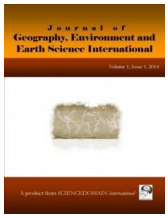

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Effect of Inter-annual Rainfall Variability on Precipitation Effectiveness in Nasarawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study investigated inter-annual rainfall variability effect on precipitation effectiveness in Nasarawa State. Tropical Rainfall Monitoring Mission (TRMM) remote sensing rainfall data was used for the study. The daily rainfall record from 1998-2015 was collected for the study. Onset, Cessation and Length of Growing season are the only precipitation effectiveness indices examined. The pentad method of calculating onset, cessation and length of rainy season was adopted for the study across the entire Local Government Areas of the state. The summary of the findings show that, the averages of Onset dates, Cessation Dates and Length of rainy season dates across the state are not uniform. Rainfall starts early in the Southern zone of the state on 12th April, followed by Western zone 6th May then the Northern zone 12th May. The cessation dates of rainfall are almost the same in all zones with the North and South having cessation dates at 16th October while the West has its cessation date as 18th October. This finding reveals that the dates of cessation are more reliable and predictable than onset dates. Onset date that run between April and May in the state is good because it has not moved far from the expected pattern.

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Keywords: Precipitation effectiveness; TRMM; onset; cessation and length of rainy season.

1. INTRODUCTION

Weather variability or fluctuations result in a decrease in agricultural output which often result in a food crisis. The economic consequences of random rainfall patterns in form of drought, flooding and storm damage are of great concern, especially in the area of food supply, because the effects of droughts last longer than the effects of excessive rainfall [1]. According to [2] and [3], it is important to determine at a reasonable accuracy the probability level of the onset of rains, cessation of rains and length of rainy period, as well as their inter-relationships, in order to assist in planning of dry land farming activities. Knowledge of the length and probable dates of the onset and cessation of the rainy season can help farmers choose the right cultivar suitable for their particular location or region [4]. Research in other parts of the world has shown that farmers are interested in obtaining the dates on which they can start planting, knowing that the likelihood of crop failure is then minimal [5].

Some of the attributes of rainfall that are important to crop production are the time of onset of the raining season, total amount of rainfall, distribution, number of rainy days and duration of rainfall as well as time of cessation [6]. [7] Also noted that in Agriculture, two of the most important phonological aspects of rainfall which are useful in decision making are the onset (ø) and cessation (¢) of the rains.

Onset of rainfall is one of the most important occurrences to the farmer: earlier onset allows them to plough land and plant earlier and benefit from the lower evaporative demand, while later onset can cause the plant critical stages that are sensitive to water stress to be aligned with months of lower rainfall and higher evaporative demand, depending on location and timing of the onset of rains [8].

In some African countries crop yield from rain-fed agriculture could be reduced by up to 50% by the year 2020 [9] When the growing period is shorter than the growth cycle of the crop, from sowing to full maturity, there is loss of yield. [10] observed that global warming would likely affect agricultural productivity due to the changes in the length period. They observed that length of growing period would increase by 10%. Loss of yield can also occur when the length of the growing period is much longer than the length of the growing cycles [11]. Pattern of rainfall variability are not necessarily harmful, the problem arises from extreme events and the uncertainties which derive from the difficulty of predicting weather beyond a week [12]. Increase in technology through a better weather forecast and farmers enlightenment can be helpful in reducing the effect of rainfall variability [13]. Therefore, countries with high inter-annual variability (typically symptomatic of ENSO or longer-term climate shifts) can be expected to lag in economic development. Furthermore, the affected countries typically lack the most common response to hydrologic variability [14]. Farmers can be said to be more concerned now with minimizing the damage to crops during periods where rainfall exceeds potential or is below expectation and when rainfall distribution does not cover the length of the growing season.

It is impossible to ensure high skill in forecasting of planting dates, but, when agro meteorological information about the behaviour of the rainy season is available, crop losses should be minimized [2,15]. Because of the uncertainties in predicting the rain, farmers now delay their time of planting. After the first or second rain, they watch the rain for some time to ensure that the rain falls is regularly enough before planting. They do this to prevent their crops from being killed when rain is delayed [11]. The changing rainfall pattern could devastate the rain-fed agriculture on which so much of the population of Nigeria depends to survive [16]. A delay of 1 or 2 weeks in the onset is sufficient to destroy the hopes of a normal harvest [17]. The loss of agricultural production associated with background variability of rainfall is significantly higher than those associated with spectacular but localised weather-related hazards like cyclone and flooding [13]. The Reliability of rainfall, particularly at critical phases of plant development, accounts for much of the variation in agriculture's potential. Inter-annual or interseasonal rainfall variability is a significant challenge for rain-dependent agricultural producers [18].

[19] study the impact of precipitation effectiveness indices in northern Nigeria. The Six precipitation indices examined were; onset, Cessation and length of rainy season, hydrology ratio, seasonality index and occurrence of pentad dry spells. Results of the analysis showed that the rains now start late but end early, as a result,

length of the rainy season is decreasing. Northern Nigeria is becoming drier as the rainy season is now spread within fewer months. This study adopted the method used by [20] in examining effects of inte-rannual rainfall variability on precipitation effectiveness in Nasarawa State with focus on only the onset, cessation and length of rainy season.

1.1 Study Area

Nasarawa State is located in the central part of Nigeria otherwise known as the middle belt. The state lies between latitude 7^0 $45^{/}$ and 9^0 $25^{/}$'N of the equator and between Longitude 7^0 and 9^0 37'E of the Greenwich meridian as shown in Fig. 1. It has a total landmass of about 27, 137.8 km^2, a population of 1,863.275 according to the 2006 census report and has a population density of 130. Nasarawa State has a total of 13 Local Government Areas which are; Akwanga, Awe, Obi, Karu, Nasarawa, Nasarawa Eggon, Keffi, Wamba, Doma, Lafia, Kokona, Toto and Keana. The State Shares boundary with Kaduna State in the North, Plateau State in the East, Benue State in the east while Kogi State and FCT bound the state in the West [21].

Precipitation in Nasarawa State like elsewhere in the tropics is variable. The mean annual rainfall across the state is between 1400mm and 1500mm, with the highest in August about 1560mm and the lowest in October about 328mm. The rapid decrease in the monthly rainfall is attributed to the rapid retreating of the ITD at a speed of 320 km per month as against 160km for the South-North movement [22]. The onset of rain varies within the state; some northern parts of the state witness rain early around 29th March then the southern part around 1st April while the western and eastern parts is between 4th and 5th April. The mean cessation date of rains in the state is 24th October. Nasarawa State has a tropical sub-humid climate, with two distinct seasons which are the wet season and dry season. The wet season lasts for seven months.

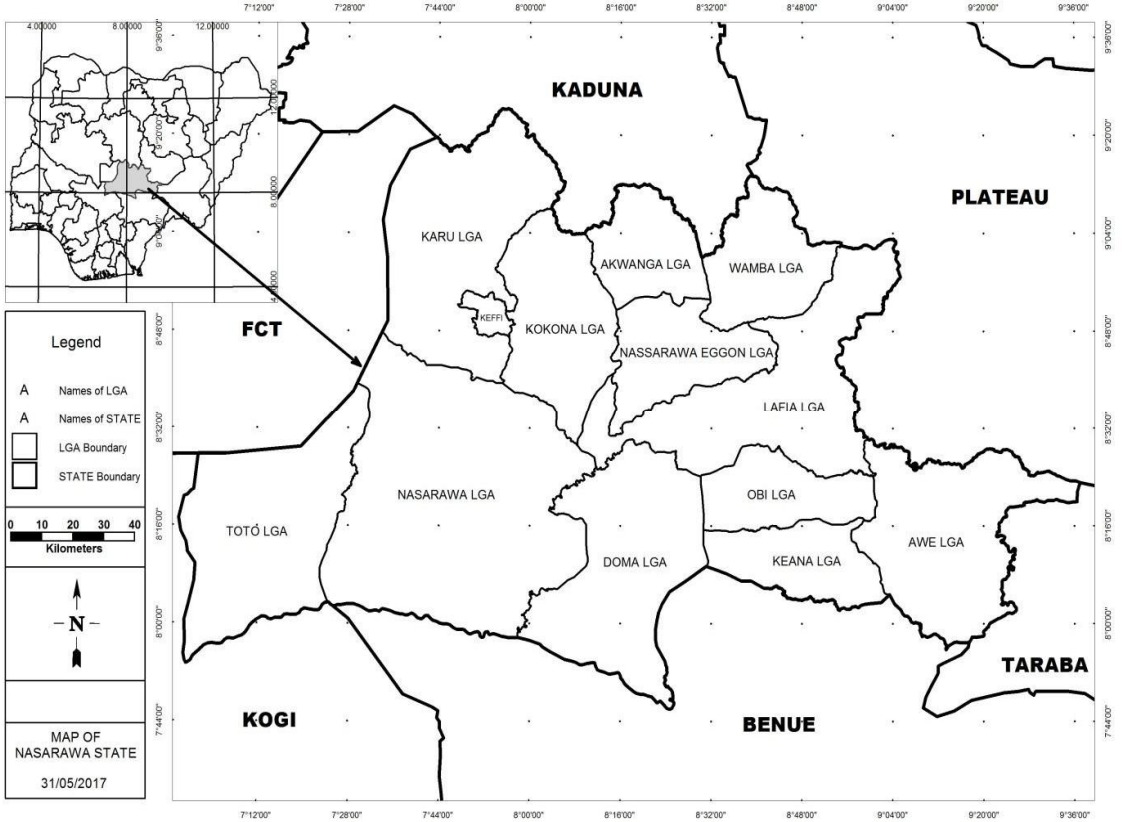

Fig. 1. Map of Nasarawa State
(Source NAGIS, 2017)

Which is between April and October, while the dry season is between November and March [23]. Temperatures are high during the day, particularly in March and April. Nasarawa State records average maximum and minimum daily temperatures of 35°C and 21°C in the rainy season and 37°C and 16°C in dry season respectively [24]. A maximum is reached in March when the temperature can be as high as 39^{o}C. The minimum temperature on the other hand in the State can drop to as low as 17^{0}C in December and January [25]. There is a spatial variation in temperature distribution over the state; mean monthly temperature ranges between 26.8^{o}C in the southern part to about 27.9^{o} in the northern part of the state [26]. The temperature in Nasarawa State is fairly high, partly because of its location in the tropical sub-humid climatic belt and the high radiation income in this part of the globe, which is evenly distributed throughout the year, [23]. Agriculture is the primary economic activity in Nasarawa State. Nasarawa State Agricultural Development Program [27] observes that farming in the state is subsistence and generally rain fed cultivation of annual crops. Although there are many rivers in the state, but the population engaged in irrigation farming are insignificant. Crops grown include grains such as rice, wheat, Soybeans, beans, maize and millet and tuber crops such as yam and cassava.

