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ASSESSING THE EFFECTS OF RAINFALL VARIABILITY IN PARTS OF BENUE STATE, NIGERIA

[1]IORNONGO TERSEER, [2]T.I YAHAYA, [3]OJOYE SAMSEDEEN, [4]ELI KOLO TSADO

1, 2&3Department of Geography, Federal University of Technology Minna

[4]Department of Agriculture, Federal University of Technology Minna

ABSTRACT

The aim of this study was to investigate the effect of rainfall variability in parts of Benue State. CMAP rainfall data were collected using orbiting satellite for the period of 30 years from 1988 to 2017 over Benue State. Data collected were subjected to various statistical analysis which include Coefficient of Variation which was used to determine the rainfall variability and Precipitation Variability Index (PVI) which was used to show the tendency of drought. The result shows that the mean rainfall distribution is normal since the mean annual precipitation is greater than 1000mm. The precipitation Variability Index in all the selected LGAs within the three zones indicates that the tendency of drought is much higher in the Northern zone of the State followed by the West and the South. Vandeikya LGA in the Western zone have Precipitation Variability Index of 19.50% in August which is an indication of least variability of moisture with high rainfall intensity, it is concluded that, in all the zones in Benue State agricultural activities should be carried out during the month of May, hence the Precipitation Variability Index values in April exceeds 30% which is an indication of higher rainfall variability.

Introduction:

Rainfall variability has become a topical issue in recent times largely because of its impacts on natural and human systems. Labiru (2016) noted that most frequently cited activities that are likely to be affected by rainfall variability include agriculture, forestry, hydrology and fisheries. Agriculture which is the mainstay of local socio-economic and National Gross Domestic Product (GDP) in some African countries is the most vulnerable to rainfall variability. This is because in spite of recent technological advances, weather and climate are still the most important determinants in agricultural production. The long term crisis between farmers and herdsmen

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Bayero University, Kano, PMB 3011, Kano State, Nigeria. +234 (0) 802 881 6063.

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Mostly in the north central part of Nigeria is primarily attributed to climate change and rainfall variability. This is because northern parts of Nigeria are getting drier and herdsmen have to move down South in search for greener pasture. Farmers on the other hand need to expand on their farm size in order to maximize higher yield as a result of the danger posed by climate change.

Rainfall is the leading climatic factor that influences crop growth and productivity. Rainfall variability is increasingly becoming a source of concern, particularly in the rain fed agricultural regions of the world; this is due to its variability, pattern, distribution and seasonality. In a typical rain fed agricultural region, scarcity of water and uncertainties in both the amount received and spread, remains a major threat to agricultural development which is usually associated with significantly poor yield and high variability in crop production on yearly basis (Agidi, 2014). Therefore a change or unpredictable pattern of rainfall onset, cessation and length of growing season in a location can have a negative effect on the farmers in the area who depend on rainfall for their farming activities (Agidi, 2017). In Benue, rainfall variability is known to affect the rain-fed agriculture in which many of the population depend on. In this region crop lose their viability and the farmers lose their source of income as well (Obasakin, 2011). Despite the great potential of Nigeria in crop production, the frequent occurrence of drought occasioned by erratic rainfall distribution and/or cessation of rain during the growing season is the greatest hindrance to increase production and this is more serious in the northern part of the country where most of the tubers are produced particularly in Benue State.

The Study Area

Benue State lies within the lower river Benue trough in the middle belt region of Nigeria. Its geographic coordinates are Latitude 6° 25' to 8° 8' North and longitude 7° 47' to 10° 0' East. The State shares boundaries with five other states namely: Nasarawa State to the north, Taraba State to the east, Cross-River State to the south, Enugu State to the south-west and Kogi State. The state has a total land area of 30,800 sq. km (National Bureau of Statistics, 2012). The total population is estimated to be 4,253,641 (National Bureau of Statistics, 2012). The

