Analysis of Onset and Cessation of Rainfall and its Effects on Groundnut Planting and Yield in Kyado, Ukum LGA, Benue State, Nigeria

Oche, C. Y. [a], Dzenda, Tomuter [a]*

[a] Department of Geography and Planning, University of Jos, Jos, Nigeria

DOI : https://doi.org/10.55248/gengpi.5.1224.3435

A B S T R A C T

The study analyzed onset and cessation of rainfall and its effects on groundnut planting and yield in Kyado, Ukum LGA of Benue State, Nigeria. Data on rainfall in millimeters (mm) were collected for the period of 24 years (2000 to 2023) from Nigerian Meteorological Agency (NiMet) Makurdi Station. The Crop (Groundnut) data are also obtained for the period of 24 years (2000 to 2023) from the Ministry of Agriculture and Food Security, Makurdi, Benue State. Monthly rainfall data were collected and the annual values were derived. Regression and correlation analyses were used to determine the effects of onset and cessation of rainfall on groundnut planting and yield. The regression model-1 was used for groundnut yield prediction for the period of 16 years (2024 to 2039). Based on the results obtained, conclusion was drawn that, early and late planting in the month of April gives a better crop growth and yield. It is therefore, recommended that, irrigation measures should particularly target the onset period in the study area. In addition, cultivation of early maturing crops (groundnut), staggering of planting in line with prevailing rainfall trends during onset and cessation should be encouraged among farmers. Also, weather forecasters should endeavor to inform groundnut farmers in the study area and Nigeria of any uncertainty that may arise in weather before planting month, (April) to take precaution of rainfall variability.

Keywords: Rainfall, Onset, Cessation, Groundnut, Planting, Yield, Kyado, Nigeria

1. Introduction

Agriculture crop yields are considered as integrated effect of soil, weather and crop management. Out of these factors, weather is most vital and cannot be controlled, while the remaining factors are controllable to some extent. Weather in general and rainfall in particular, profoundly influence groundnut yields (Parmar, et al., 2014). Agriculture is a main contributor to Nigeria economy, employing 70% of the rural population and contributing 23% to the nation GDP (Binbol and Zemba, 2007) cited by Labiru et al (2023). Majority of agricultural practices in Nigeria depends on rainfall which is characterized by high variability both seasonally and annually. The seasonal rainfall variation affects cropping calendar, the timings of land preparation, planting, crop growing and even post-harvest activities relating to storage are often characterized by weather irregularities. Annual rainfall variability on the other hand affects agriculture more in terms of the frequency and intensity of rainfall. While agriculture is generally considered highly climate sensitive, climate change is projected to further exacerbate this sensitivity either positively or negatively. This is because analyses of rainfall trend in the recent past over Nigeria suggests a downward trend in most northern locations, while the southern stations demonstrate an upward trend (NiMet, 2018) cited by Labiru et al (2023).

Rainfall is an important element of climate especially in tropical areas. It provides water for various activities that include; farming, industrial works, buildings construction, and so on (Olatunde and Love, 2018). However, its importance is more pronounced in farming activities because farming in most tropical and developing countries depends on rainfall. Therefore, rainfall onset and cessation dates are significant parameters in the agricultural calendar in most tropical regions. Rainfall onset is the period at the beginning of the rainy season, when rainfall distribution is adequate for crop development, while rainfall cessation refers to the period, towards the end of the rainy season, when rainfall distribution may no longer sustain crop growth (Odekunle, 2006).

