Effects of Precipitation Indices on the Yield of Rice and Maize in Dadin Kowa, Yamaltu Deba LGA, Gombe State

[1]Audu, H.O., [2]Okafor, G.C., [3]Daniel, B.E., [4]Dahuwa, A.A., [1]Bose, M.M. & [5]Garba, B.

[1]Department of Geography Federal University of Kashere, Gombe Nigeria
[2]Department of Meteorology and Climate Change Nigerian Maritime University Okerenkoro Delta State.
[3]Geography Unit, Department of Social Sciences, Gombe State College of Education Billiri.
[4]Department of Geography Sch. of Sec. Edu. Aminu Saleh College of Education Azare, Bauchi State
[5]Department of Agricultural Extension and Management Collage of Horticulture Dadin-Kowa Gombe State.
Email: mongareenho3@gmail.com

Abstract

This study examines the effects of precipitation indices on the yield of rice and maize in Dadin-Kowa, Yamaltu Deba Local Government Area of Gombe State, Nigeria. The study involved three (3) specific objectives; to determine the onset, cessation of rain and the length of hydrological growing season in the study area; to assess the trend in yield of rice and maize in the study area; and finally; to analyze precipitation indices and their effects on the yield of rice and maize in the study area. Seventy (70) respondents were interviewed. Rainfall data from 2000 to 2020 (21 years) was obtained from Upper Benue River Basin Development Authority, Dadin - Kowa meteorological station. The analysis using Cumulative Rainfall Model clearly demonstrated early onset of rainy season, early cessation of rainy season and extension of the length of hydrological growing season. The findings further revealed 17th April as the earliest onset date, the late cessation date is 31st October and hydrological growing season is having a mean of 146 days. Farmers make sequential decision such as planting early in response to early onset of rainy season while changing crop variety in respond to late cessation and extended length of hydrological growing season. In the case of rice production, early onset of rainy season significantly increases productivity and growth in rice production. The findings of the study revealed that the decrease in yield of maize is because of rainfall variability. The study recommends strategies for improving effective farm practices such as provision of extension services to train farmers as it relates to methods and best farm practices to boost crop yield. Services of the Dadin – Kowa dam should be prioritized and optimized, Upper Benue River basin development agency should serve more farmers with irrigation and support to cushion the effects of rainfall variability in the study area. Similarly, the study also recommends that government should consider the provision of efficient water management techniques to put in place to ensure development of farm practices.

Keywords: Yamaltu Deba, Onset, Cessation, Length of growing season, Cumulative Rainfall Model.

Introduction

Rainfall is considered as the leading climatic factor that has effects on crop productivity. Variability of rainfall is progressively becoming a thing of concern, most especially in the agricultural rain-fed places of the world because of its distributions, pattern, and seasonality (Agidi, 2014). Therefore, the unpredictable pattern of the onset and cessation of rain and length of growing season in a location can negatively affect the farmers in an area that depends on rainfall for their farming activities (Agidi, 2017). In Nigeria, rainfall variability affects the rain-fed agriculture in which many of the population depend on in this region. Crops loss their viability, and the farmers lost their income source. The reason for crop yield decline may be due to inter-annual variation in climatic parameters (Osman, 2015).

Annual variation of rainfall, particularly in northern Nigeria, is large, often resulting in climate hazards, especially floods and droughts with devastating effects on food production and associated calamities and sufferings (Osman, 2015). Despite the great potentials 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 increasing production and this is more serious in the northern part of the country where most of the cereal crops are produced (Idris *et al,* 2012).

In Nigeria, rain falls in different months of the year at different places, as the rain belt appears to follow the relative northward and southward movements of the sun (Odekunle, 2006). In this situation of a marked seasonal rainfall regime, variability of the onset and cessation of rain is highly significant, and its estimation and prediction are necessary (Ati, Stiter & Oladipo, 2002). A delay of 1 or 2 weeks in the onset is sufficient to destroy the hopes of a normal harvest while a "false start" of planting, encouraged by a false start of rainfall may be followed by prolonged dry spells whose duration of two weeks or more may be critical to plant germination and growth (Mugalayai, Kipkorir, Raes & Rao, 2008).

