with a long drier season
3	1989-1998	9.312	0.931	Markedly seasonal with a long drier season
4	1999-2008	9.338	0.933	Markedly seasonal with a long drier season
5	2009-2018	7.561	0.756	Seasonal

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The 50 years (1969-2018) Mean SI value was estimated as follows

Total RSI data for 50 years (for five deciles) was calculated using

$=\sum \frac{Xi}{N}$

X = Total number RSI values for a given periods of study (five decades)

N= Number of recorded years of study (=50 years)

$= \frac{8.842+9.073+9.312+9.338+7.561}{50}$

$= \frac{44.126}{50}$ = **0.882** ***markedly seasonal with a long drier season***

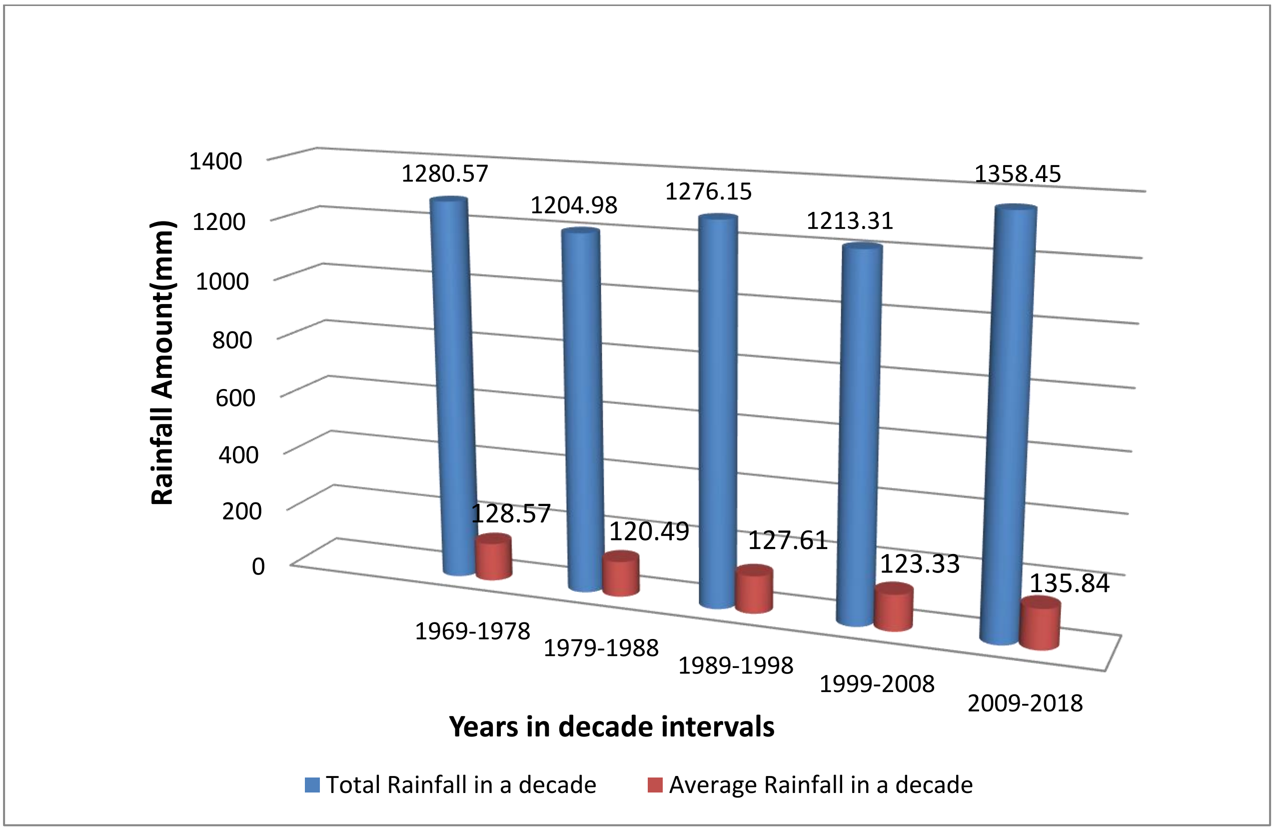

Figure 6: Shows the Total and Mean Rainfall Values (mm) for the Five Decades Periods of Study