Many regions all over the world suffer weather and climate vagaries which have started to affect the onset and cessation of the rainy season leading to irregular seasons over the years (Salack, Muller and Gaye, 2011). This makes it difficult for farmers to optimize the crop planting period and adjust to changing length of the growing season (Olaniran, 1983; Mugalavai, Kipkorir, Raes and Rao, 2008; Ndomba, 2010). The immediate consequences are the decrease of agricultural and food production and an increase in the risk of hunger and famine. Therefore, the determination of the dates of onset and cessation of rainfall and their effects on agricultural practices and activities in various regions of the world has become a great concern for many farmers and researches. The schedule of agricultural activities, right from land preparation, through crop selection and planting, to the time of

harvesting, for a developing country like Nigeria, is rainfall dependent, (Ati, Stigter and Oladipo, 2002). The assessment and prediction of the onset and cessation dates of the rainy season is therefore crucial to the success of agricultural activities in Nigeria. The variability in the onset and cessation of rainfall poses socio-economic and developmental challenges as they threaten food security and induce poverty (Cooper, Dimes, Rao, Shapiro, Twomlow, 2008). This is so because significant delays in rainfall affect the country's overall production of food and, in particular, cereals (maize, groundnut, millet, soya bean and rice), which form the main staple food in the country. In addition, the onset and cessation dates of rainfall affect the transmission of disease vectors, as the life cycle of the disease transmission vectors is sensitive to the variability and changes in temperature and rainfall. For example, the mosquito population is likely to increase rapidly during the warmer humid conditions (Tompkins and Emert, 2013) cited by Olatunde, and Love, (2018).

1.1 Theories of Rainfall Onset and Cessation

Generally, onset day is the first day of a number of consecutive days receiving a certain amount of precipitation (wet spell) and not followed by a number of consecutive dry days receiving less than 5 mm within a given time span (Ferijal, et al., 2022). Cessation of the rainy season is assumed when cluster mean (Ks) drops below 0.40 cm within the cessation window. At that moment the crop experiences severe water stress and early canopy senescence is likely to be triggered (Mugalavai, et al., 2008). Kowal and Knabe (1972) explore northern Nigeria and came out with explanatory notes and tables of the atlas, which covers 6 northern States of Nigeria, showing the physical environment of the area, agricultural production, rainfall (water availability) and evaporation. Furthermore, Ati, Stigter and Oladipo (2002) attempted a determination of rainfall onset and cessation of the growing season in northern Nigeria. The minimum annual rainfall required for groundnut is between 450 to 1250 mm. High altitudes, cold and frost are not suitable for groundnut farming (www.techno-preneur.net>food>Groun...). Inconsistency in the onset and cessation dates of rainfall will affect the entire economy of Nigeria as agriculture employs about 70% of the Nigerian population (Olatunde, and Love, 2018). Benue State in central Nigeria is situated in AW climatic region which is good for the crop productivity. Consequently, these variations in rainfall characteristics especially onset and cessation pose adverse effects on crop production. Hence, a detailed knowledge of rainfall pattern is an important prerequisite to combat climate change. Hence, the objectives of the study are to:

- analyze the onset and cessation time of rainfall in the study area from 2000 to 2023.

- examine the effects of onset and cessation of rainfall on groundnut planting and yield in Kyado.

- evaluate sustainable adaptation techniques required to mitigate the effects of onset and cessation anomalies as the crop (groundnut) planting and yield.