2. SOURCES OF DATA

The rainfall data was based on the (TRMM) satellite data version for the period 1998–2015 across the entire state, as shown in Fig. 2 Satellite-based rainfall estimates, are based on the electromagnetic spectrum, which can be measured by thermal infrared or passive microwave sensors [26]. The TRMM satellite combines both sensors, overcoming their intrinsic limitations. For instance, the first sensor tends to underestimate warm rain and the second one is not available in geostationary satellites [27]. TRMM data was downloaded from the Mirador website (http://mirador.gsfc.nasa.gov/) and rainfall time series for the study area was extracted using GrADS (Grid Analysis and Display System) software. Gridded rainfall from TRMM have a spatial resolution of 0.25º over regions between 50º N and 50º S [28] and 3-hourly data since 01/01/1998 is available.

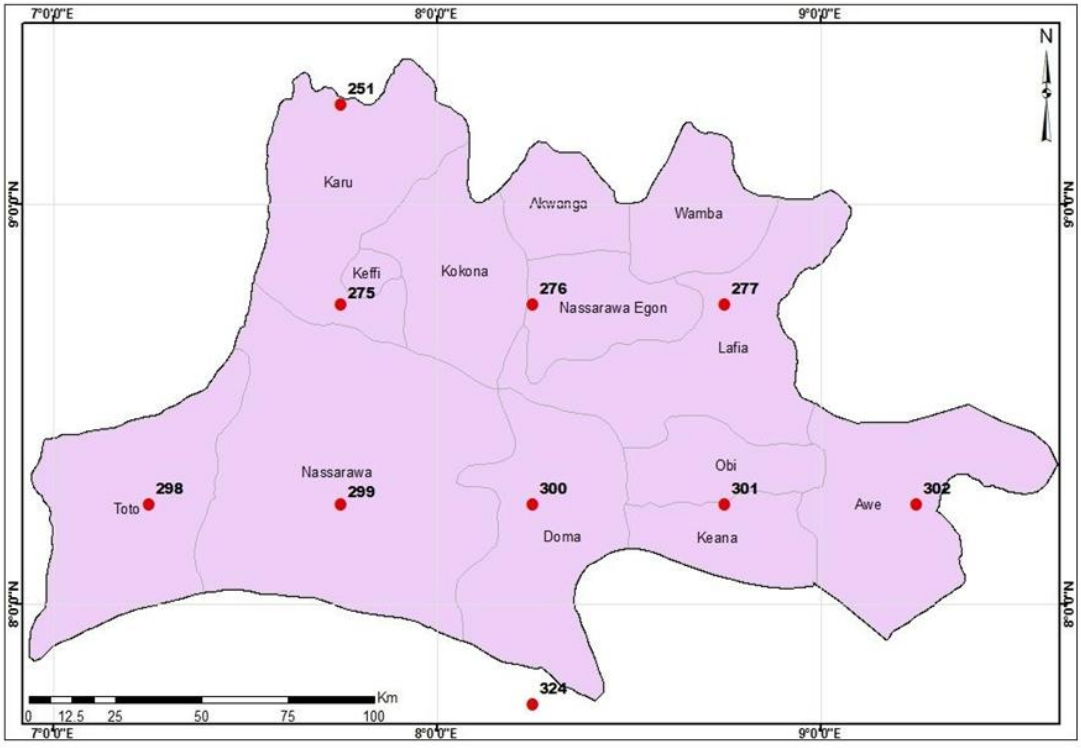

Fig. 2. Map of Nasarawa State showing TRMM Points

3. METHOD OF DATA ANALYSIS

3.1 Computation of Onset, Length Season and Cessation

There are several methods of computing onset, length of rainy season and cessation as shown by [29] and [30,31,17,2]. The definition of Onset, Cessation and Length of the Rainy Season in tropical climates has been a problematic one due to the intermittent and patchy nature of rainfall in the region as noted by [19] the definition usually depends on the purpose of a research. [17] defines Onset "as the time a place receives an accumulated amount of rainfall sufficient for growing of crops. It is not the first day the rain falls. Cessation means termination of the effective rainy season. It does not imply the last day rain fell, but when rainfall can no more be assured or be effective. Length of the rainy season is the period between the onset and cessation dates". [30] applied the ogive method and determined the start of the growing season for some places in northern Nigeria. Each month of the year was divided into pentads giving a total number of 72 a times 73 pentads. Then using the pentad calendar, rainfall was calculated for each Pentad and a cumulative frequency of the pentad is also calculated. An ogive of the cumulative frequency of the pentad was constructed as shown in Fig. 3. The first points of maximum inflexion on the ogive is the exact date of the onset while the last point of maximum inflexion is the exact date of cessation.

Length of the rainy season is obtained by subtracting the onset pentad from the cessation pentad and multiplying the difference by 5 (i.e. number of days in a pentad.

[30] noted that the Ogive method is more accurate than the others. Thus, this was the approach used for the determination of onset, cessation and length of the rainy season in this study. The determination of this trio is a critical aspect of this study.

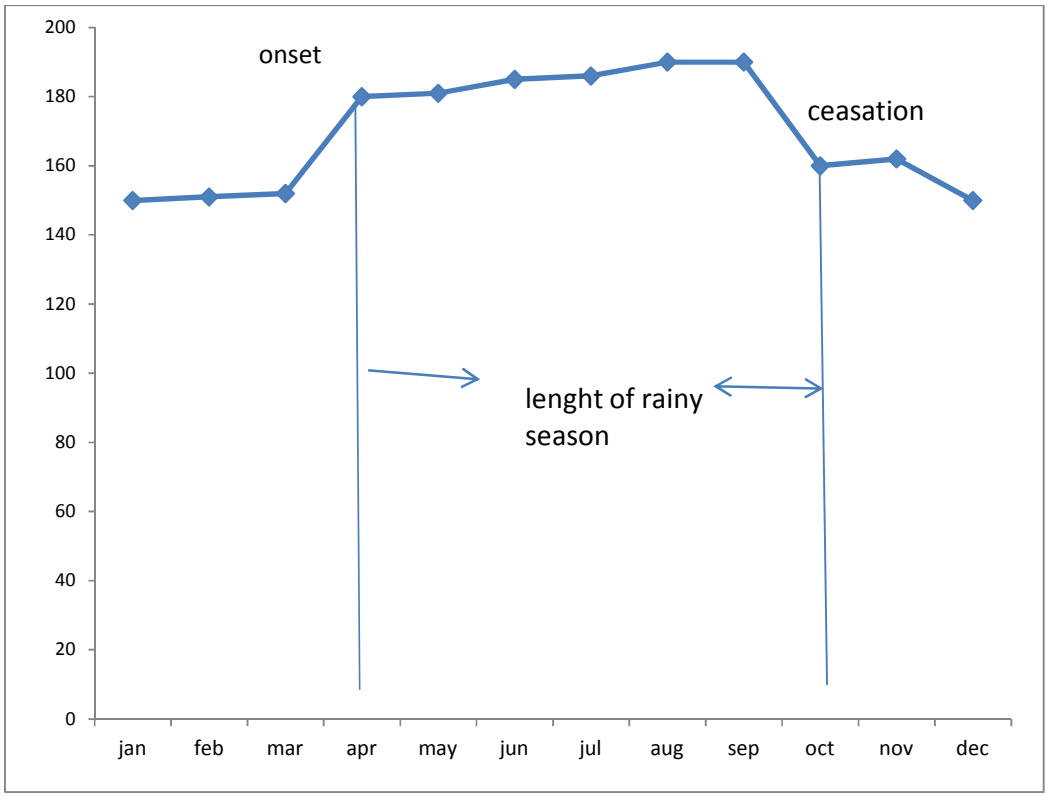

Fig. 3. Ogive method of calculating onset, length of rainy season and cesation

4. RESULTS AND DISCUSSION

4.1 Time Series Analysis of Onset, Cessation and Length of Raining Season

These are also very important features critical for effective farming in the tropics. This is because the Onset, Cessation and Length of rainy season forms important component of moisture resources status for determining the production of various crops [31].

The three components (Onset, Cessation and Length of Rainy Season) shall be presented together for each Local Government Area or TRMM point. The onset is the date on the first point of maximum inflexion on the Pentad calendar while the cessation is the last point of maximum inflexion on the Pentad calendar. The length of the rainy season is the difference between the Onset and Cessation pentads multiplied by 5.