Inter-Governmental Panel on Climate Change (IPCC)(2012), studied the inter-annual pattern in climate and particularly the magnitude of rainfall variability impacts on human activities, including crop production. For example, Adamgbe and Ujoh (2012), observed that over the period 1997 to 1999, the north arid zone of Nigeria experienced a decline in annual rainfall which led to a decline in crops - based farming systems. The zonal pattern of rainfall variability, especially in the North Central area of Nigeria is noted in the differences in the types of crops cultivated and the yield rate (Idris *et al*, 2012). Despite sufficient rain, its irregularity can affect yields adversely if rains fail to arrive during the actual growing stage of crops (Hassan, 2013). According to Odewumi (2013), rainfall is the climatic factor which influence the pattern and productivity of rain-fed agriculture in Nigeria, the availability of water to crops is by far the most important. He further points out that the pattern of rainfall distribution explains why drought resistant crops such as millet and sorghum are grown largely in the Northern part while more moisture-demanding crops such as rice, maize, and cassava are grown in the North Central areas of Nigeria extensively. To date, much of the effort to analyze rainfall patterns in Nigeria as relate to agriculture, is generally focused on the exploitation of the seasonal rainfall (Yamusa *et al,* 2013). He further state that the seasonal distribution of rainfall and its subsequent effects on crop productivity has received less attention, although its effects may be as important as the total seasonal rainfall. To better understand the issue of rainfall availability in tropical rain-fed agriculture, much more attention needs to be given to the quantification of seasonal rainfall patterns (Yamusa *et al*, 2013). This will allow a prior assessment of the expected severity and duration of dry spells during the season and provide a sound basis for developing improved water management techniques in tropical agriculture. Most farmers in developing countries solely depend on traditional farming methods, which place them at a disadvantage with many alterations in nature (Yamusa *et al*, 2013) The Intergovernmental Panel on Climate Change (IPCC, 2012) observed that, the increasing temperature, erratic rains, drought, floods, desertification, and other weather extremes have a severe effect on agriculture, especially in the developing world. This explains why most developing countries cannot predict and swiftly act in terms of extreme weather hazards. It is against this background that this study seeks to examine the effects of precipitation indices on the yield of rice and maize in Dadin-Kowa, Yamaltu Deba LGA, Gombe State.

Description of Study Area

Dadin-Kowa is in Yamaltu Local Government Area of Gombe State in the Northeast of Nigeria. Dadin-Kowa town is located between latitudes 10°19′19″N and 10.32194°N, longitude 11°28′54″E and 11.48167°E. It shares common boundary with Akko L.G.A. in the South and West, Yamaltu-Deba to the East and Kwami to the North. Dadin-Kowa has an altitude of about 370 meters above sea level. It is a residential and commercial area with such amenities as schools, motor park market etc (Alhassan *et al*, 2016).

Yamaltu-Deba is characterized by two distinct climates, the dry season (November–March) and the rainy season (April–October) with an average rainfall of 850mm^3 and the mean annual temperature is about 32°C (Ikusemoran *et al,* 2016). He further state that the dry season comes with the northeastern trade wind over the region originating from Sahara belt, the wind is dry and dust laden accompanied by low pressure system. The wet season comes with the south-westerly wind which is moisture laden and originates from high pressure zone over the Atlantic Ocean to the low-pressure zone over the Sahara (Bachama *et al*, 2020).

Relief of the Dadin-Kowa town ranges between 370m in the Eastern part to 650m in the Western parts. The area in the Eastern parts is dominated by flat terrain with hills of sandstones in the western part of the study area. (Ibeje *et al,* 2013)**.** Dadin-Kowa is drained by the Gongola River which is dammed at a point to regulate the flow of water down the channel to control flooding in the area and is later drained by River Benue at Numan in Adamawa State.