2. Materials and Methods

2.1 The Study Area

Kyado is located in Mbazun Council ward of Ukum Local Government Area in Benue State. It lies geographically, between latitudes 7° 38′ 15″ N and 7° 39′ 15″ N of the equator and longitudes 9° 43′ 15″ E and 9° 44′ 15″ E, of the Greenwich meridian. The area experiences tropical Monsoon climate, with marked dry and wet seasons. The former (dry season) runs from November to March while the latter (wet season) is from April to October. Annual rainfall total ranges generally from 1200 mm to 1400 mm while temperatures fluctuate between 26o and 27oC. Temperature follows the general two seasons, (dry and wet). The higher temperatures tend to occur at the end of the dry season (Late February-Early April) and the lowest temperature in the peak harmattan period (December-January). However, temperature varies within the year as the case may be (Dada, 2006).
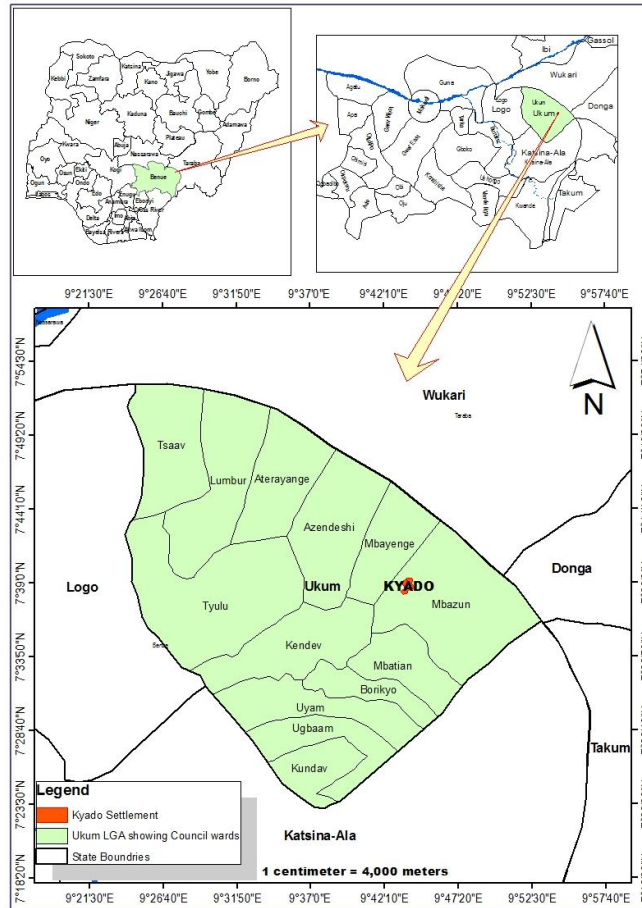
Figure 1: Map of the Study Area.

Source: GIS Lab. Benue State University (BSU), Makurdi, January, 2024.

2.2 Methodology

The research made use of secondary data, particularly data on rainfall and crop (groundnut) yields. Data on rainfall in millimeters (mm) were collected for the period of 24 years (2000 to 2023) was obtained from Nigerian Meteorological Agency (NiMet) Makurdi Station. Crop (Groundnut) data was also obtained for the period of 24 years (2000 to 2023) from the Ministry of Agriculture and Food Security, Makurdi, Benue State. Rainfall data was collected as monthly values and annual values were derived from the monthly records. Annual crop production measured (in metric ton) constitute the bulk production data for the study spanning a period of 24years.

The study made use of Statistical package for Social Sciences, SPSS version 25.0. Regression and correlation analysis were used to determine the effects of onset and cessation of rainfall on groundnut planting and yield in Kyado, Ukum LGA, Benue State, Nigeria. The significance of the regression and correlation coefficient was used to determine the relationship between two or more variables.

3. Results

3.1 Annual Rainfall and Groundnut Yield (2000 – 2023)

Table 1 – Annual Rainfall and Groundnut Yield (2000 – 2023)

Year	Total Annual Rainfall (mm)	Groundnut Yield ('000 MT)
2000	1099.8	365
2001	1072.1	358
2002	1287.5	343

2003	751.8	97
2004	867.3	105
2005	884.9	108
2006	1343	315
2007	1328.2	311
2008	1001.8	297
2009	1435	380
2010	1065.3	372
2011	1219.9	274
2012	1468.8	398
2013	1315.6	379
2014	1345.2	381
2015	953.3	114
2016	1270.8	373
2017	1003	351.52
2018	1041.1	352
2019	1564.6	311.63
2020	1268.5	307.8
2021	872.7	277.6
2022	996.6	279.9
2023	1086.6	270.8
Total	**27543.4**	**7121.2**