Onset, Cessation and Length of Rainy Season in Western Zone KARU L.G.A (TRMM Point 251)

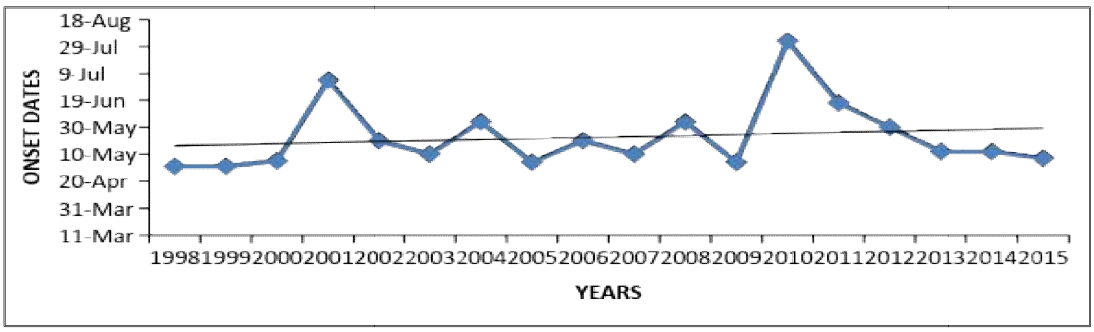

Fig. 4. Onset of rains in Karu, L.G.A point 251

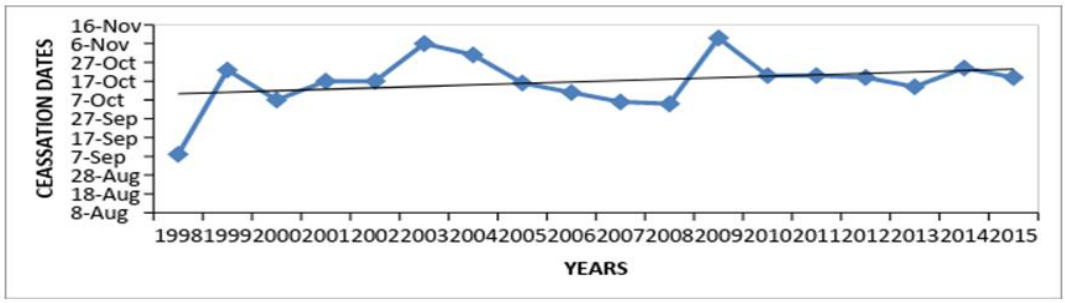

Fig. 5. Cessation of rains in Karu, L.G.A point 251

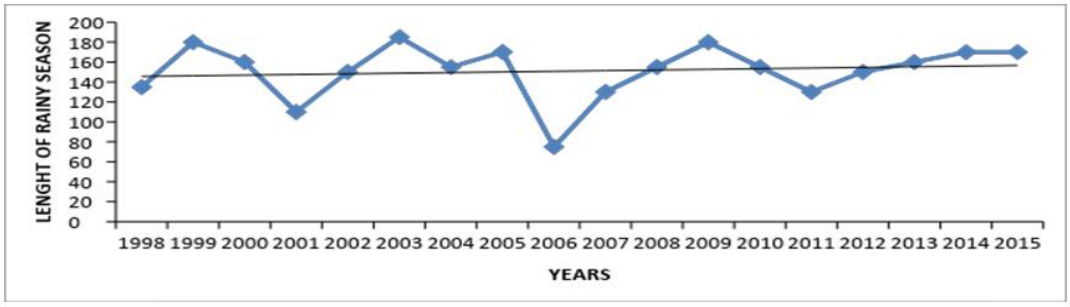

Fig. 6. Length of raining Season in Karu, L.G.A point 251

Figs. 4 to 6 shows the trend in onset, cessation and length of raining season in point 251 which fall within Karu Local Government Area. The onset has a positive trend of Y= 0. 7668x+42506, this implies that the onset date in point 251 is progressing increasing from an average date of 22nd May, which means there will be late onset in this point. The cessation of rainfall also has a positive trend of which means the cessation date of rains in this point is increasing against the average date of 16th October, which implies late cessation of rains in point 251. While the length of rainy season also has a positive trend which means the area is progressively having a longer rainy season.

KEFFI AND KARU L.G.A (TRMM POINT 275)

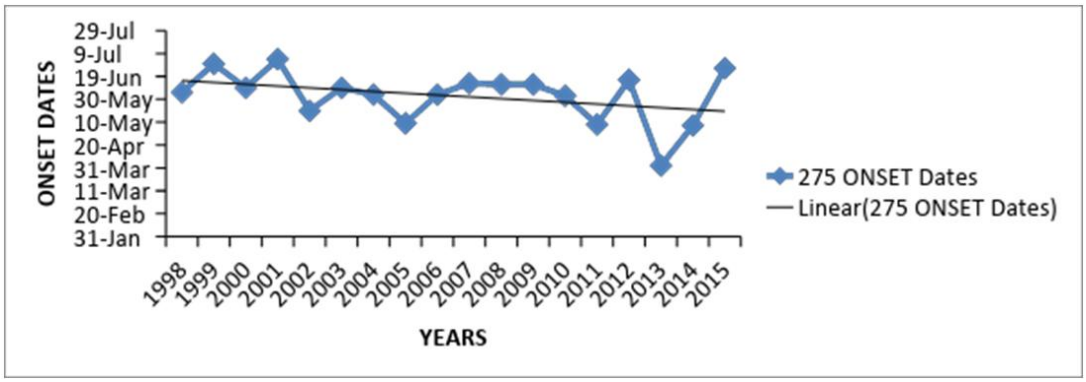

Fig. 7. Onset of rainfall dates in Keffi and Karu L.G.A point 275

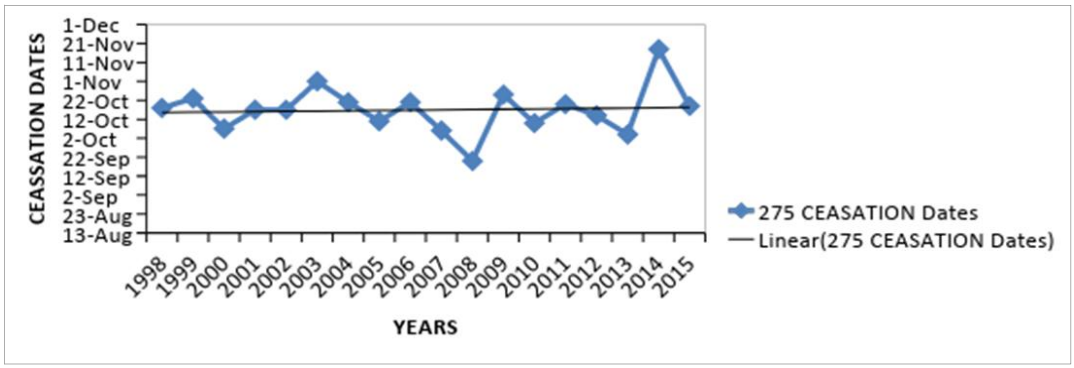

Fig. 8. Cessation of rainfall dates Keffi and Karu L.G.A, point 275

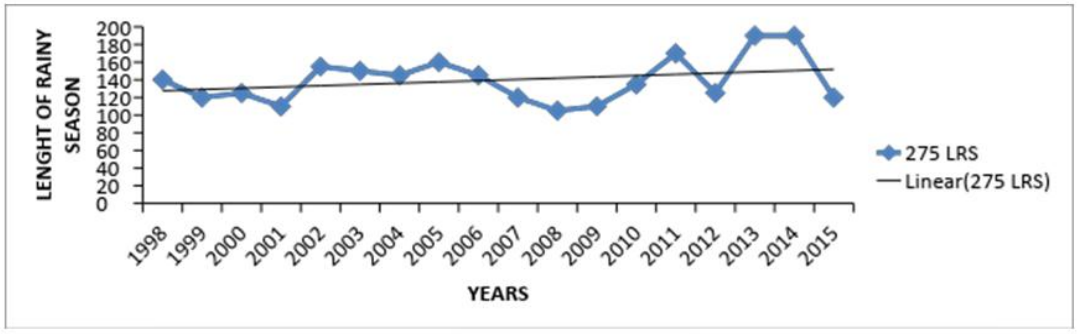

Fig. 9. Length of raining season in Keffi and Karu L.G.A, point 275

Fig. 7 to Fig. 9 shows the onset date. Cessation date and length of raining season in point 275 which fall within Keffi and Karu LG.A. The onset of rains has a negative trend which implies that the onset of rains in this point will be earlier than June 1st which is the average date of the onset.

The cessation on the other hand has a positive trend which means the cessation dates will be later than the average date of 16th October.

The length of the rainy season which is the difference between the onset and cessation has a negative trend which means the length of the rainy season in this point will increase.

TOTO L.G.A (TRMM POINT 298)