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Estimation of the fifty (50) years Mean Rainfall value

The 50 years (1969-2018) Mean Rainfall value was estimated as follows;

Total amount of Rainfall data for 50 years (five decades) was calculated using the formular

$$= \sum \frac{Xi}{N}$$

X i= Total values of rainfall for a given periods (five decades)

N= Number of recorded years (=50 years)

$$= \frac{1280.573+1204.988+1276.157+1213.31+1358.45}{50}$$

$$= \frac{6533.478}{50} = 126.66 \text{ mm}$$

DISCUSSIONS

Results from figure 1 show the mean RSI for the first decade (1969-1978). RSI values varied between 0.793 to 0.914, where in all the years the SI was rated as markedly seasonal with a linear values ranged from (0.80-0.99) except in the year 1973 and 1971 estimated to had seasonal rainfall regime with SI values of 0.793 and 0.799 classified as seasonal have an effect on the agricultural production in the area with a moderate crop growth in 1971 and 1973 accordingly. Similarly, results from figure 2 depicted the mean RSI for the second decade (1979-1988). In the second decade of the study, RSI values varied between 0.882 to 0.915, which all the periods of ten (10) years were rated as markedly seasonal with a long drier season (SI value of = 0.80-0.99) than wet condition. This decade was probably the unprecedented drier decade experienced in the area with few and shorter wetness condition. Thus, it is rated as markedly seasonal with a long drier season based on Walsh & Lawler (1981) SI classifications. Moreover, results from figure 3 depicted the mean SI for the third decade (1989-1998). The trends remained the same as in second decade where all the years were rated as markedly seasonal with a long drier season (SI value of = 0.80-0.99) with the exception of 1991 having SI value 0f 1.164 with most rain in 3 months (May =217 mm, August=215 mm, and October=241 mm) with an average annual rainfall of 123.11 mm respectively. In addition, the results from figure 4 portrayed the mean SI for the fourth decade (1999-2008). The trend appeared similar as in third decade where all the years were classified as markedly seasonal with a long drier season (SI value of = 0.80-0.99) except in 2003 with SI value of 1.089 with most rain in 3 months or less (July =143.3 mm, August=198.8 mm, and October= 183.7 mm) with a recorded average annual rainfall of 112.10 mm respectively. Furthermore, the results from figure 5 illustrated the mean SI for the fifth decade (2009-2018). In this decade there were apparent variations of SI among the years in the decade. It was revealed that in the year; 2010, 2011, 2014, 2015, 2017 and 2018 were classified as markedly seasonal with a long drier season regime (SI value= 0.80-0.99), while 2009 and 2012 were classified under most rain in 3 months or less regime with the RSI values of 1.03 and 1.033 (2009; June = 2002.2 mm, August= 246.5 mm and Sept =238.1 mm), (2012; June = 240 mm and Sept =214 mm) respectively. Conversely, 2013 was considered as very equable with the RSI values of -0.62 and seasonal rainfall year was occurred in the 2016 in the decade with the RSI values of 0.752 correspondingly.

Effects of Rainfall Seasonality Changes on Agriculture and Environment

Studies have shown that northern Nigeria is subject to frequent floods and droughts as a result of its large inter-annual variability of rainfall; and the most devastating impacts of these extreme events especially flood is the washing away of farmlands thereby affecting agricultural production and food security, destruction of houses, increased health risks and the spread of infectious diseases, and changing livelihood systems (Sawa, 2002; Sawa and Adebayo, 2011; Abaje *et al*, 2014; Abaje *et al*, 2016; Abashiya *et al.*, 2017). Similarly, in Yola South LGA, studies have apparently described the both flood and drought effects on agriculture and environment as discussed below;