Source: Nigerian Meteorological Agency (NiMet) Makurdi Station, 2024; Benue State Ministry of Agriculture and Food Security, 2024.
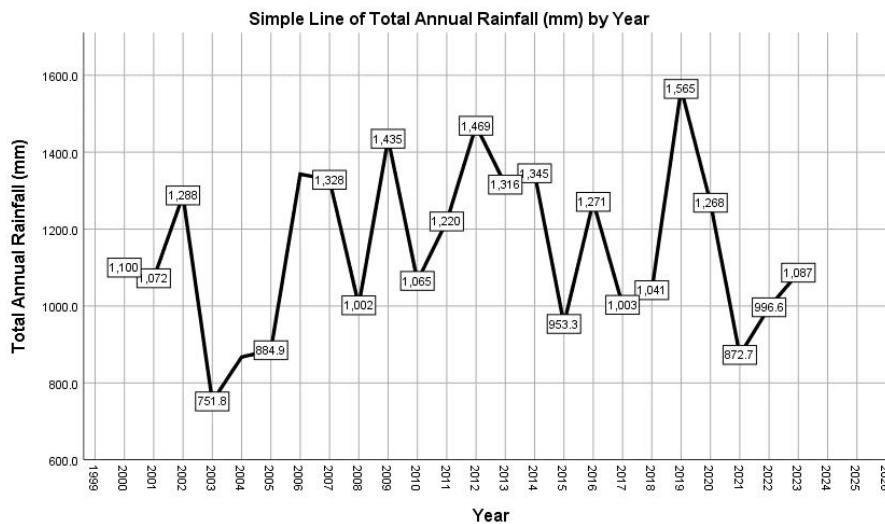

Figure 2: Total Annual Rainfall Distribution of the Study Area.

Figure 2 above shows variation pattern of the annual rainfall over the period (2000 to 2023). The year 2003 had the list amount of rainfall 751.8 mm, while 2019 experienced the highest rainfall total of 1565.0 mm.

3.2 Onset Time of Rainfall in the study area.

To analyze the onset time of rainfall in the study area from 2000 – 2023, simple descriptive statistics of centrality and dispersion were employed. The results are summarized and presented on Table 2.

Table 2 - Descriptive Statistics of Onset Rainfall (April)

Item	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Onset Rainfall (April)	24	284	17.70	180.6	2034	84.75	406.4467	165198.9375
Valid N (listwise)	24							

Table 2 presents descriptive statistics for the variable "Onset Rainfall (April)" based on a sample size of 24-year observations. The data shows a wide range of rainfall values, spanning from a minimum of 17.70 mm to a maximum of 180.6 mm, with a total sum of 2034 mm. The average onset rainfall for April is calculated to be 84.75 mm, indicating the central tendency of the dataset. However, there is notable variability in the data, as reflected by the high standard deviation of 406.4467 and variance of 165198.9375. These metrics suggest that the onset rainfall values exhibit considerable dispersion around the mean. All 24-year observations in the dataset are valid, providing a complete picture of the onset rainfall distribution for April.
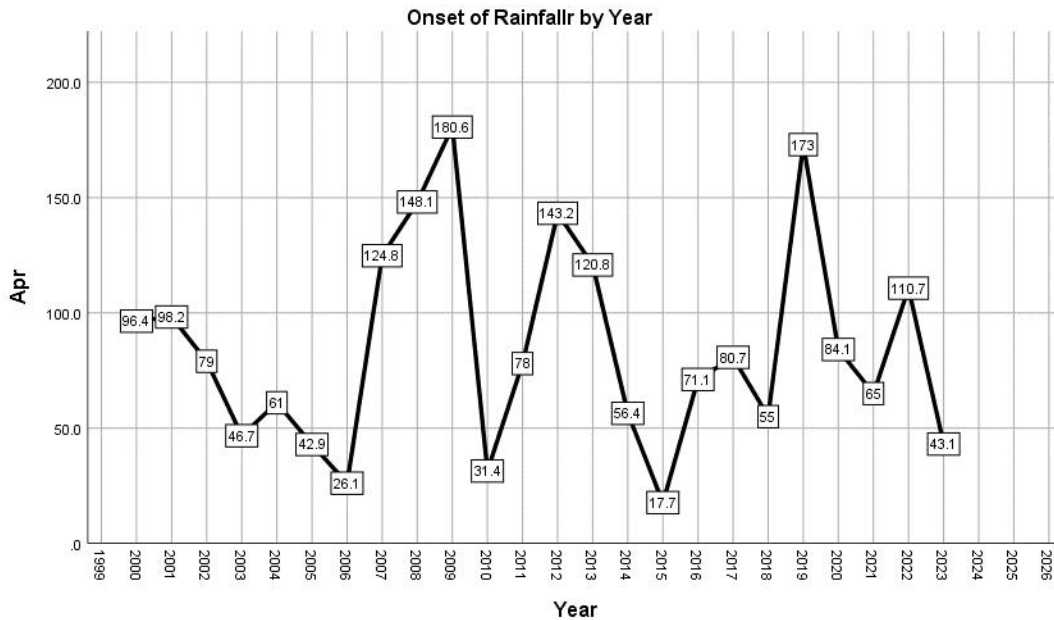