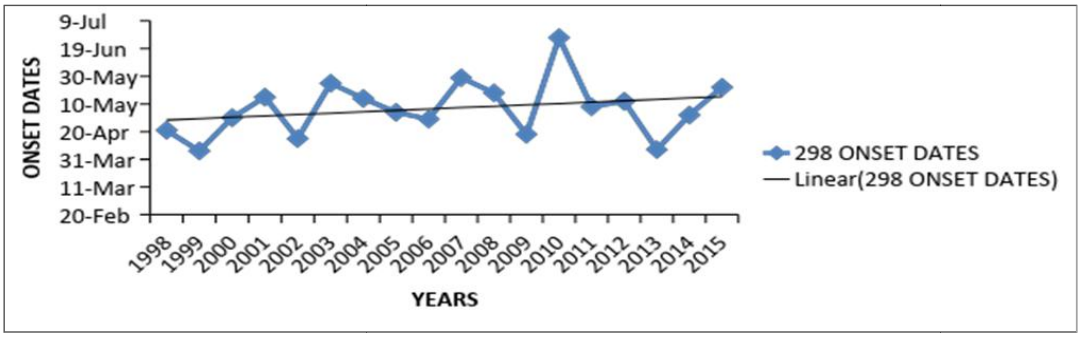

Fig. 10. Onset of rainfall in Toto L.G.A, point 298

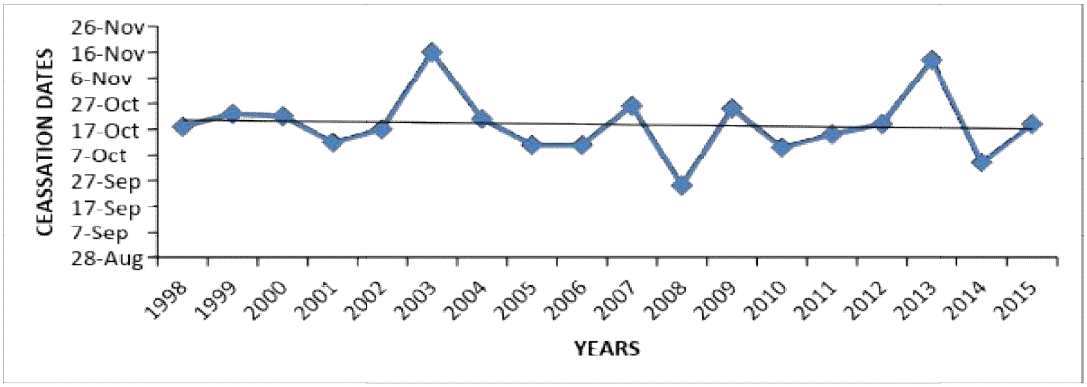

Fig. 11. Cessation of rainfall in in Toto L.G.A, point 298

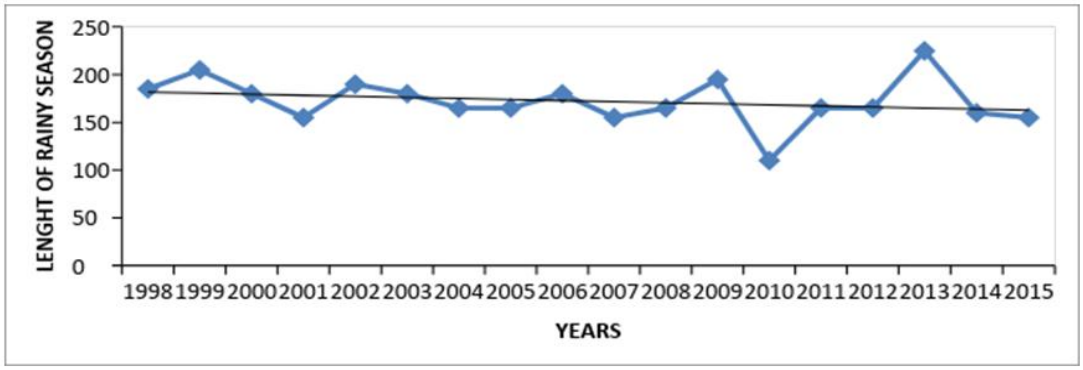

Fig. 12. Length of raining season in in Toto L.G.A, point 298

Fig. 10 to Fig. 12 shows the trend of onset of rainfall cessation of rainfall and length of rainy season respectively in point 298 which falls within Toto Local Government Area.

The trend in onset date in point 298 shows a positive trend which indicates that the rains will start on a date later than the average date of 6th May which means there will be late onset in point 298.the cessation of rainfall has a negative trend which infers that the date of cessation shall be earlier than the average date of 18th October by implication an early cessation of rains in this point. While the length of the rainy season which is the difference between the onset and cessation has a negative trend which means the length of rainy season is reducing around Toto L.G.A.

NASARAWA L.G.A (TRMM POINT 299)

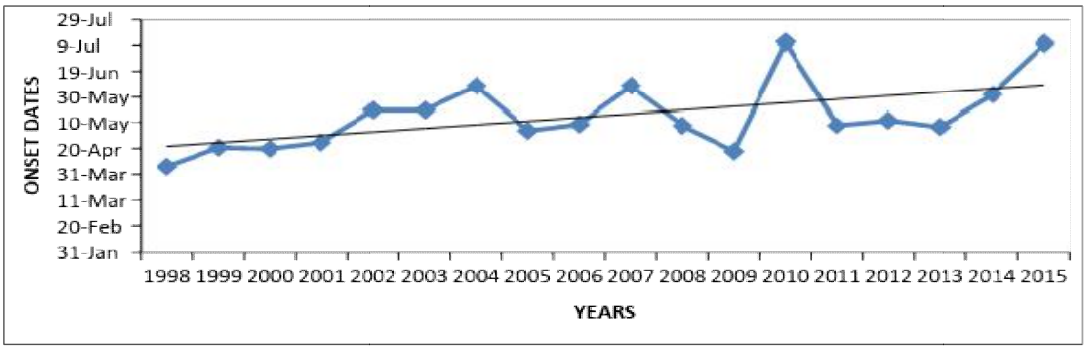

Fig. 13. Onset of rainfall in Nasarawa L.G.A, Point 299

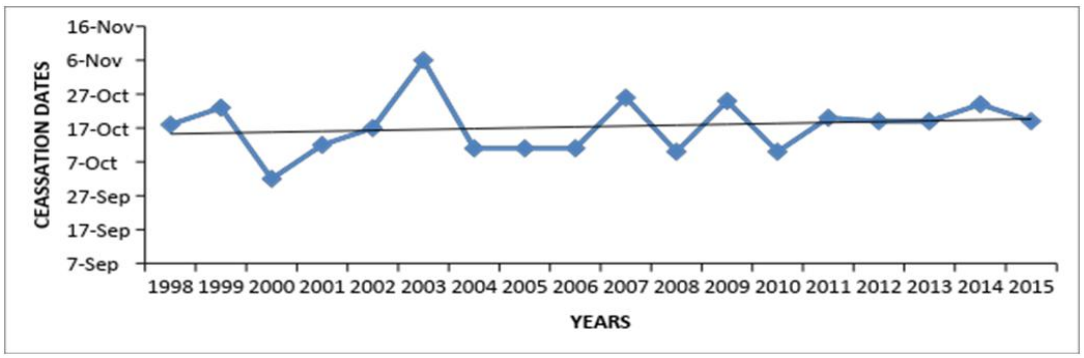

Fig. 14. Cessation of rainfall in Nasarawa L.G.A, Point 299

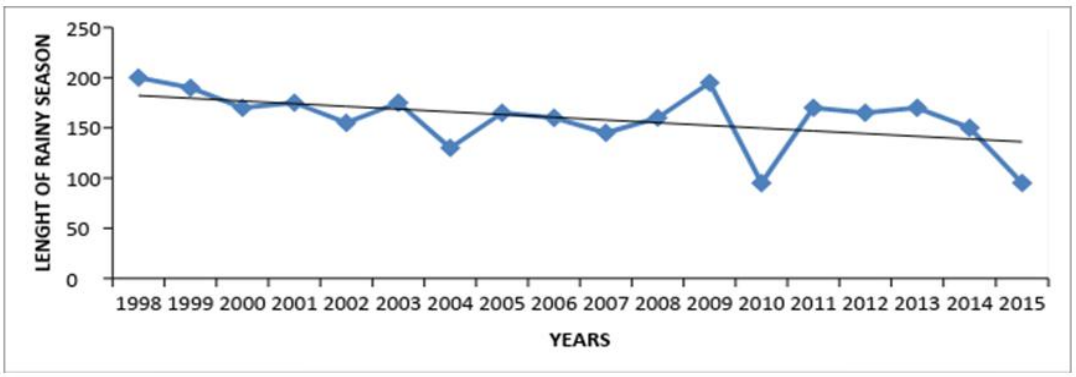

Fig. 15. Length of raining season in in Nasarawa L.G.A, Point 299

Fig. 13 to Fig. 15 shows the trend of onset of rainfall, cessation of rainfall and length of rainy season respectively in point 299 which falls within Nasarawa Local Government Area. It reveals that the onset of rains in this point has a positive trend which implies the date of onset shall be later than the average date of 15th May. That also means there will be late onset of rains around Nasarawa L.G.A. The trend in cessation of rains also shows a positive trend, which means the cessation of rains in point 299 shall be on a later date than the average date of 17th October, which implies late cessation of rains. While the length of raining season has a negative trend which means there will be reduction in the length of rainy season around Nasarawa Local Government Area.

Table 1 shows the average distributions of Onsets date, Cessations date and the length of rainy season in western zone of Nasarawa State which has L.G.A's such as Karu, Keffi, Nasarawa and Toto. The Onset date in these LGAs range from 6th May to 1st June. While Cessation date ranges between 16th October and 18th October. The length of rainy season ranges between 139 to 172 days. While the onset date seem to be changing from one LGA to the other, the cessation date is almost constant. The LRS is not uniform, the least are four (4) months in Karu and Keffi and the longest is in Toto LGA with 5 and half month.

Table 1. Mean dates of onset of rains, cessation of rains and length of rainy season in Western Zone

TRMM points	Average onset date	Average cessation dates	Average length of rainy season
251	22-May	16-Oct	151
275	01-Jun	16-Oct	139
298	06-May	18-Oct	172
299	15-May	17-Oct	159

Onset, Cessation and Length of Rainy Season in Northern Zone
AKWANGA (TRMM POINT 252)

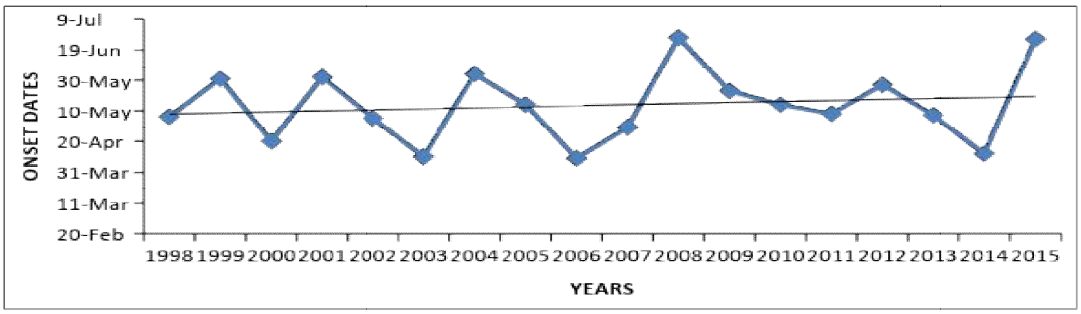

Fig. 16. Onset of rains in Akwanga LGA, Point 252

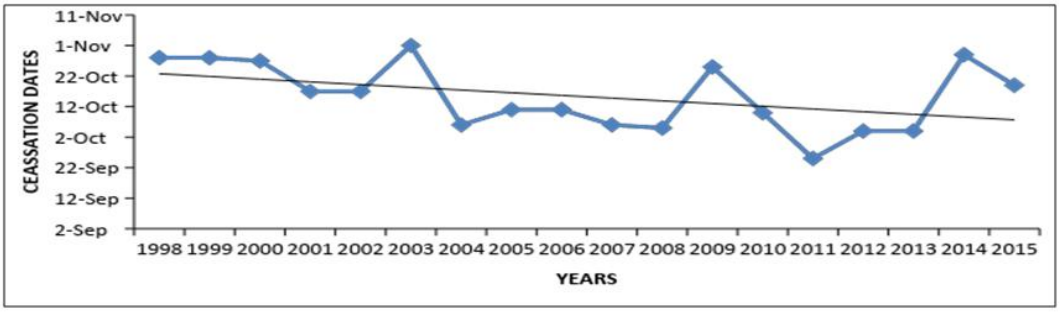

Fig. 17. Rainfall cessation Akwanga LGA, Point 252

Fig. 16 to Fig. 18 shows the trend of onset of rainfall cessation of rainfall and length of rainy season respectively in point 252 which covers Akwanga.