Effect of Flood on Agriculture and Environment in the Study Area

In Nigeria, Adamawa state is one of the most occurring flooded states over the decade with a large extent of vulnerability leading to devastating loss of lives, properties, farmlands, displacement and negatively affecting the socio-economic activities in the state (Sadiq and Hena, 2018). According recent findings of Sadiq *et al.*, (2019a) revealed that the hundred hectares farmlands had been affected by flood (see plates 1 below) and this led to negative impacts on the farming community members who engaged primarily in farming activities with loss of more than 61-80 % due to flood events. Similar result was reported by Sadiq *et al*., (2019b) explained that many farmlands both arable and agro-foresting were detached by soil creeping, solifluction and covered by siltation effects where hundreds of hectares farmlands where been lost seasonally. In addition, Sadiq and Faruk (2020) conducted a research from the five selected areas in the study area, the results obtained at Yolde pate, Wuro-chekke and Anguwan Tabo farm locations shows that loamy clay sediments were deposited to an average depth ranges from 25cm-75cm over period of 10-19 years covering about 15-60 hectares of land where irrigation farming are intensively carried out which has positive impact on their farming activities. Conversely, at Mbamba and Bole farm locations were assessed to had coarse sandy sediment depositions over fertile clayey soil (see plates 1 below) to an average depth of 35-40 cm for a period of 5-7 years wrapping a range of 2-9 hectares of fertile land with a negative impact of 60 % damaged of their productivity.

Plates 1: Shows the Apparent Flooding Damaging Crops and Arable Lands in the Study Area

Source:Adopted from Sadiq et al.,2019a; Sadiq and Faruk, 2020.

Moreover, flood effect can lead to damage of dams, reservoirs and lakes where water is harvested, stored and utilize for irrigation and livestock management. In Yola South LGA, Sadiq (2019) reported that Njuwa lakes is an ox-bow lake, which used to host the annual Njuwa fishing festival, until recently when it dried up mainly as a result of siltation effects caused by sediment deposition from river Chochi affecting farming activities due to drying of the lake as depicted in plates 2 below. Thus, Njuwa Lake is located at the lower course of river Chochi where deposition process occurred.

(a) December, 2020 *(b) February, 2020* *(c) April, 2020*

Plates 2. Shows the Gradual Drying up of Njuwa Lake due to Sediment Deposition in the study.

Generally speaking, the repeated occurrence of catastrophic flood episodes in Adamawa state, particularly in Yola South LGA the impacts of flooding have increasingly assumed from significant to threatening proportions. Table 8 and plate 3 below depicted the effects of flood in the area described by Sadiq *et al.,* (2019b).

Table 8: What are the Types of Effects or Damages that Usually Caused by the Flood in the Area.

Variables	Frequency	Percentage (%)
Loss of lives	23.1	6
Destruction of farmland	65.45	17
Spread of diseases	26.95	7
Loss of livestock	50.05	13
Destruction of buildings	53.9	14
Loss of properties	88.55	23
Paralyze of socio-economic activities	50.05	13
Contamination of water	26.95	7
	TOTAL N = 385	**TOTAL P = 100**

Source: Sadiq et al., (2019b)

From the result on table 7, 23 % of them had the opinion that huge properties were lost annually in the area due to flood. Similarly, 17 % of the respondents had conceived to had destruct farmlands in the area, while 14 % of the respondents had attributed the flood damage on destruction of buildings. Loss of livestock and Paralyze of socio-economic activities were due to flood forming 13 % each. Plates 3 below depicted some evidence of floods effects in the study area (Sadiq *et al.*, 2019b).

Plate 3: Depicted Some Adverse Effect of Flood at Tashan Sani Market and Modere area in the Yola South LGA, Adamawa State.

Effect of Drought on Agriculture and Environment

A drought impact is an observable loss or change at a specific time because of drought. It is important that drought indicators or indices accurately reflect and represent the impacts being experienced during droughts. As droughts evolve, the impacts can vary by region and by season. (WMO and GWP, 2016). Thus, of all the extreme meteorological events affecting agriculture and forestry, drought is perhaps the most important hazard with serious implications for the economic well being of the farming community. (Byun, and Kim, 2010).