State generally has about 5-7 months of rainfall. Temperatures are constantly high throughout the year, with average temperatures ranging from 23°C-32°C. This work focus areas will comprise of twelve out of the twenty three Local Government Areas in the State four Local Government Areas from each zones where agricultural activities is at maximum. The zones include Northern zone (Ushongo, Vandeikya, Ukum and Kwande), Eastern zone (Gboko, Gwer- West, Makurdi and Tarka) and Southern zone (Gwer- East, Ado Ohimini and Otukpo)

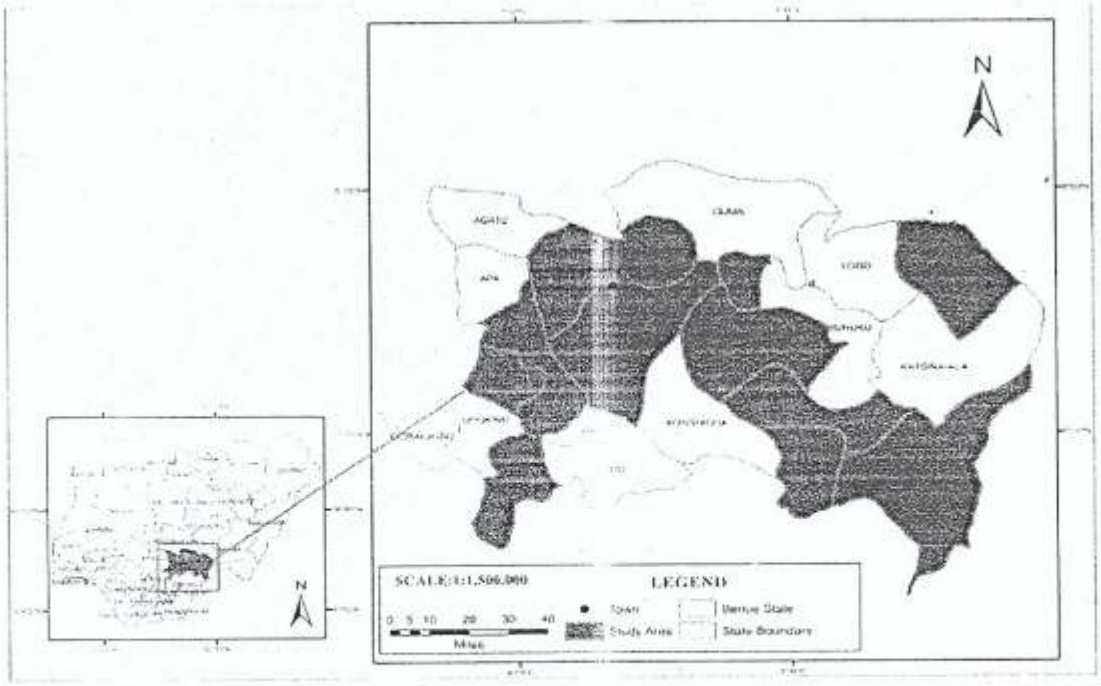

Fig1.1 The study Areas
Source: Geography Department, Federal University of Technology, Minna, 2019.

Literature review

Rainfall trend in Nigeria

Nigeria's population and economy are linked to climate sensitive activities including rain-fed agriculture. An understanding of current and historical rainfall trends and variation is inevitable to her future development especially in agriculture and hydrological sectors. Previous studies have analyzed rainfall trends over entire or part of Nigeria. For example, Adefolalu (1986) examines trends in rainfall pattern using 70-year period (1911–1980) rainfall data from 28 meteorological stations. Bello (1998) extended the work and compared the

seasonality of rainfall distribution in Nigeria for two climate periods, 1930–1961 and 1962–1993.