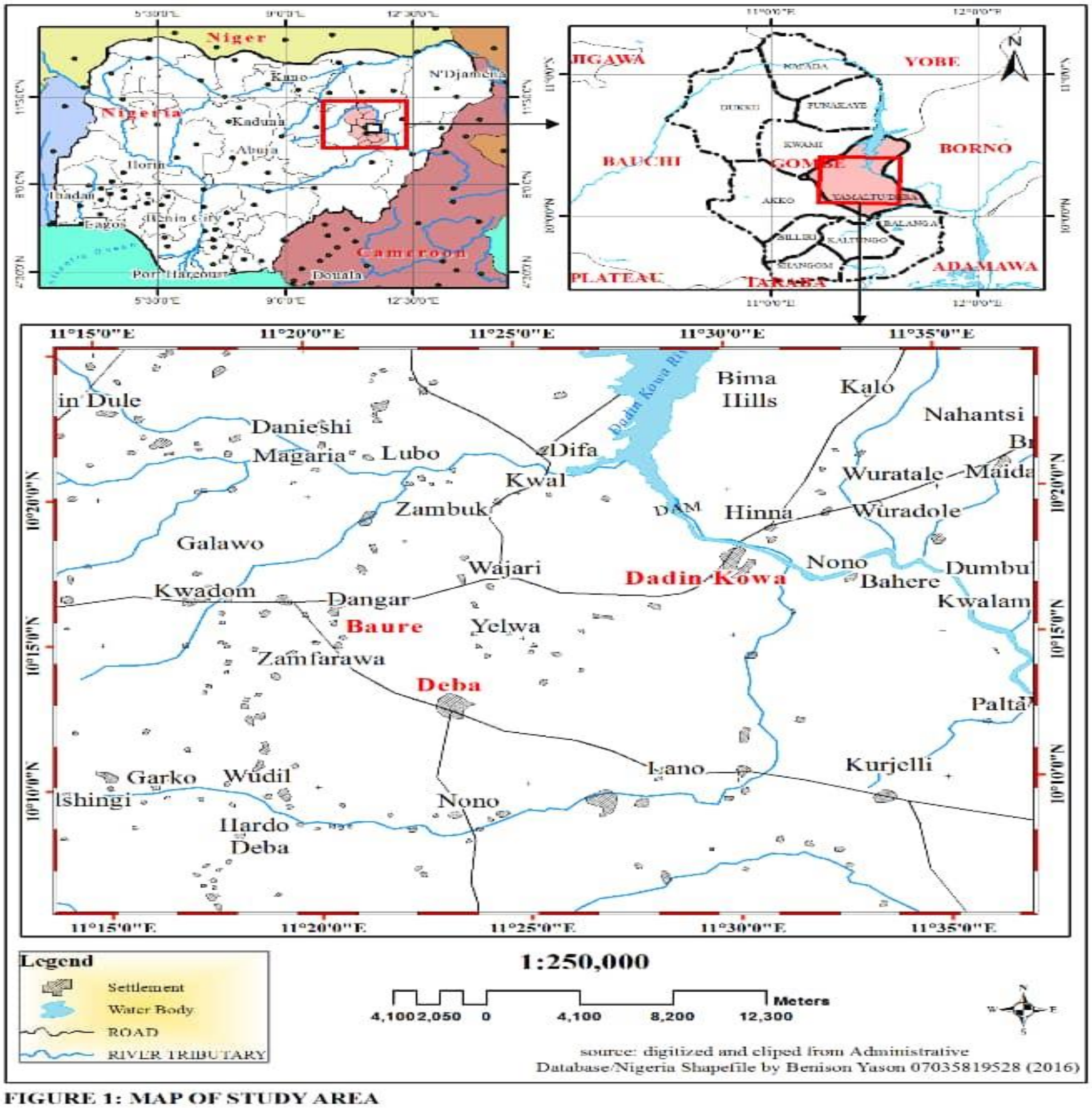


Fig.1 Map of Yamaltu-Deba Local Government Area Gombe State.
Source: FUK GIS Lab

Materials and Methods

Primary data include surveys, observations, questionnaire, personal interview. The primary data for this study was obtained by administering questionnaire on rice and maize farmers in the study area. Secondary data for this work includes Daily rainfall data for twenty years (2000 - 2020) which was collected from the Upper Benue River Basin Development Authority office in Dadin-Kowa, Gombe State, other information on the research was obtained from books, journals, thesis, and other public media relevant to the study. A multi-stage sampling technique was used to select respondents for the study. The first stage of selection entails purposive selection of 7 locations within the study area, in the second stage, the household was chosen by random sampling technique. To fulfill the objectives of the intended study, a structured questionnaire survey was conducted, and 70 respondents were sampled for the study. The settlements sampled within the study area included Wuratale, Wuradole, Hina, Nono, Bahere, Kwalam and Palta.

Computational and Analytical Techniques

The rainfall onset and cessation dates, as well as the length of the rainy season were determined by adopting the percentage mean cumulative rainfall method (Dalezios *et al*, 2017). The method has the advantage of directly using the rainfall data or rainy days, rather than inferring the rainfall amount from other related parameters, making it appropriate for this study (Dalezios *et al*, 2017).

Onset, Cessation and HGS Computation

Firstly, the monthly mean rainfall amount or rainy days from the entire data record (2000–2020) are calculated for the determination of onset, cessation, and length of the rainy season (LRS) or Hydrological Growing Season HGS) in the study area.

Onset Computation

Walter’s (1967) definition of onset date is expressed mathematically as;

Onset = $\frac{DM}{TM} \times (51 - A)$

Where:
DM = number of days in the month with cumulative rainfall ≥ to 51mm.
TM = total rainfall of the month in which 51mm or more is reach.
A = total rainfall of the previous month.
51mm = minimum soil moisture index.

From the above computational procedure, (fluctuations of onset frequencies of rainfall curves) for each of the years were plotted. This procedure was adopted for each year throughout the 20 years period to derive and deduct the length of rainy season (LRS) or the hydrological growing season (HGS).

Cessation computation

The reversed of Walter’s (1967) equation was used in determining the cessation, starting from December to January.

Cessation = $\frac{DM}{TM} \times (51 - A)$

Where:
DM = number of days in the month with the cumulative rainfall ≥ to 51mm.
TM = total rainfall of the month in which 51mm or more is reached
A = total rainfall of the previous month.
51mm = minimum soil moisture index

Hydrological growing season

Hydrological growing season is the number of days between the onset and the cessation dates.

Frequency distribution table is used to ascertain the frequency (f) and percentage (%) of the demographic characteristics of the respondents. This applies to Respondents awareness of changes in rainfall variation and perceived effect of rainfall variation on rice and maize yield.

$$P = \frac{f}{n} \times 100$$

Where:
P= percentage (%)
f = frequency
n = number of respondents

Descriptive statistics were used to analyze rainfall characteristics and yam production for the period under investigation. A linear regression model was used to determine the trends of onset, cessation of rains and length of growing season. Also, tables bar graph was used to present the data.