Figure 3: Onset of Rainfall in April of every Study Year.

Significant rainfall commenced in 2007, with rainfall amount of 124.8 mm. In some years, such as 2007, 2008, 2009, 20012, 2013, 2019, and 2022, there are relatively higher annual rainfall values compared to other years. These years indicate the onset of the rainy season, as they often follow years with lower rainfall amounts.

Table 3 - Correlation of Onset Rainfall (April) and Groundnut Yield ('000MT)

Variables	Pearson Correlation	Sig. (2-tailed)	N
Onset Years	0.995	0.01	24
Groundnut Yield ('000 MT)	0.995	0.01	24

Table 3 presents correlation coefficients between April conditions of rainfall onset and groundnut yield ('000 MT) from a dataset comprising 24-year observations. The Pearson correlation coefficient between April rainfall onset and groundnut yield is exceptionally high at 0.995, indicating a strong positive linear relationship between the two variables. This implies that as April conditions change, there is a corresponding change in groundnut yield, and vice versa, in a consistent and predictable manner. The correlation is deemed statistically significant at the 0.01 level, suggesting that this

relationship is unlikely to have occurred by chance. Overall, the results suggest a strong association between April conditions and groundnut yield, providing valuable insights for agricultural planning and forecasting.

3.3 Cessation Period of Rainfall in the study area

To also assess the cessation period of rainfall in the study area from 2000 – 2023, a similar statistical approach used for onset was employed.

Table 4 - Descriptive Statistics of Cessation rainfall

Item	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Cessation of rainfall (October)	24	284	36.90	320.9	3197.3	133.2208	638.90467	408199.1888
Valid N (listwise)	24							

Table 4 presents descriptive statistics summary for the variable "Cessation of rainfall (October)" based on a sample size of 24-year observations. The data indicates a considerable range in cessation of rainfall values, with the difference between the minimum and maximum being 284. The minimum cessation of rainfall observed is 36.90 mm, while the maximum is 320.9 mm. The total sum of cessation of rainfall values is 3197.3, and the mean, or average cessation of rainfall is calculated to be 133.2208. However, there appears to be notable variability in the data, as evidenced by the relatively high standard deviation of 638.90467 and variance of 408199.1888. These statistics suggest that the cessation of rainfall values exhibit significant dispersion around the mean. All 24-year observations in the dataset are valid, ensuring a comprehensive overview of the cessation of rainfall distribution for October.
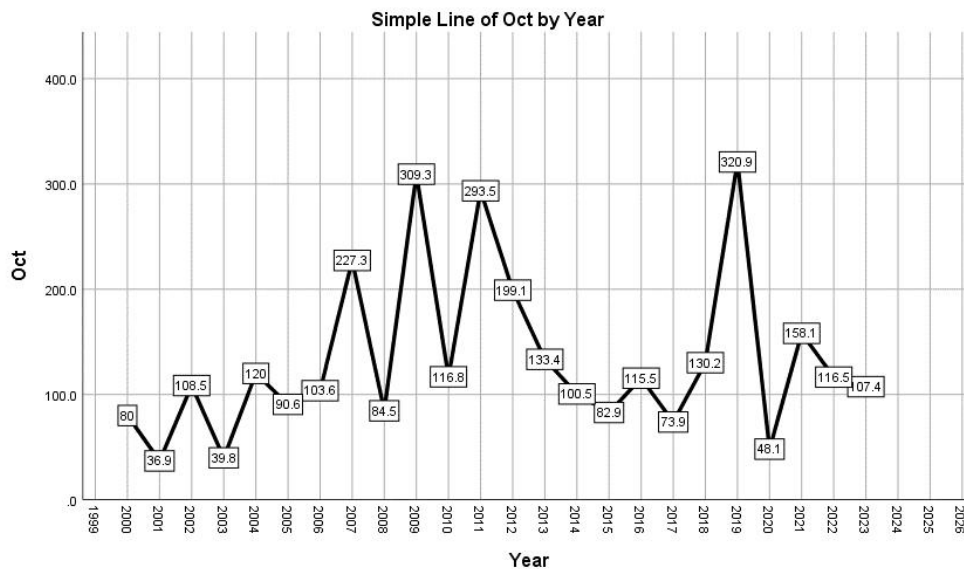