The trend in onset dates around Akwanga L.G.A shows a positive trend which indicates that the rains will start on a date later than the average date of 13th May which means there will be late onset in point 252.the cessation of rainfall has a negative trend which infers that the date of cessation shall be earlier than the average date of 13th October by implication an early cessation of rains in this point. While the length of the rainy season which is the difference between the onset and cessation has a negative trend which means the length of rainy season is reducing around Akwanga L.G.A.

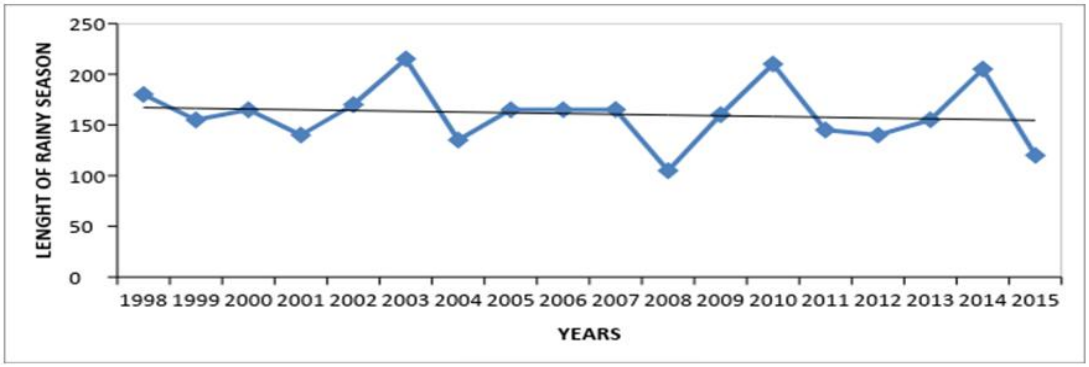

Fig. 18. Length of raining season in Akwanga LGA, Point 252

WAMBA L.G.A (TRMM POINT 253)

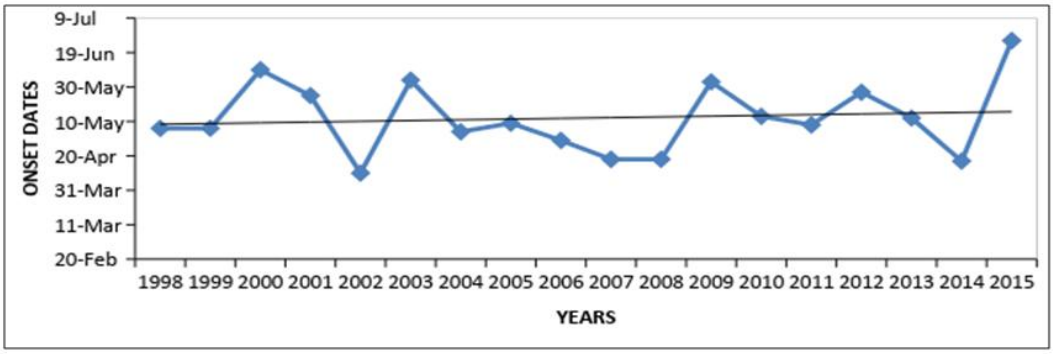

Fig. 19. Onset of Rains in Wamba LGA, Point 253

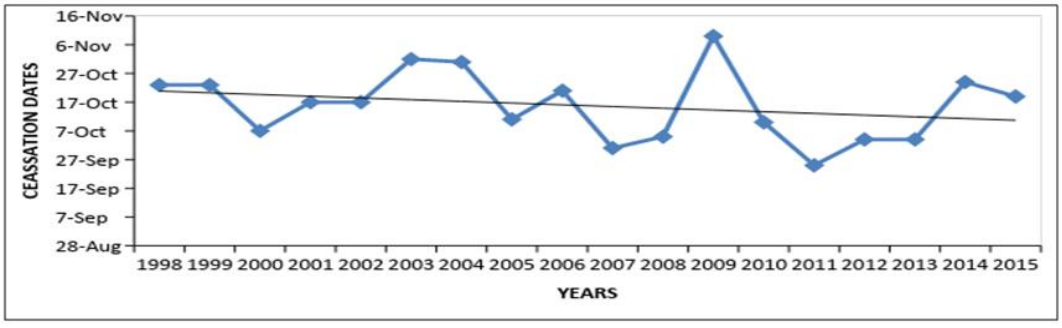

Fig. 20. Cessation of rains in Wamba LGA, Point 253

Figs. 18 to 21 shows the trend in onset, cessation and length of raining season in point 253 which falls within Wamba Local Government Area. The onset of rains has a positive trend which means the raining season will progressively start in a later date than 6th may. The average onset date for this point is 12th may.

The cessation date has a negative trend which indicates that the rains will end earlier than 19th October. The average cessation date for this point is 15th October.

The length of rainy season has a negative trend also which is an indication that the length of raining season in Wamba LGA is decreasing from 180 days downward.

Figs. 22 to 24 shows the trend of onset of rainfall, cessation of rainfall and length of rainy season in point 276 which covers Kokona and Nasarawa Eggon Local Government Area of Nasarawa State. The trend shows that the onset of of rains will progressively start on a later date than the average date of 25th may which means there will be late onset.

The cessation of rainfall in this point also has a positive trend which implies that the cessation of rains will be on a later date than the average date of 16th October. The length of the rainy season has a negative trend which implies a reduction in the length of the raining season.

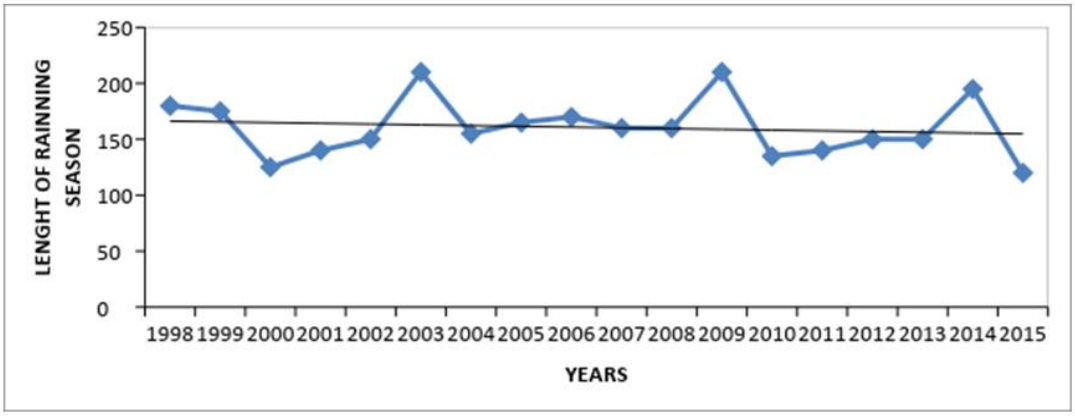

Fig. 21. Length of raining season in Wamba LGA, Point 253

KOKONA AND NASARAWA EGGON L.G.A
(TRMM POINT 276)