Demographic Characteristics of Respondents

Table 1 shows the demographic characteristics of the respondents in the study area where 81% were males and 19% females. The low percentage of the females engaged in rice and maize cultivation in the study area could be associated with the believe of the predominant population that men are to provide food for the family. Youths engage less in agriculture, due to less attractiveness of the sector. This agrees with the findings of Oluwatosin (2013) where he stated that in Nigeria, where the largest proportion of the population is involved in agriculture faces a great challenge as majority of replacement generations of youth do not intend to get involved in agriculture. looking at the issue of provision of fertilizer and chemicals essential to the practice, thereby reducing labor and productiveness of the sector Adults aged 36 – 45 (37%) engage more in farming, this might be because of family responsibility as most of those in this age group are married people. And those under 46 years and above also are less when it comes to farming as many engage hired labour. Similarly, marital status is very important factor in agriculture couple with the current situation where a bag of maize is sold above fifty-thousand-naira people in 2023 when this data was collected resolve to agriculture as the little salary can not be enough to feed the family. The singles with just (11.4%) shows that most singles prefer white collar jobs. Separated had only (7.2%) engaged in agriculture as most prefer to be in urban centres like the youths. The enlightened or educated ones can source information on farming from different sources, while those that are not might even bother as it could have little or no impact on their farming activities. This high level of awareness might relate to the level of education as indicated where majority had an educational background. However, educational level plays a greater role in rice and maize farming in the study area as those with primary and secondary educational level engage more in cultivation as they have (27 and 40%) respectively.

Table 1. Demographic Characteristics of respondents

Variable description	Frequency (f)	Percentage (%)
Gender		
Male	57	81.0
Female	19	19.0
Age (Years)		
15-25	11	16.0
26-35	20	29.0
36-45	26	37.0
>46	13	19.0
Marital Status		
Single	15	21.4
Married	42	60.0
Divorced	8	11.4
Separated	5	7.2
Educational Level		
Informal	11	16.0
Primary education	19	27.0
Secondary	28	40.0
Tertiary	12	17.0
Farm Size (in hectare)		
0 – 0.5	25	36.0
0.6 – 1	34	49.0
2 and above	11	15.0
Years of Experience		
0 – 5	8	11.4
6 – 10	30	43.0
10 – 15	22	31.4
15 and above	10	14.2

Source: Fieldwork, 2023

Data in Table 1 reveal the educational background of the respondents, which is an important factor as it supports making contemporary findings as it relates to new methods and practices for efficient and sustainable farming activities and how respondents get information as it relates to variation in rainfall as it affect the yield of rice and maize to better adjust to current conditions, years of experience provide knowledge of variations in rainfall, the determination of better date to start planting based on the soil moisture requirement of the crop and also putting into cognizant the onset date, if rain start early it might be a good period for planting of rice as it could take only 3months to reach maturity, giving room for another planting within the same season. Maize might not do well in the case of early onset, as should the HGS be longer than crop might get damaged resulting in low yield.

Looking at Table 2 majority of respondents are aware of the variation and its effects on crop yield, of which 52 respondents, making 74% of the total population agreed to being aware, while 18 respondents, making 26 of the respondents said they are not aware of the variation in rainfall and its impact on crop yield, this is a function of literacy level or the method practice (irrigation farming).

Table 2. Respondent awareness of changes, effects, and variability in rainfall.

Variable description	Frequency (f)	Percentage (%)
Awareness of Changes, Effects and Variability in Rainfall.		
Yes	52	74.0
No	18	26.0

Table 2 shows the respondent's perception as it relates to length of rainy season, where majority attest to being aware that it is on the increase, they comprise 43 (61.4%) of the respondents, 17 respondents (24.3%) of the respondents perceived the length of rainy season to be on the decrease, while, 10 respondents (14.3%) perceived length of rainy season to be static, this perception could be as a result of personal experiences and personal beliefs which varies within the respondents. However, there view on length of growing season is contrary to the result of trend analysis of figure 3 which shows a declining trend only 24.3% of the respondent seems to agree with the trend analysis result.

Table 3. Perception on the length of rainy season

Variable description	Frequency (f)	Percentage (%)
Length of Rainy Season		
Increasing	43	61.4
Decreasing	17	24.3
The Same	10	14.3

Source: Authors Field work 2023.

Table 3 shows the respondent's perception on the yield of rice and maize denotes whether it is favorable. This varies because of experiences and the knowledge they have gathered over the years while farming. In this regard, 54% perceived rice and maize yield to be favorable, while 46% perceived rice and maize yield to be unfavorable, this varies across smaller units of the study area. This high percentage of unfavorable conditions perceived by respondents might relate to rainfall variability of the tropical region. Also, as noted by Omotosho, Balogun, and Ogunjobi (2000) that the variations in the onset date could be up to 70 days (10 weeks) from one year to another at a single station.

Table 4. Respondent's perception on rice and maize

Variable description	Frequency (f)	Percentage (%)
Perception on Rice and maize Yield		
Favorable	38	54.0
Un-favorable	32	46.0

Source: Authors Field work 2023.