Figure 4: Cessation of Rainfall in October of every Study Year

Significant rainfall ended in October 2022 characterized with rainfall amount of approximately 116.5 mm units. In some years, such as 2000, 2001, 2003, 2004, 2005, 2008, 2010, 2011, 2015, 2017, 2018, 2020, 2021, 2022 and 2023, there was relatively low annual rainfall values compared to other study years. These years indicate the cessation of the rainy season, as they often follow years with lower rainfall amounts.

Effects of onset and cessation of rainfall on groundnut planting and yield in the study area.

Table 5 - Correlation of Cessation of Rainfall (October) and Groundnut Yield ('000MT)

Variables	Pearson Correlation	Sig. (2-tailed)	N
Cessation Years	0.212	0.448	24
Groundnut Yield ('000 MT)	0.212	0.448	24

The correlation analysis conducted between cessation of rainfall and groundnut yield during the study period (2000 - 2023) shown in Table 5 revealed a weak positive linear relationship (Pearson correlation coefficient = 0.212). However, the correlation was found to be statistically insignificant at the 0.05 significance level (p-value = 0.448).

Consequently, there is insufficient evidence to reject the hypothesis that cessation of rainfall has no significant effects on groundnut planting and yield in the study area during the specified period. These findings suggest that other factors beyond cessation of rainfall may exert a more substantial influence on groundnut planting and yield within the context of the study, reliable association between the timing of rainfall cessation and groundnut yield based on the provided data.

3.4 Planting schedule effects on groundnut yield in the study area.

Many scholars have reported that planting schedule has effects on crop(s) yield. Lauer et al. (1999) cited by Sajid and Hu (2022) claimed that crop breeds or populations tend to have higher yields when planted within a specific time window, and ignoring the planting window will reduce yield (Swanson and Wilhelm, 1996; Darby and Lauer, 2002; Anapalli et al., 2005; Williams, 2006; Van Roekel and Coulter, 2011) cited by Sajid and Hu (2022). In addition, interactions between the planting date and soil temperature (Bollero et al., 1996) cited by Sajid and Hu (2022) and interactions between the planting date and fertilizer application (Hankinson et al., 2015; Kaiser et al., 2016) cited by Sajid and Hu (2022) have significant impact on crop yield irrespective of geographical location (Beiragi, 2011; Tsimba et al., 2013) cited by Sajid and Hu (2022). Ying and Swaminathan (2020) took a study on improved crop productivity through optimized planting schedules in Southern Africa and demonstrated a significant relative profit advantage of the optimal planting schedule over commonly used heuristics in practice. Therefore, it is of paramount important to stay in the preferred planting window. Our study revealed that schedule time for planting groundnut is in the months of April and early May.