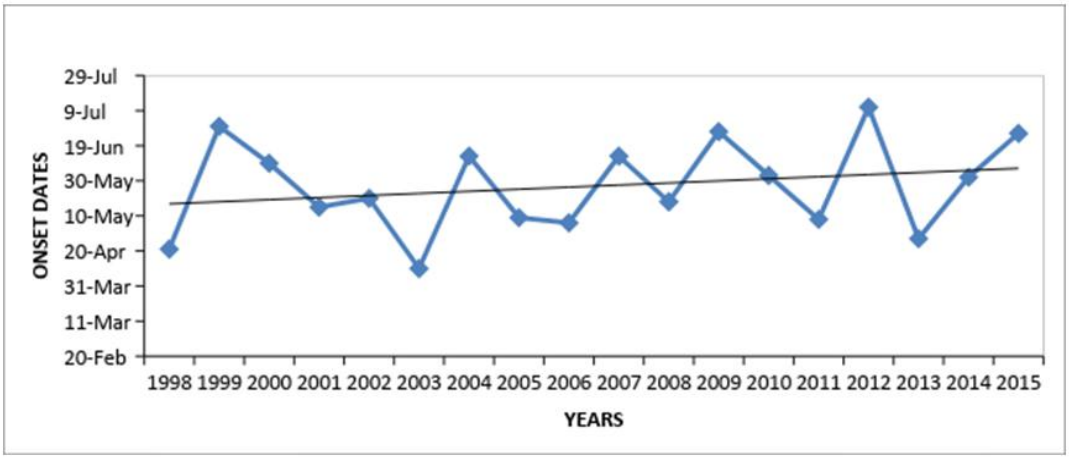

Fig. 22. Onset of rains in KOKONA and NASARAWA EGGON L.G.A, point 276

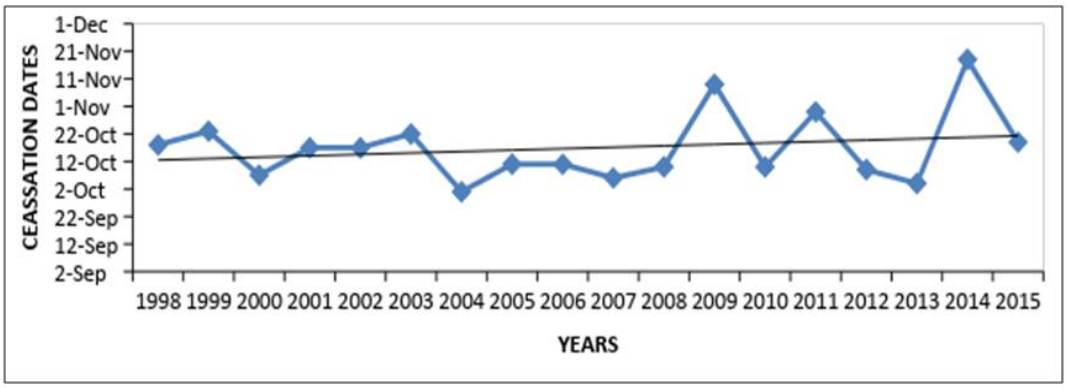

Fig. 23. Cessation of rainfall in KOKONA and NASARAWA EGGON L.G.A point 276

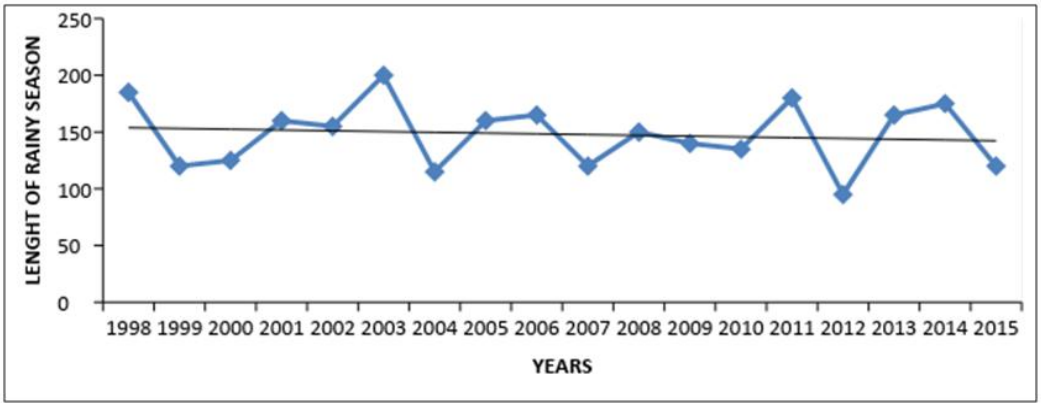

Fig. 24. Length of raining season in Kokona and Nasarawa Eggon L.G.A point 276

Table 2. Shows the average dates of onset of rain, cessation of rains and length of rainy season in the Northern zone

TRMM points	Average onset date	Average cessation dates	Average length of rainy season
252	13-May	15-Oct	161
253	12-May	15-Oct	161
276	26-May	16-Oct	148

Table 2 shows the distribution of the onset of rainfall date, cessation of rainfall date and length of rainy season in the Northern zone of Nasarawa State. This Zone has Akwanga L.G.A, Nasarawa Eggon L.G.A, Kokona L.G.A and Wamba L.G.A.

Onset date range from 12th to 26th May which indicates a little bit of inconsistency which might cause troubles to rain fed farmers who are used to the onset pattern. The Cessation date range from 15th October to 16th October in the zone. This indicates that the cessation dates are consistent as well. The length of rainy season ranges between 148 days and 161 days.

Fig. 25 to Fig. 27 shows the trend of onset of rainfall cessation of rainfall and length of rainy season respectively in point 277 which falls within Lafia Local Government Area. It reveals that the onset of rains in this point has a negative trend which implies the date on onset shall be earlier than the average date of 19th May. That also means there will be early onset of rains in point 277. The trend in cessation of rains also shows a negative trend, which means the

cessation of rains in point 277 shall be reduce from the average date of 16th October, which implies early cessation of rains. While the length of rainy season has a positive trend which means there will be increased length of rainy season in point 277.

Onset, Cessation and Length of Rainy Season in Southern Zone LAFIA L.G.A (TRMM POINT 277)

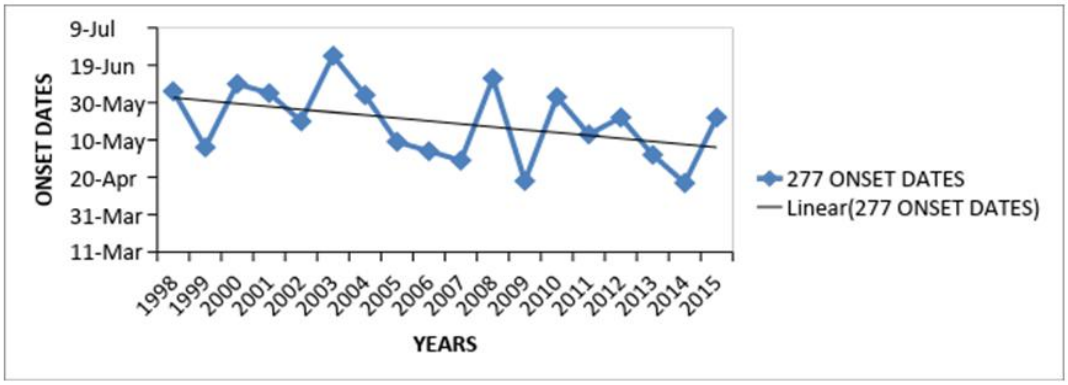

Fig. 25. Onset of rainfall in Lafia L.G.A, point 277

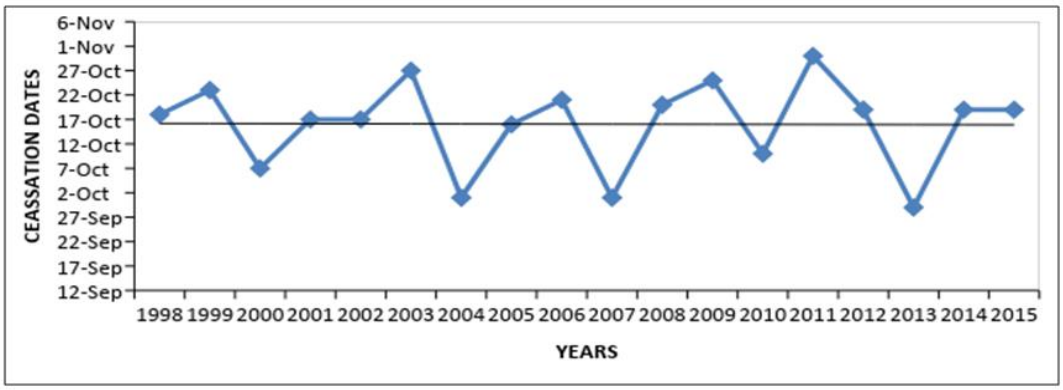

Fig. 26. Cessation of rainfall in Lafia L.G.A, point 277

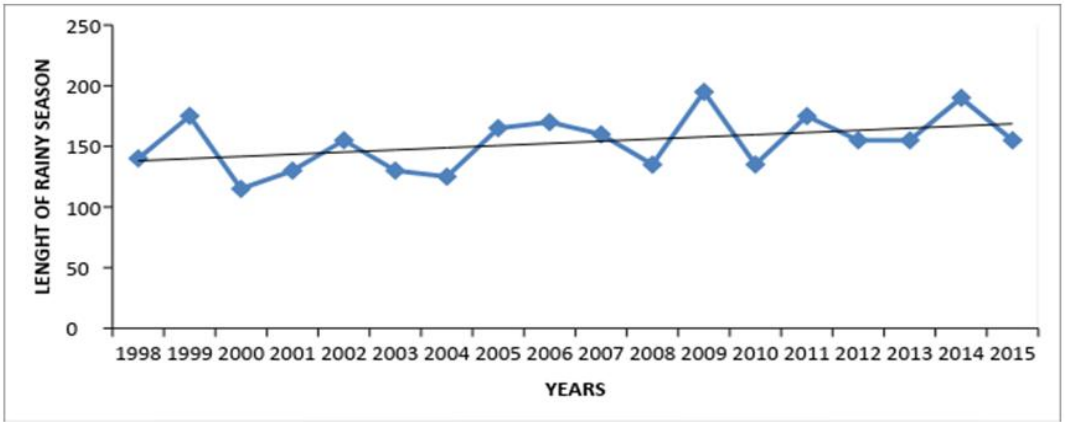

Fig. 27. Length of rainy season in Lafia L.G.A, point 277

DOMA L.G.A (TRMM POINT 300)