Nigerian agriculture depends profoundly on rainfall, which is the principal driver of crop yield and growth, (Webber, 2017). Produce from farm generally need a specific measure of precipitation during growth stages for best yield when this ends up extreme, it prompts poor harvest. Additionally, when this is added to high temperature the condition of the soil will exhibit conducive to the micro-organism, which disintegrates biomass into organic or natural matters. This situation will result in soil unproductiveness that may prompt extremely poor yield. This sets changing climate as an essential element in agricultural production for food security for both locals and universally (Webber, 2017).

Determination of Onset and its Implication

A closer look at Table 5, the onset of rainfall varies throughout the years with some year experiencing onset of rainfall earlier, others having onset normal average period and others having onset much later which all have impact on the yield of rice and maize. Early onset of rainfall experienced between 17th April to 10th May, where majority of the years between 2000 and 2020 are having early onset of rainfall, years such as 2000, 2001, 2005,2006, 2007, 2008, 2009, 2010, 2014, and 2015 about 50% of the study period falls under this category, this means that crop germination would not be hampered as enough soil moisture is ensured. Farmers perception as regards onset of rain in the study area indicates that farmers are aware of the effects of early onset of rainfall as planting commenced early in those years, this is the perception of farmers that have over 10years of experience.

The moderate onset of rainfall in the study area sways between 11th May to 17th May, this is the suitable range of rainfall onset, the soil moisture for plant germination and subsequent growth and development, putting cognizance to hydrological growing season, which is a function of cessation dates, years with moderate dates are 2004, 2012, 2016, 2018, and 2020, making up 14% of the study period. Famers perceived this period to be more suitable for planting, through experiences of these farmers, plants germination and development within this period is quiet optimum.

Late onset is detrimental to plant growth and development as plants germination and development will be very slow and could affect crop yield if cessation of rainfall occurred early. The late onset for study time duration sways between 18th to June 14th, years with such as 2002, 2003, 2011, 2013, 2017, and 2019 experience late onset of rainfall out of all these years only 2013 surpass with longer growing period, the implication is that less crop yield might be experienced during these periods.

Table 5. Computed Onset and Cessation dates, and Hydrological growing season (HGS) from 2000 – 2020.

Year	Onset Date	Cessation Date	Hgs In Days
2000	5th May	5th October	154
2001	5th May	5th October	154
2002	14th June	5th October	113
2003	4th June	1st October	120
2004	12th May	13th October	154
2005	9th May	20 October	167
2006	6th May	30th September	148
2007	28th April	3rd October	159
2008	17th April	13th October	179
2009	28th April	10th October	166
2010	3rd May	15th October	166
2011	21st May	1st October	134
2012	17th May	18th October	155
2013	3rd June	31st October	143
2014	28th April	7th September	133
2015	6th April	21st October	199
2016	14th May	6th September	116
2017	1st June	14th September	105
2018	14th May	4th September	114
2019	4th June	14th October	133
2020	20th May	27th October	161