3.5 Groundnut Yield Forecast (2024 to 2039)

Figure 5 outlines predictions for "Groundnut Yield" in '000 metric tons from 2024 to 2039 using "Regression Model_1." Notably, the forecasted yield remains constant at 296.7 across all forecasted years, suggesting a consistent prediction of no change in groundnut yield throughout the specified period. Upper and lower control limits (UCL and LCL) are provided alongside the forecasts, indicating the expected range within which actual yield values may fall with a certain level of confidence. Both the UCL and LCL remain steady at 493.2 and 100.2, respectively, for each forecasted year.
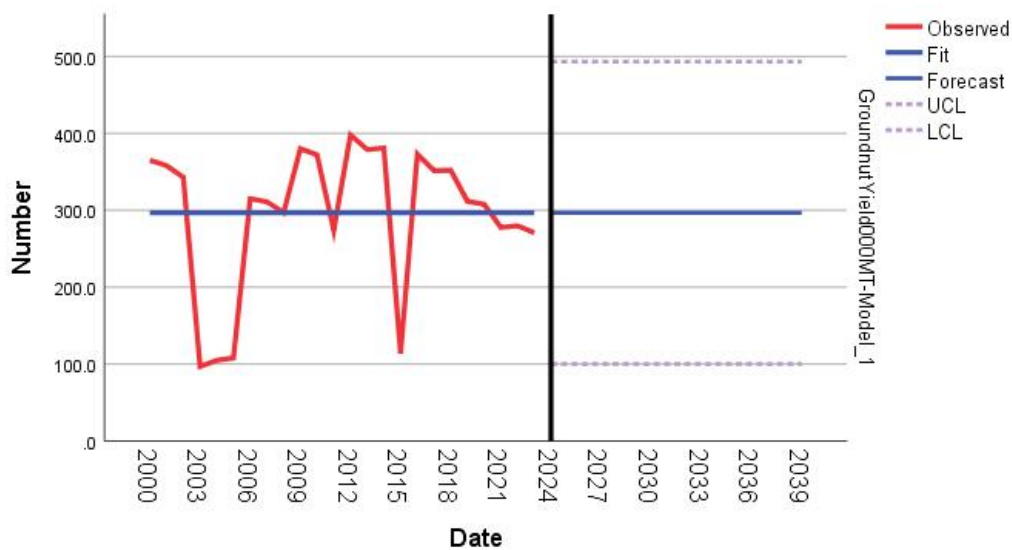

Figure 5: Forecast of Groundnut Yield, 2024 to 2039

This consistent forecast suggests that the model may not adequately capture potential variations or trends in groundnut yield data, hinting at possible limitations or the need for further refinement to enhance its predictive accuracy.

4. Discussion

The onset and cessation of rains are controlling factors of the calendar of agricultural activities (Labiru et al., 2023). The onset and cessation date of rainfall for the study period (2000 to 2023) was analyzed base on the data collected. The results showed that the earliest onset date was early April, of the studied years. While the most distinct onset year was in 2009 (Figure 3). Similar results were reported by Olatunde, and Love, (2018). The cessation month occurred mostly in late October of the studied years, and the most distinct month was in the year 2019 (Figure 4). In general, the onset date of rainfall within the study period occurred in the first four months of every year, but January, February and March had insignificant rainfall enough to sustain crop growth until in April that significant rainfall commences. Thus, the onset month of rainfall in Kyado occurs most often in the month of

April. This implies that planting of crops usually commences from early April to early May. In the same vein, the month of significant cessation was observed to occur in October of every studied year (Figure 4). Onset and cessation periods of rainfall are very important to groundnut farmers in the study area. Late onset and early cessation of rainfall induce poor crop yields despite above normal annual rainfall amount (Mugo et al., 2016).

5. Conclusion

The paper analyzed onset and cessation of rainfall and its effects on groundnut planting and yield in Kyado, Ukum LGA, Benue State, Nigeria. This study, based on results obtained concludes that onset of rainfall in the study area is certain in the month of April, groundnut farming gives high yield in the April month planting unless otherwise due to uncertainties in climate change. This will help planning well for agricultural activities in planting season of the years. Irrigation measures should particularly target the onset period in the study area. In addition, cultivation of early maturing crops (groundnut), staggering of planting in line with prevailing rainfall trends during onset and cessation should be encouraged among farmers. Also, weather forecasters should endeavor to inform groundnut farmers in the study area and Nigeria of any uncertainty that may arise in weather before planting month of April in order to take precaution(s).