Ati *et al.* (2009) reported significant increase in rainfall over nine stations in northern Nigeria between 1953 and 2002. The results showed a general decline of dry season's contribution to annual rainfall i.e. dry period is getting drier. More recently, Oguntunde *et al.* (2011) analyzed rainfall trends over Nigeria using 1901–2002 rainfall data from Global Gridded Climatology of Climate Research Unit Time series (CRU TS.2.1). They concluded that annual rainfall has been reduced significantly over 20 % of the landscape and the amount of annual rainfall reduced by 50–350 mm in 64 % portion of Nigeria. It is important to state that rainfall of Nigeria and West Africa in general is influenced by the dynamics of continental air mass and maritime air mass which meet along a slanting surface called Inter-Tropical Discontinuity (ITD) (Odekunle, 2004). Varying degrees of convective activity and precipitation takes place at the south of ITD while little or no cloud development or precipitation occur in the northern part of ITD. Ezikiel *et al.* (2012) in his study of general impact of Climate Change in Nigeria noted that, within the 105 years studied, rainfall amount in Nigeria dropped by 81mm. The declining rainfall became worst from the early 1970s, and the pattern has continued till date. Although, he noted that there is a general decrease in rainfall in Nigeria, the coastal areas of Nigeria like Warri, Brass and Calabar are observed to be experiencing slightly increasing rainfall in recent times. He further revealed that the number of rain days dropped by 53 % in the north-eastern Nigeria and 14 % in the Niger-Delta coastal areas.

Rainfall variability and its impact on crop yield

Rainfall variability is arguably one of the most important challenges facing African countries, largely due to their geographic exposure, low income, greater reliance on climate-sensitive sectors such as agriculture, and weak capacity to adapt to the changing climate (Belloumi, 2014). However, there are limited studies that have documented adverse socio-economic impacts of extreme weather events specifically in Kenya. The effects have been felt on almost all sectors such as health, agriculture, livestock, environment, hydropower generation and tourism (SEI, 2009). Kenya is adversely affected by climatic variability and change because of her dependency on rain-fed agriculture, with variability in rainfall and temperature directly affecting crop and livestock yields.

Climate change was defined by Odjugo (2013) as change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Ngaira (2007) defined Climate change as the changes in long term trends in the average weather, such as changes in average rainfalls and temperatures. WMO (2010) refers to climate change as a change in average weather conditions, or in the time variation of weather within the context of longer-term average conditions. In the United Nations Framework Convention on Climate Change UNFCCC) refers to a change in climate that is attributable directly or indirectly to human activity that alters the atmospheric composition which in addition to natural climatic variability is observed over a comparable time periods (IPCC, 2012). Climate variability refers to shorter term (daily, seasonal, annual, inter-annual, several years) variations in climate, including the fluctuations associated with El Niño (dry) or La Niña (wet) events (Maduka, 2012). Orindi (2013), climate variability is the shift from the normal experienced rainfall pattern of seasons to abnormal rainfall pattern. The climate therefore thought of as a long term summing up of weather conditions, taking account of the average conditions as well as the variability of these conditions, thus, the fluctuations that occur from year to year, and the statistics of extreme conditions such as rigorous storms or unusually hot seasons, are referred to climatic variability (UNDP, 2007).

Based on IFPRI (2007) stated on how rainfall variability and pattern may affect food systems in several ways ranging from direct effect on crop production (for example change in cropping practices), to exchange in markets, food prices and supply chain infrastructure. Rainfall variability has significantly affected global agriculture in the 21st century and the Intergovernmental Panel on Climate Change (IPCC) assessment report indicates that most countries will experience an increase in average temperature, more frequent heat waves, more stressed water resources, desertification, and periods of heavy precipitation (IPCC, 2014). The past three decades have been the warmest in history, with each decade being warmer than the preceding period according to (Osman, 2008). Further, the reports indicate that the African continent is warmer than it was 100 years ago, future impacts are projected to worsen as the temperature continues to rise and precipitation becomes more unreliable. Ajetomobi, (2010) argued that social vulnerability to climate change is a key dimension in the constitution of vulnerability, and that it shifts emphasis onto the underlying, rather than the proximate causes of vulnerability. In Kenya, smallholder farmers have been