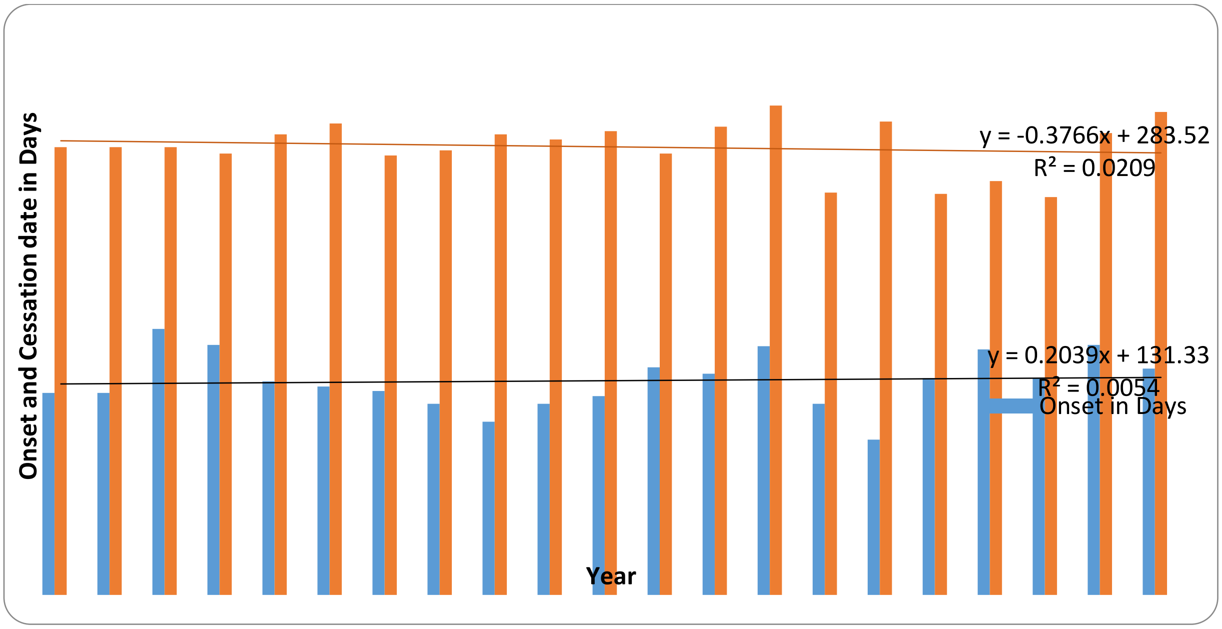
Source: Authors Field work 2023

Determination of Cessation and Implication

Cessation of rainfall implies the time where soil moisture index is 51mm in the upper limit denoting the end of the rainy season which are of varying degrees such as, early cessation, moderate cessation, and late cessation. Early cessation can hamper the growth of crops especially when the onset of rainfall is late resulting in short hydrological growing season, this period sways between 5th September to 5th October. Years with early cessation dates includes, 2000, 2001, 2002, 2003, 2006, 2007, 2011, 2014, 2016, 2017 and 2018, this could be as result shorter hydrological season and less crop yield.

Moderate cessation of rainfall is the period which is more supportive in plant growth and development, as it supports full growth of crops also resulting in more crop yield or bumper harvest if combine with early or moderate onset of rainfall, this time period ranges between 6th October to June 18th, through examining of Table 5, the years includes 2004, 2008, 2009, 2010, 2012, and 2019, this is a moderate of soil moisture essential for plant growth and development.

Late cessation of rainfall refers to an extension rainy season as it relates to when the rain ceases, this could impact crops negatively, especially maize as this could damage the yield of maize. Rice is better adapted to such moisture condition depending on the variety planted. A closer look at Table 1 the range of late cessation dates sways between 19th October to 31st October, and years that have such range includes, 2005, 2013, 2015 and 2020.

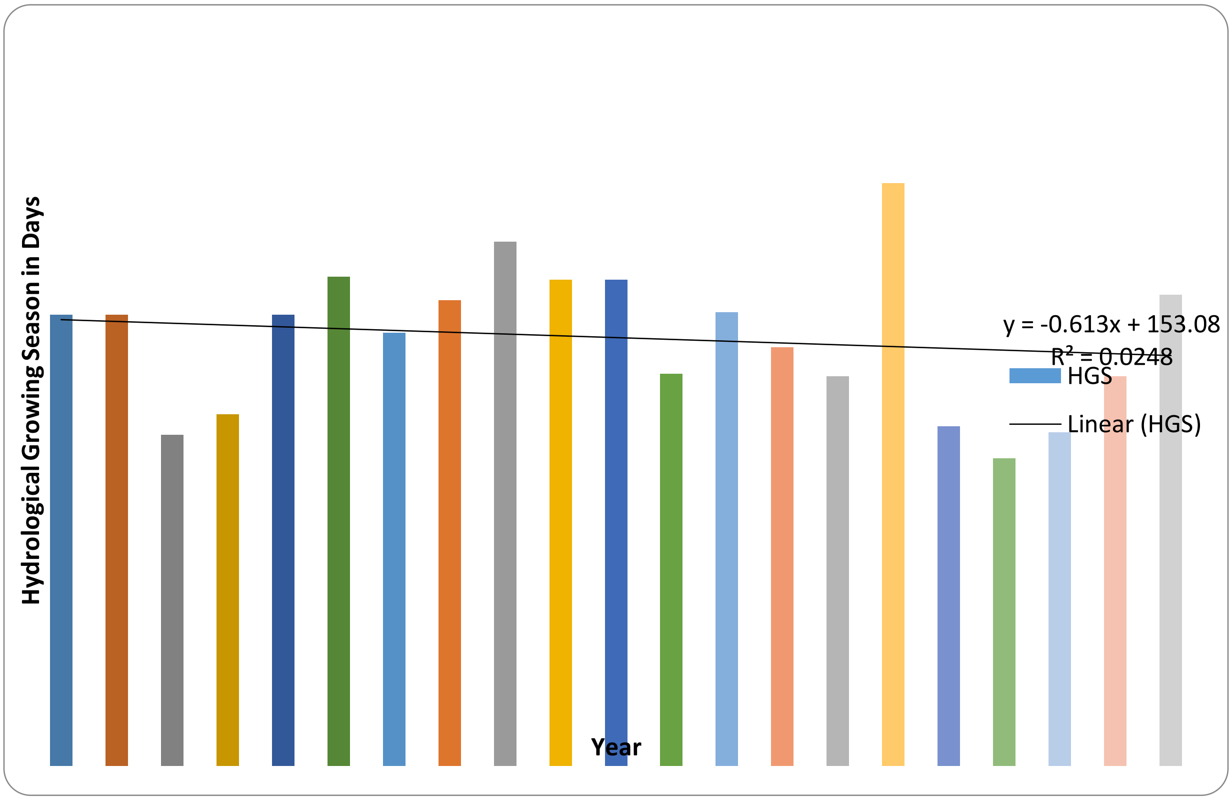


Source Authors computation

Figure 2 Onset and cessation days showing trend lines in the study area.