References

Ati, O.F., Stigter, C.J., Oladipo, E.O., (2002). "A Comparison of Methods to Determine the Onset of Growing Season in Northern Nigeria". *Journal of Climatology* 22, 731–742.

Benue State Ministry of Agriculture and Food Security (2024).

Cooper, P.; Dimes, J.; Rao, K.; Shapiro, B.; Shiferaw, B.; Twomlow, (2008). "Coping Better with Current Climatic Variability in the Rain-Fed Farming Systems of Sub-Saharan Africa: An Essential First Step in Adapting to Future Climate Change?". *J. Agric. Ecosyst. Environ*. 2008, 126, 24–35.

Dada, F.O.A., Jibrin, G.M. and Ijeoma, A. (2006). Macmillan Nigeria Secondary Atlas Lagos: Macmillan Nigeria. https://tivpedia.org.ng.

Ferijal, T., Batelaan, O., Shanafield, M., and Alfahmi, F. (2022). Determination of rainy season onset and cessation based on a flexible driest period. *Theoretical and Applied Climatology*, Vol. 148, Pp 91-104.

GIS Laboratory, Benue State University (BSU), Makurdi. January, 2024.

Kowal, J.M. and Knabe, D.T. (1972). An Agro-Climatological Atlas of the Northern States of Nigeria with explanatory notes. View from cabidigitallibrary.org link. Springer.com>article Retrieved 19th November, 2024.

Labiru, M. A., Binbol, N. L., Simi, S. Goyol., Salamatu, J. F., Maton, S. M., Oche, C. Y., Sadiku Yahaya., Abubakar, A. G., Ibrahim Iro. I., Dabis, N. D., Galadima, J. S., Maigida, G.T., Adedire, O., Nguwap, Y. H., Badamasi, J. S., Muazu, A. B., Abdullahi, M. B. Y., Ramlah, A. Nashehu., Mallau, T. A. and Alalade, O. (2023). Exploring the relationship between rainfall characteristic and the yield of Irish Potato on the Jos Plateau Nigeria. *Journal of Meteorology and Climate Science* 22(1): 101- 121.

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 Forest Meteorology*. 148, 1123–1135.

Mugo, R. M., Ininda, J. M. and Okoola, R. E., (2016) Inter Annual Variability of Onset and Cessation of the Long Rains in Kenya. *Journal of Meteorology and Related Sciences*, 9:30-47.

Nigerian Meteorological Agency (NiMet) (2024), Makurdi Station.

Odekunle, O.T. (2006). "Determining Rainy Season Onset and Retreat Over Nigeria from Precipitation Amount and Number of Rainy Days". *Journal of Theoretical and Applied Climatology*. Vol. (83), 193-201.

Olaniran, O.J. (1983). The Onset of the Rains and the Start of the Growing Season in Nigeria. *Nigerian Geographical Journal* 26: 81–88.

Olatunde, A. F. and Love, J. O. (2018). Recent changes in onset and cessation dates of rainfall and their effects on farming activities in sub urban areas of Lokoja. *International Journal of Social Sciences*.

Parmar, R. S., Parmar, D. J., and Ghodasara, Y. R. (2014). Influence of rainfall distribution on the productivity of groundnut in Amreli and Rajkot districts of Gujarat State.

Sajid, S.S. and Hu, G. (2022). Optimizing Crop Planting Schedule Considering Planting Window and Storage Capacity. Sec. Technical Advances in Plant Science, Vol. 13.

Salack, S. Muller, B. and Gaye A.T. (2011). "Rain-Based Factors of High Agricultural Impacts Over Senegal". Part I. Integration of Local to Sub-Regional Trends. *Theoretical and Applied Climatology* 106: 1–22, DOI: 10.1007/s00704-011-0414-z.

Ying, Z. and Swaminathan, J. M. (2020). Improved Crop Productivity through Optimized Planting Schedules. *Manufacturing and Service Operations Management*, 22(6), 1165-1180. www.techno-preneur.net>food>Groun Retrieved 19th November, 2024