In Nigeria, analysis of long- term meteorological data show discernable evidence of climate change which leads to warmer seasons; increased frequency and intensity of weather extreme events such as drought, decline in rainfall amount by about 15-20%, increased incidence of dry spell (Adebayo, 1998; Anuforom, 2010; Muhammad et al., 2013). This is due to the fact that majority of the countries' population engage in agriculture as their primary occupation and agriculture in the country is mainly rain fed (Muhammad *et al.*, 2013). In Adamawa State, the trends of annual rainfall results showed that there was a general downward trend of annual rainfall all over the state and also the onset dates of rains exhibit an upward trend which indicates that rainfall is starting late and hence the beginning of growing season is being delayed all over the state while length of rainy season is decreasing in all locations. (Adebayo *et al.,* 2012)

Likewise, Yola South LGA, is among the area with considerable arable lands for agricultural production in the state which produces a large proportion of grains and staple diet of the growing population. Yet the area is frequently under drought attack and this negatively affects food production in the area and is continuously reoccurring most especially in the recent decades. Adebayo *et al.*, (2012) explained that cessation dates of rains displays a downward trend Yola indicating that rains now end earlier in these locations. According to Sadiq (2019) revealed that Njuwa lake is subjected to seasonal drying which sometimes lead to reduction of crop yield due to insufficient of water at flowering stage. Similarly, drought effects had also manifested in the area in terms of vegetation los subjecting the area into desertification process thereby forcing an indiscriminate movement of cattle by the herdsmen to Cameroon border threatens permanent soil degradation, cracking and drying of soils and disrupts crop growth. Plate 4 below portrayed some exacerbated effects on drought in the area.

Plate 4: Gradual Encroachment of Desert, Loss of Pastures for Cattle and Drying of Farmlands due to Drought Events in Yola South LGA

Source: Adopted from Sadiq et al.,2019c and Sadiq, 2019).

Conclusively, Drought disrupts cropping programs, reduces breeding stock, and threatens permanent erosion of the capital and resource base of farming enterprises and the risk of serious environmental damage, particularly through vegetation loss and soil erosion, as has happened in the Sahel during the 70s, has long term implications for the sustainability of agriculture (Byun, and Kim, 2010). According to World Meteorological Organization (WMO) and Global Water Partnership (GWP) (2016). Droughts are one of the more costly natural hazards affecting many economic sectors and adversely affecting agriculture and food security. Thus, its effect appears apparently in Yola South LGA respectively.

CONCLUSION

It is obvious from the findings of this study that rainfall seasonality in Yola South LGA was insufficient to support adequately the agricultural production and rejuvenation of the ecosystem due to decline in the quantity and temporal variability in the periods of study. The insufficiency of rainfall had led to establishment of drought scenario in the area affecting the agricultural production, loss of vegetation, pasture, (grazing land) desertification and destabilizing the entire ecosystem. However, the rainfall amount was considered as seasonal in some years which had led to flood scenarios affecting farmlands, farm communities and socio-economic activities in the area. Therefore, the information on the seasonal variability index will be highly essential and useful to the farmers, farm mangers, decision makers and extension agents in soil and water management strategies and conservation techniques, irrigation techniques, crop management, risk management and flood control for sustainable food production and healthy environment that will support human development and productivity.

RECOMMENDATIONS

Based on the findings obtained from this study, it is therefore recommended that;

- Due to long drier condition experienced in the area farmers should adopt the use of early matured crop varieties with high resistant to drought severity for optimum food production.
- Farming activities, buildings and other socio-economic activities should not be carried out in flood prone areas in the study area with the aim of minimizing risk and damage which might be caused by the flood due to decrease in rainfall seasonality index values.
- Complementary efforts through synergistic approaches of multidisciplinary techniques and skills should be geared on the causes and effects of drought and flood control strategies due to climatic change on agriculture and the environment over a period of time with the aim of sustaining the ecosystem and food availability.

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