From the start of the rainy season to its end, figure 2 represents a fluctuating pattern of the season's onset and cessation. The early onset date was 6th April (in 2015) June 14th (in 2002). This suggests that farmers in Yamaltu-Deba may begin planting their crops late April to May of of every year. The best-fit equation (y= 0.203x + 131.3) reveals that the onset days are decreasing in Dadin Kowa. A similar trend was observed at Gboko by Shaibu, Fanen, and Yusuf (2022), that the best-fit equation (y= 0.1407x + 44617) reveals that the onset days are decreasing in Gboko, and the trend line points in a positive direction.

Figure 3 demonstrates how the pattern of the end date of the rainy season changes throughout the course of the study period. The rainy season officially ceased on 4th September in 2018 which is the earliest during the study period. Late cessation was observed in the year 2013 on 31st October during the study period. The trend line shows a pattern with the best-fit equation, which suggests that the cessation days are getting shorter longer in Dadin Kowa (y= -0.376x + 283.5). This is contrary to the findings in Gboko where a positive trend was observed by (Shaibu, Fanen, & Yusuf, 2022). This might be due to the latitudinal locations of both study areas from the equator.



Source: Authors computation

Figure 3. Showing the trend of Hydrological growing season in the study area

From Figure 3 above the trend of the hydrological growing season shows a negative trend indicating that the length of growing season is reducing. This might be true as indicated in figure 2 where onset is increasing, and cessation is decreasing thereby shortening the length of growing season in the study area. This trend might relate to climate change in the study area.

Determination of Hydrological Growing Season and its Implication

The hydrological growing season is the number of days between the onset and cessation dates. This could vary across the study period. A closer look at Table 1 would show those years with shorter, average, and longer HGS across the years.

Shorter hydrological season implies to those years that have HGS between 110 to 135, years such as, 2002, 2003, 2011, 2014, 2016, 2017, 2018, and 2019, about 35% of the study area experience shorter hydrological period. For rice some variety might do well while others might not do well, this period generally occurs between 3 to 4 months. For maize, it is not good for its growth and development, only certain variety can survive this condition. This confirms the findings by (Ifabiyi & Omoyosoye, 2011) where they discovered that annual rain days and annual amount had the greatest effect on maize yield in a similar study conducted in Kwara State, Nigeria. Thus, the higher the amount of rainfall spread over the number of rain days in a year, the higher the yield of maize per hectare in the area.

Average hydrological growing season refers to most suitable duration or length of rainy season this is usually between 5 – 6 months with around 135 – 165 days. Years with such hydrological season includes, 2000, 2001, 2004, 2006, 2007, 2012, 2013 and 2020. In this period, favorable condition for plant growth is ensured. Perception of farmers through analysis of the questionnaire suggest similar as farmers who have experience between 6 – 20 years gave similar opinion, abundant soil moisture could be the driving force,

Longer hydrological growing season refers to an extension of HGS above average, which detrimental to plant growth and development as this could result to slow growth and damaged crops. This ranges between 165 days to 199 days. Years with such variation includes, 2005, 2008, 2009, 2010 and 2015, with the highest, 199 days in 2015.

Findings from the study have revealed that farmers are aware of the changes as it relates to variation in growing season, revealing that growing season is becoming longer in recent years, with early onset and delayed cessation has extended the hydrological growing season giving rise to low maize yield more rice yield. Irrigation is a better option for farmers in the study area, as it regulates soil moisture itself, giving room for little or no impact in the case of late onset and early cessation and the subsequent shorter HGS throughout the course of their farming operation.

Conclusion

This study has examined the effects of precipitation indices on the yield of rice and maize in Dadin Kowa, Yamaltu Deba LGA, Gombe State, Nigeria. The finding of the study revealed tha rice and maize are important food staples in the country, hence, the need to put into cognizance variability in rainfall pattern, as it is one of the major factors influencing plants growth and development, through the understanding of the moisture requirement for rice and maize crops, to ensure high crop yield. Some farmers who are relatively closer to Dadin – Kowa dam which supplies water for irrigation, do not see the need to make important observations as they relate to understanding of onset and cessation of rainfall, which are apparently important in farm practices that will shape the future generation of farmers around the region as some of them perceived rainfall variability to be of little or no impact on their farm practices and they also perceived rainfall variability to be at steady level. The study findings revealed important aspect of rainfall characteristics which if treated as a matter of priority will aid farming operations.

Recommendations

Based on the findings of the study, the following recommendations are made;

i. Provision of extension officers or workers to train farmers as it relates to methods and best farm practices to boost crop yield. Services of the Dadin – Kowa dam should be prioritized and optimized.

ii. Upper Benue River basin development agency should serve more farmers with irrigation and support to cushion the effects of rainfall variability in the study area.

iii. Efficient water management techniques should be put in place ensure development of farm practices.

Reference

Adamgbe, E., & Ujoh, F. (2012). Variations in Climatic Parameters and Food Crop Yields: Implications on Food Security in Benue State, Nigeria. *Confluence Journal of Environemntal Studies*, 7, 59–67. Retrieved from https://works.bepress.com/cjes_kogistateuniversity/17/ %0Ahttp://www.journalhome.com/cjes

Agidi, V.A. (2014). Inter Annual Rainfall variability and crop yields in Nasarawa State. Unpublished master's Thesis, University of Abuja.