found to respond to drought through diversification into off-farm employment activities (Downing 1997). Kabubo-Mariara and Karanja (2012) also showed that adaptation measures in terms of micro-level farm adaptations, market responses, technological developments and institutional changes have a large potential in reducing negative impacts of global warming and climate change Bilham (2014) noted that rainfall had more impact on crop yields than temperature. Jones and Thornton (2013) showed that maize production in Africa and Latin America would reduce by 10 % by 2055 and recommended that climate change effects should be assessed at household level so that the poor who depend on agriculture can be targeted for advice.

Methodology

The daily rainfall records was obtained from CMAP data for a period of 1988 to 2017 across the twelve LGAs under study which were extracted and computed to get the daily, mean monthly, seasonal and annual rainfall records from which other relevant precipitation indices were derived.

Coefficient of Variation (CV) is a measure of relative variability which comprises of mean and standard deviation were used to determine the variability. This can be expressed as:

$$CV = \left[\frac{SD}{\overline{RF}}\right] \times 100\%$$

Standard deviation (sd) is defined by

$$SD = \frac{(RF - \overline{RF})}{N}$$

where RF = the annual rainfall for a given period

$\overline{RF}$ = the average annual

N= number of variable

Precipitation Variability index (PVI)

This model (Precipitation Variability index) is a modification of precipitation periodicity index (PPI) developed by Hassan (2012) and later modified by (Hassan and Usman, 2015). It can beexpressed as:

$$PVI = \left(\frac{A}{Y} - \frac{B}{Y}\right) 100\% = \frac{Hd}{M} - \frac{Ld}{My}$$

Where PVI is Precipitation Variation Index

Hd= highest daily rainfall in a month

Ld= lowest daily rainfall in a month
M= monthly rainfall total
My= Monthly total* annual total
Y= Total annual rainfall

PVI is an improve version of Precipitation Periodicity Index (PPI) developed by Hassan (2012). This model can explain the tendency of drought in a given rainy season. It has three threshold levels that explain the regions variability in the dryness and vulnerability to drought. That is

Table 1.1 Precipitation Periodicity Index (PPI)

S/No	Precipitation periodicity Index	Implication
1	≤ 20%	Least variability
2	≥20% but ≤30%	Moderate variability
3	≥30%	High variability

Source: Adapted from Hassan (2012)

1. Is a normal distribution rainfall with adequate moisture for cropping period
2. Is a moderately rainfall distribution with enough moisture but may require some measure of moisture supplement during the cropping season
3. Is prone to dry spells during the cropping season which certainly require some form of irrigation to complement the rain waters.

Results and Discussion

Distribution of Selected LGAs in Benue State

To understand the rainfall data in this study, it is very important to know how these Local Government Areas are been categorized into their zones in Benue State as shown in table 1.2

Table 1.2 Distribution of selected LGAs and their respective zones

S/N	Local Government Areas	Zones
1	Makurdi	Northern
2	Gwer-West	Northern
3	Tarka	Northern
4	Gboko	Northern
5	Otukpo	Southern

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6	Ado	Southern
7	Ohimini	Southern
8	Gwer-East	Southern
9	Kwande,	Western
10	Vandeikya,	Western
11	Ukum	Western
12	Ushongo	Western

Source: (Author, 2019)

Table 1.2 shows the distribution of the selected LGAs and their respective zones in Benue State. The Northern zone comprises of Makurdi, Gwer-West, Tarka and Gboko, the Southern zone comprises of Otukpo, Ado, Ohimini and Gwer-East and Western zone comprises of Kwande, Vandeikya, Ukum and Ushongo. This constituted a total of 12 selected LGAs in Benue State to be considered.