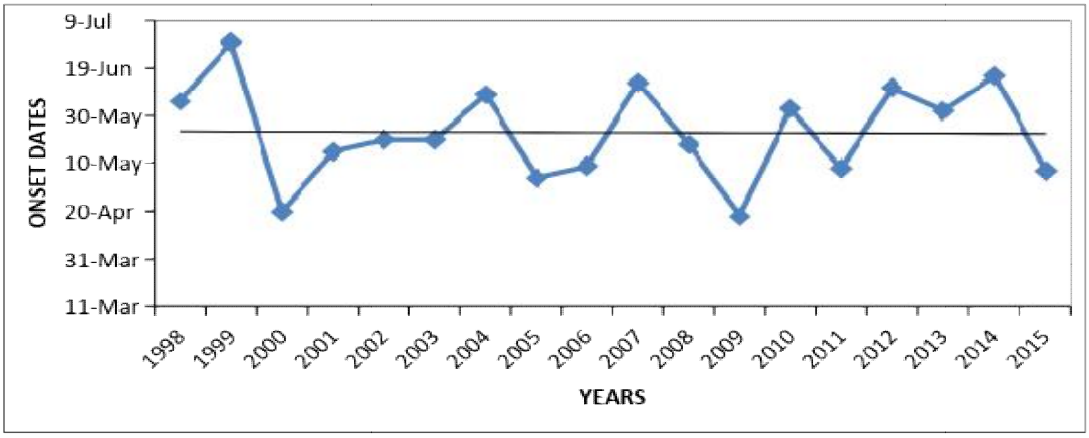

Fig. 28. Onset of rainfall in Doma LGA point 300

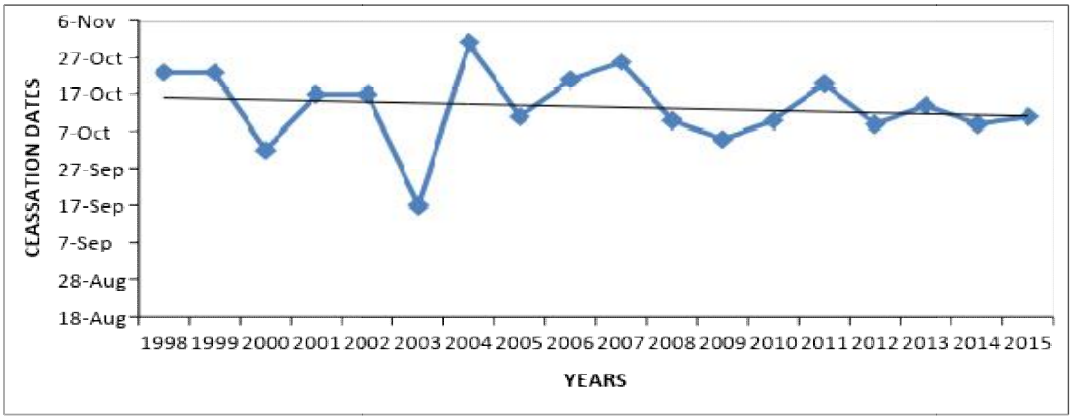

Fig. 29. Cessation of rainfall in doma LGA point 300

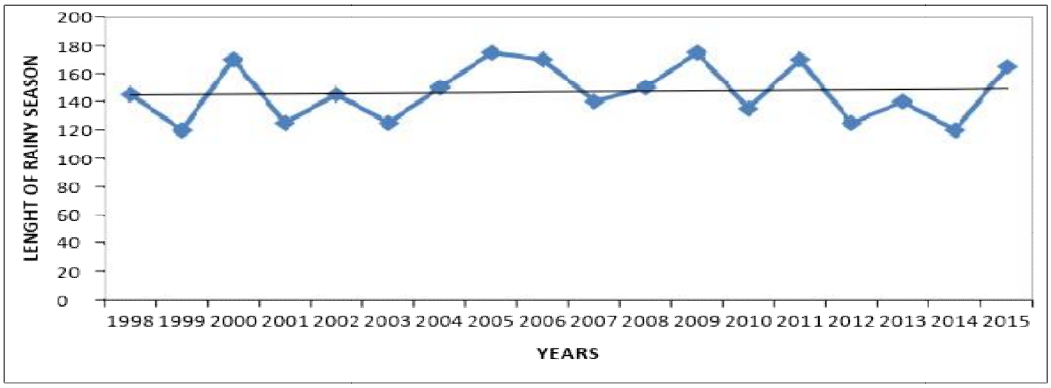

Fig. 30. Length of raining season in Doma LGA point 300

Fig. 28 to Fig. 30 shows the trend of onset of rainfall cessation of rainfall and length of rainy season respectively in point 300 which covers Doma Local Government Area. It reveals that the onset of rains in this point has a negative trend which implies the date on onset shall be earlier

than the average date of 22nd May. That also means there will be early onset of rains in point 300. The trend in cessation of rains also shows a negative trend, which means the cessation of rains in point 300 shall be earlier than the average date of 13th October, which implies early cessation of rains. While the length of rainy season has a positive trend which means there will be increase in length of rainy season in point 300.

OBI AND KEANA L.G.A (TRMM POINT 301)

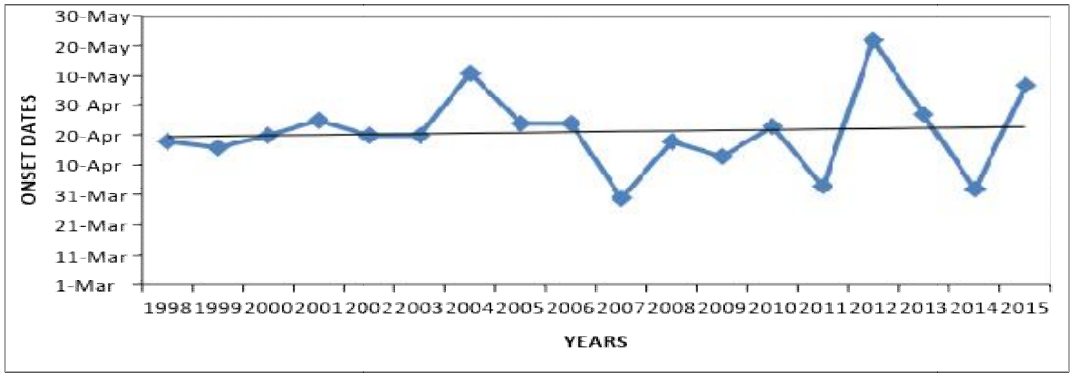

Fig. 31. Onset of rainfall dates in OBI AND KEANA L.G.A point 301

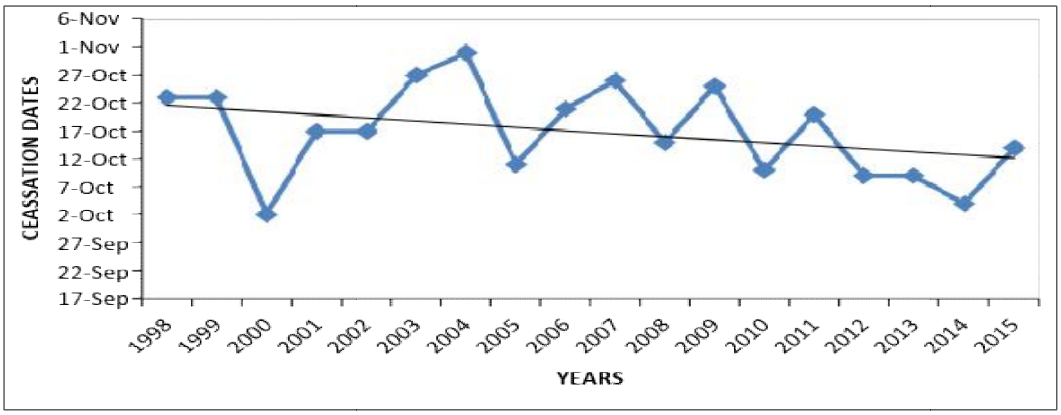

Fig. 32. Cessation of rainfall dates in OBI AND KEANA L.G.A point 301

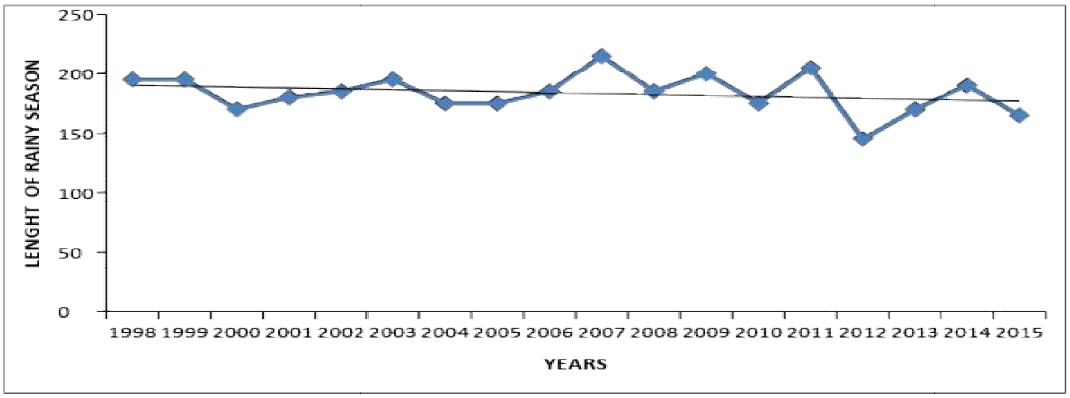

Fig. 33. Length of raining season in OBI AND KEANA L.G.A point 301

Fig. 31 to Fig. 33 shows the trend of onset of rainfall cessation of rainfall and length of rainy season respectively in point 301 which falls within Obi and Keana Local Government Area of Nasarawa State. It reveals that the onset of rains in this point has a positive trend which implies the date of onset shall be later than the average date of 21st April, it also means, there will be late onset of rains in point 301. The trend in cessation of rains has a negative trend which means the cessation of rains in point 301 shall be on an earlier date than the average date of 16th October, which implies early cessation of rains. While the length of rainy season has a negative trend which means there will be reduction in the length of raining season in point 301.