Agidi, V.A. (2017). Inter- Annual Rainfall Variability and crop yields in Nasarawa State. PhD Thesis, University of Abuja.

Alhassan, I., Saddiq, A.M., Gashua, A.G., Dantata, I.J. and Gwiokura, K.K. (2016). Evaluation of Irtion Water Requirements of some Crops in Dadin-kowa Dam Irrigational Scheme of Nigeria. *Gashua Journal of Irrigation and Desertification Studies*, Vol. 2.

Ati, O.F., Stigter, C.S. and Oladipo, E.O. (2002) A Comparison of Methods to Determine the Onset of the Growing Season in Northern Nigeria. *International Journal of Climatology*, 22, 731-742. https://doi.org/10.1002/joc.712

Bachama, B.N., Audu, H.O., Ibrahim, A.K., Matai, E.P., Adamu Muhammed Kamaludeen, & Tarki Sadiq Kubmuto. (2020). Farmers' perception on the effect of rainfall variability on rice yield in Dadin-Kowa of Gombe, Gombe State. *International Journal of Archaeology*. 8(2), 15-21.

Dalezios, Nicolas & Gobin, Anne & Tarquis, Ana M. & Eslamian, Saeid. (2017). Agricultural Drought Indices: Combining Crop, Climate, and Soil Factors. Handbook of Drought and Water Scarcity: Principles of Drought and Water Scarcity.

Hassan, S.M. (2013). Climate Variability and crop zones classification for the Federal Capital Territory. *Conference Journal of Environmental Science*, 2(3), 45-53.

Ibeje, A.O. and Okoro, B.C. (2013). Short Term Forecasting of Dadin-kowa Reservoir Inflow Using ArtificialNeuralNetwork.IJES.63-73. *Artificial Neural Network.* IJES. 63-73.

Idris, U.D., Muhammad, F.I., Yamusa, A.M., and Bashir, M. (2012). Rainfall Variability and Agricultural Drought at Samaru, Northern Nigeria. *Journal of Environment Health*. (SOSEH). 1(1), 56-61.

Ifabiyi, I.P and Omoyosoye, O. (2011). Rainfall Characteristics and Maize Yield in Kwara State," *Nigeria Journal of Applied Sciences*, (1), 3.

IPCC, (2012) The scientific basis, Summary for policy makers, impacts, adaptations, and vulnerability of climate change: Scientific-technical analyses. Contribution of Working Group II to the IPCC Second Assessment Report, Cambridge University Press, Cambridge, United Kingdom.

Ikusemoran, M., Bala, B.W. and Lazarus, A.M. (2016). Geospatial Techniques for Terrain Analysis of Gombe State Nigeria. *Journal of Geography Environment and Earth Science International* (6): 1-20.

Mugalavai, E.M., Kipkorir, E.C., Raes, D. and Rao, M.S. (2008) Analysis of Rainfall Onset, Cessation and Length of Growing Season for Western Kenya. *Agricultural and Forest Meteorology*, 148, 1123-1135. https://doi.org/10.1016/j.agrformet.2008.02.013.

Odekunle, T. (2006). Determining Wet Season Onset and Retreat over Nigeria from Precipitation amount and Number of Wet Days. *Applied Climatology*, 83, 193-201. https://doi.org/10.1007/s00704-005-0166-8

Odewumi, T.O. (2013). Rainfall and the length of the growing season in Nigeria. *International*

Journal of Climatology, 36(2), 354-370.

Oluwatosin, O.F. (2013). Farmers perception of the effect of Aging on their Agricultural Activities in Ondo State, Nigeria. Venets: *The Belogradchik Journal for Local History, Cultural Heritage and Folk Studies*, 4(3), 371-387.

Omotosho, J.B., Balogun, A.A. & Ogunjobi, K. (2000). Predicting monthly and seasonal rainfall, onset, and cessation of the rainy season, in West Africa, using only surface data. *International Journal of Climatology* 20: 865–880.

Osman, J. (2015). Implications of Climate Change, Global Warming and Environmental Degradation in Africa, *Proceeding of the International Conference of the Nigeria Meteorological Society*, 6-7.

Shaibu, J.I., Fanen, T., and Yusuf, B. (2022). Variability in some Selected Rainfall Characteristics and Yam Production in Makurdi and Gboko, Benue State, Nigeria. *FUDMA Journal of Agriculture and Agricultural Technology*, 8(1), 313-322.

Webber, H. (2017). Canopy temperature for simulation of heat stress in irrigated wheat in a semiarid environment: a multi-model comparison Field. *Journal of crop research.* 12(3) 21–35.

Yamusa, A.M., Abu, S.T., Yahaya, R.A., and Musa, I.J. (2013). Assessing the planting dates of sorghum in a changing climate at Samaru, Northern Nigeria. Bayero University Kano Nigeria. *International Journal of Biological Environmental Science.* 10(2), 21-26.