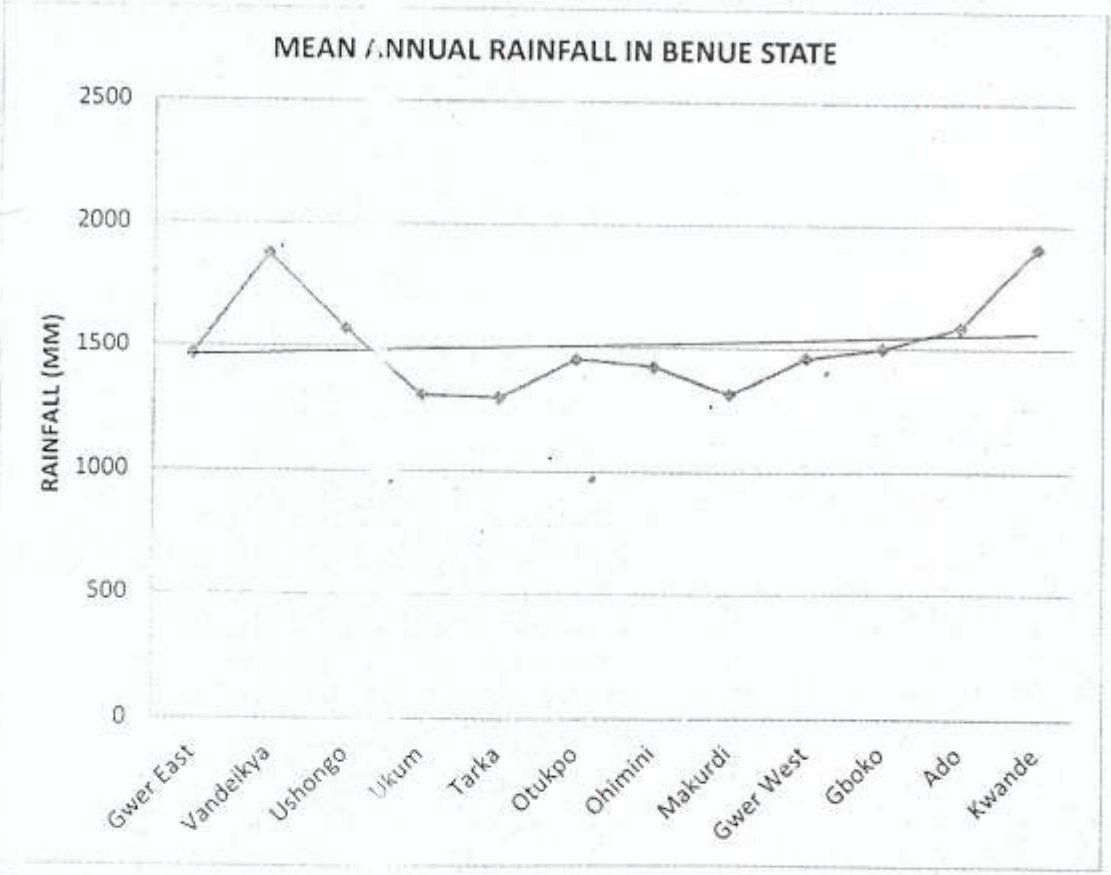

Fig. 1.2 Mean annual Rainfall in Benue State

The distribution of rainfall in Benue State indicates that all the selected LGAs have a mean annual rainfall of above 1200mm. Kwande LGA in the Western zone has the highest mean annual rainfall of 1906.8mm. The LGA which has the lowest mean annual rainfall is recorded in Tarka with total of 1292.8mm. The trend line indicates a normal mean annual rainfall in Benue State since all the LGAs have above 1200mm annually, which agrees with Adejuwon (2006) and Odekunle (2004) that the total rainfall distribution in Nigeria is generally normal if the mean is greater than 750mm. Therefore, the trend line shows a normal distribution of mean annual rainfall in Benue State.