AWE L.G.A (TRMM POINT 302)

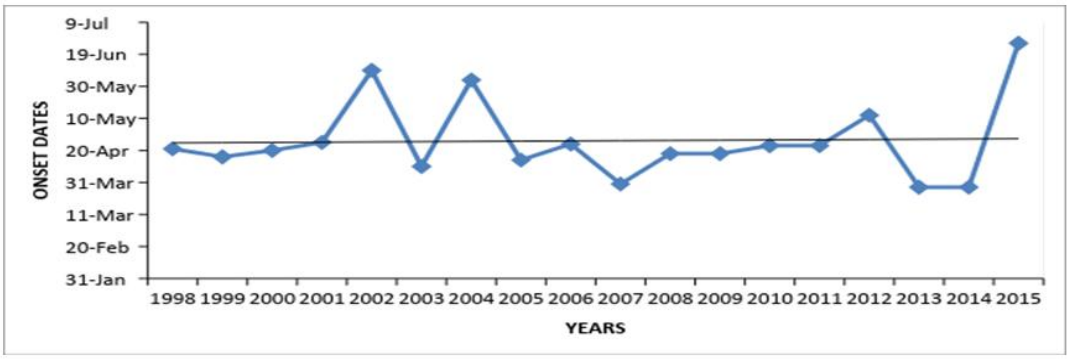

Fig. 34. Onset of rainfall dates in Awe L.G.A point 302

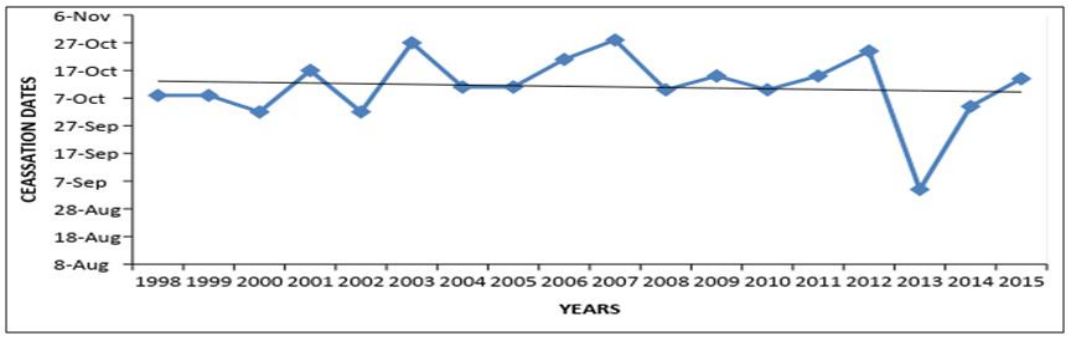

Fig. 35. Cessation of rainfall dates in Awe L.G.A point 302

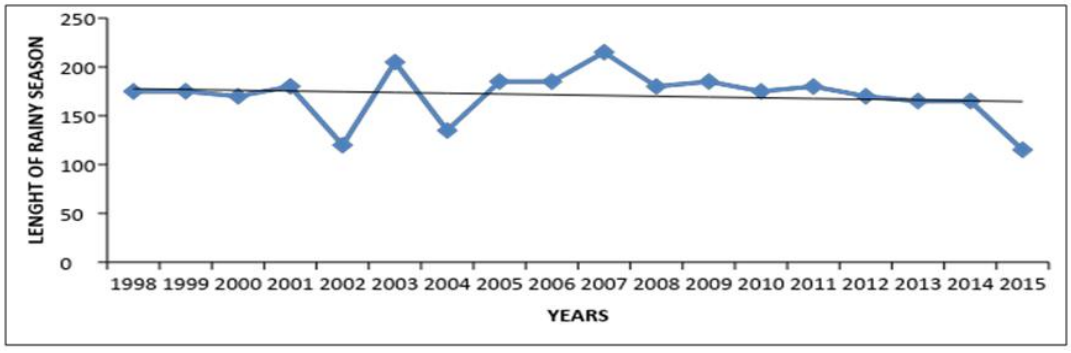

Fig. 36. Length of raining season in in Awe L.G.A point 302

Fig. 34 to Fig. 36 shows the trend of onset of rainfall cessation of rainfall and length of rainy season respectively in point 302 which falls within Awe Local Government Area. It reveals that the onset of rains in this point has a positive trend which implies the date of onset shall be later than the average date of 26th April, it also means, there will be late onset of rains in point 302. The trend in cessation of rains has a negative trend which means the cessation of rains in point 302 shall be on an earlier date than the average date of 11th October, which implies early cessation of rains. While the length of rainy season has a negative trend which means there will be reduction in the length of raining season in point 302.

DOMA L.G.A (TRMM POINT 324)

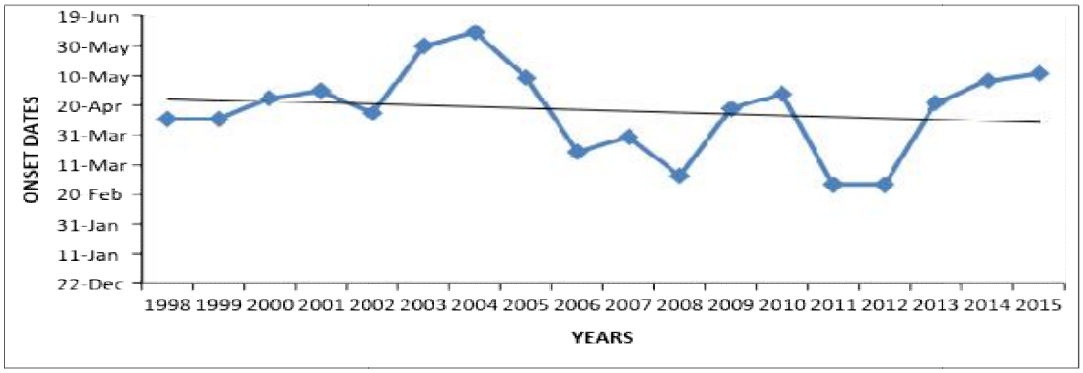

Fig. 37. Onset of rainfall dates point 324

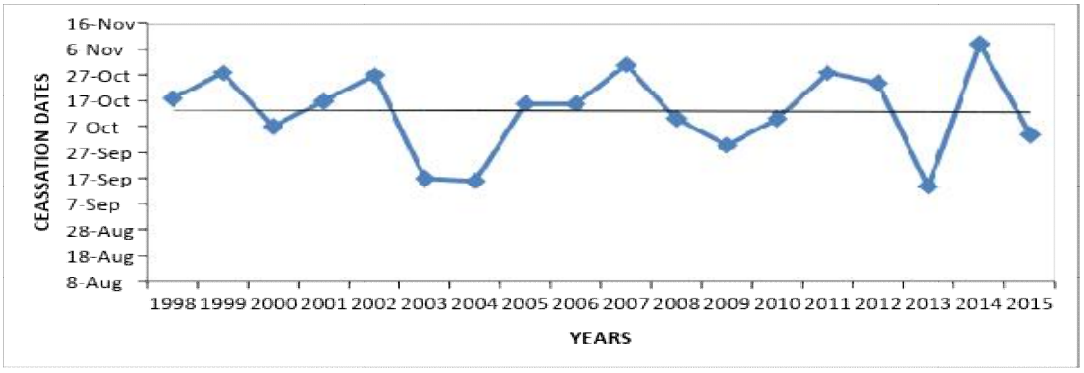

Fig. 38. Cessation of rainfall dates in Doma LGA or point 324

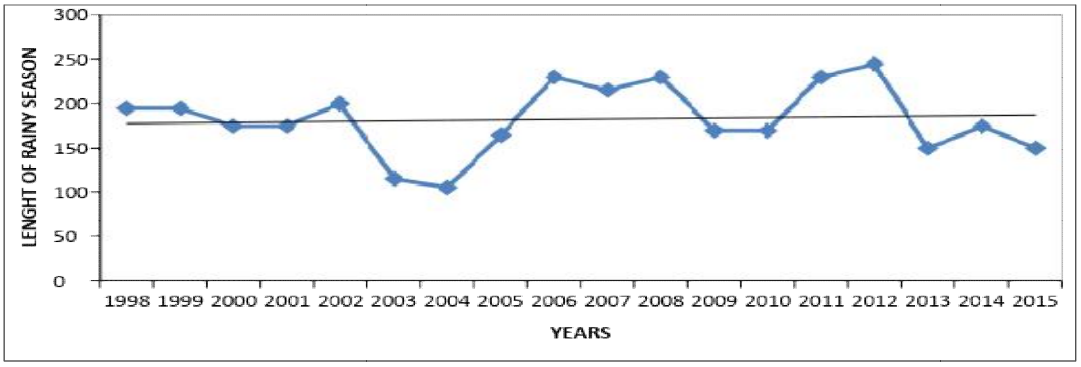

Fig. 39. Length of raining season in Doma LGA or point 324

Table 3. Average dates of onset of rains, cessation of rains and length of rainy season in southern zone

TRMM points	Average onset date	Average cessation dates	Average length of rainy season
277	19-May	16-Oct	153
300	22-May	13-Oct	146
301	21-Apr	16-Oct	183
302	26-Apr	11-Oct	171
324	16-Apr	12-Oct	182

Fig. 37 to Fig. 39 shows the trend of onset of rainfall cessation and length of rainy season respectively in point 324 which correspond to Doma Local Government Area. It reveals that the onset of rains in this point has a negative trend which implies the date on onset shall be earlier than the average date of 16th April. That also means there will be early onset of rains in point 324. The trend in cessation of rains also shows a negative trend, which means the cessation of rains in point 324 shall be earlier than the average date of 12th October, which implies early cessation of rains. While the length of rainy season has a positive trend which means there will be increase in length of rainy season in point 324.

Table 3 shows the distributions of average dates of onset of Rainfall, Cessation of rainfall and Length of rainy Season. The onset dates ranges from 16th April in Doma to 19th May in Lafia. The cessation dates on the other hand ranges from 11th to 16th October, which shows that the differences in cessation date in the zone is not wide, this will give farmers ample opportunity to plan better, knowing fully, Cessation dates are fairly constant. This zone has the longest Length of Rainy Season (LRS) amongst the three zones. LRS ranges from 146 days to 182 days which is equal to 5-6 months. This shows there is a long period of rainfall in this region and hence adequate moisture for rain fed farming in the Zone.

5. CONCLUSION

The study examines the effect of inter annual rainfall variability on precipitation effectiveness in Nasarawa State. It found out that the Cessation dates of rainfall in all zones of the state are almost constant while Onset is highly variable. The Southern zone has the highest Length of Rainy Season with 183 days followed by the Western Zone with 172 and the then Northern Zone with 161days. The summary of the averages of Onset dates, Cessation Date and Length of rainy season date shows that rainfall starts early in the Southern zone on 12th April, followed by Western zone 6th May then the Northern zone 12th May. They cessation date of rainfall is almost the same in all zones with the North and South having cessation dates at 16th October while the west has its cessation date as 18th October. This finding reveals that the date of cessation is more reliable and predictable than onset dates. Onset date that run between April and May in the state is good because they have not moved far from the expected pattern.

The Southern zone has the highest Length of Rainy Season with 183 days followed by the Western Zone with 172 and the then Northern Zone with 161 days. It means in all the zones there is sufficient length of the rainy season that will support agriculture. Because the cessation is almost uniform it makes it easier for farmers to be able to plan their cropping season well in other not to be taken unawares by sudden ceasation of rains.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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