Precipitation Variability Index (PVI)

Precipitation variability index for each Local Government in Benue State for the three zones was calculated and the results presented in fig1.3. For clearer understanding and ease of interpretation, PVI distributions are presented in months for each Local Government Area. This will give an idea of the months with high or low tendency of moisture stress or drought. The PVI is presented in percentage of drought tendency in those areas. It gives more insight of moisture requirements for agriculture. This allow us understand tiny details that could otherwise be lump up in sum and means of precipitation. It is a known fact that the average annual or seasonal rainfall at a place does not give sufficient information regarding its capacity to support crop production. Daily, monthly and Seasonal rainfall pattern does.

Table 1.3 shows the summary of PVI in (%) in the three zones of Benue State

		April	May	June	July	August	September	October
Northern zone	Makurdi	37.23	26.76	26.40	22.48	23.19	23.55	24.98
	Gwer West	36.32	26.46	25.40	22.47	21.53	22.94	36.34
	Tarka	39.24	32.34	27.64	23.60	23.62	26.02	26.41
	Gboko	35.23	26.92	26.51	22.85	21.86	35.45	23.71
Southern zone	Otukpo	36.85	27.44	25.25	22.87	21.70	23.01	22.69
	Ado	35.35	26.23	25.77	25.39	34.00	22.81	24.00
	Ohimini	36.09	25.68	25.55	22.86	21.07	22.65	23.54
	Gwer east	36.28	26.4276	24.70	22.86	20.30	22.18	37.34

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	Kwande	31.99	27.92	21.01	20.04	21.41	21.37	25.09
Western zone	Vandeikya	31.68	25.92	25.42	22.43	19.50	23.07	23.73
	Ukum	24.55	38.25	26.09	22.21	22.99	22.59	24.55
	Ushongo	32.12	25.82	26.23	23.04	22.16	23.98	42.46

Source: (Author, 2019)

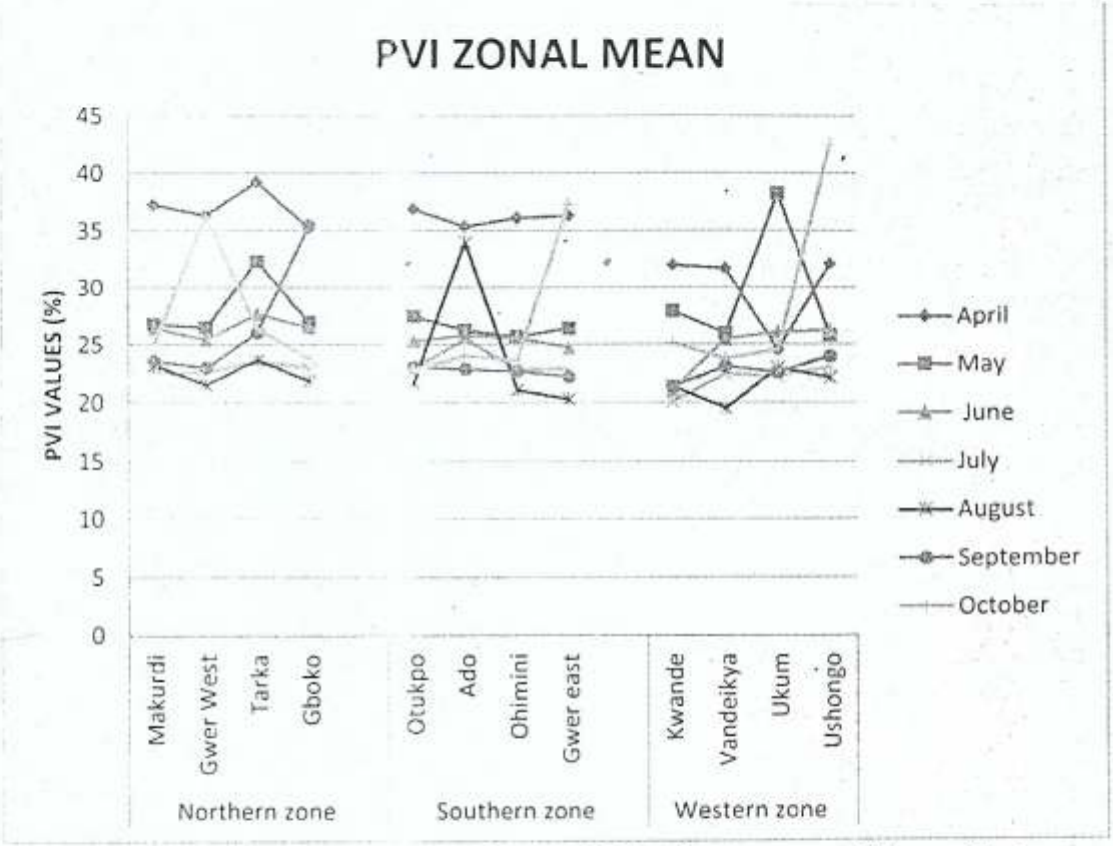

Fig 1.3 PVI Mean for Western, Northern and Southern zones of Benue State

Fig 1.3 is the summary of PVI in the Northern, Western and Southern zone of Benue State.

The Northern zone is categorized into four selected LGA which includes, Makurdi, Gwer- West, Tarka and Gboko. The mean precipitation index in this zone indicate that apart from April in all the LGA, May, September and October in Tarka, Gboko and Gwer- West, all the remaining months shows modérate variability of moisture. Gwer-West LGA has 4 months with moderate variability from May – September which is good for farming activities and perhaps encourages high crop yield. This indicates that rain fed agricultural activities in Gwer- West LGA may

not suffer water availability. While Makurdi, Tarka and Gboko has four months which most of the months have PVI of greater than 25% which implies that, the rain fed agricultural activities will be subjected to drought except an alternative means of moisture to support rainfall will be put in place to have maximum yield. Farmers in this zone need to delay planting around April – May to avoid water stress that may affect plant growth which will lead to low yield.

The southern zone on the other hand, has the following LGA which include, Otukpo, Ado, Ohimini and Gwer- East. The mean PVI shows that only Otukpo from May- October have moderate variability of moisture, that is PVI is greater than 20 % but less than 30 %. Month of April for all the LGA have PVI of high moisture variability. Otukpo and Ohimini has 6 months (May- October) with moderate variability, while Ado and Gwer –East has 5 months of moderate variability in May, June July, September, October and May- September respectively. This shows that for adequate farming activities to succeed, other alternative source is needed in this zone hence most of the month have high moisture index which will be subjected to drought and may affect the growing season.

The Western zone has the following LGA which includes, Kwande, Vandeikya, Ukum and Ushongo. The month of April is considered as the dry month within the zone except in Ukum Local Government with a PVI of 24.55% which is an indication of moderate variability of moisture. Kwande, Vandeikya and Ukum has 6 months of moderate variability Exception of Ushongo with only 5 months. The highest PVI recorded in this zone is in Ushongo in October with 42.46%. This implies that there is high variability of moisture in Ushongo and there should be an alternative source of moisture other than rainfall, this will enhance in rain fed farming activities in Ushongo. In this zone, planting should not be done during the month of April especially in Kwande, Vandeikya and Ushongo to avoid poor growth.

Conclusion

The study focus on rainfall variability in Parts of Benue State, considering the perception of rainfall variability CMAP data were used from 1988 to 2017. Moisture variability distribution is high in the Northern zone and least in the Western and Southern zone of the State. It is concluded that, agricultural activities should be carried out in the month of May in all the three zones, hence the onset of rain normally take place in late April and early May.

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Recommendations

Having looked into the effects of rainfall variability in Benue State. I would like to make the following recommendations

i. Government should intensify effort toward irrigation farming in order to curtail the uncertainty attached to rain fed agriculture.
ii. Looking at the threat of drought especially in the southern zone attention should be given to alternative sources of water for farming and best water management idea should be utilized.
iii. With the findings of precipitation Variability Index, crop zone classification can be done for the State.

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