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ANALYSIS OF ONSET AND CESSATION OF RAINFALL IN SOUTHWEST NIGERIA: FOOD SECURITY IMPACT OF OF VARIABILITY IN THE LENGTH OF GROWING SEASON

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Abstract

The analysis of onset and cessation of rainfall for selected locations in South west Nigeria was carried out using daily meteorological data for five synoptic stations (Ikeja, Abeokuta, Ondo, Ibadan and Osogbo) in the region. The FAO Rainfall–Evapotranspiration model was used to elucidate the length of growing season and the impact of climate change on climatic variables and agricultural productivity. Results revealed that the wet season lasts from March to November within the period (2001–2014). The onset and cessation dates varied across the five locations that were considered; Ibadan and Ondo had an early onset of rain while Ondo and Oshogbo had a late cessation, while other stations considered had similar onset and cessation days. The length of the growing season range from 219 – 228 days within the region, this suggests the types of crops that can be supported by the rain fed cropping system predominantly practiced in the region and the number of growing cycles that can be accommodated. The study also revealed that weekly analysis of data gave better result than monthly analysis, while daily analysis did not lead to any useful results. The results are of inestimable value for the planning, organization and execution of agricultural activities in the region and in areas of similar climate around the world.

Keywords

Rain–fed farming, rainfall Onset, cessation, growing season, Nigeria

1. Introduction

Crop production in Nigeria is predominantly rainfed especially in the south west region where irrigation development is very low. The length of growing season had always been uncertain due to high variability of onset and cessation of the wet season [1]. In some years the rains start early, while in other years it arrives late. This yearly variation makes the planning of selection and sowing of crop types and varieties difficult.

The seasonal and inter annual variability of the weather is caused by the El Niño-Southern Oscillation (ENSO) as a result of the shifts in the sea surface temperatures (SST) in the Eastern and Western Equatorial Pacific, coupled with shifts in barometric pressure gradients and wind patterns in the tropical Pacific (the Southern Oscillation); the ENSO phenominon influences rainfall which in turn impacts rainfed crop production system.

Generally, crop yields may suffer significantly with either a late onset or an early cessation of the growing season as well as with a high frequency of dry spells within the growing season. The ability to estimate effectively the actual start of the season therefore becomes vital. In order to plan rainfed agriculture, dependable probability levels of onset date and cessation date of rainfall and length of growing season are important. Climate change has affected rainfall distribution across Sub Saharan Africa (SSA), as there is either less or more rainfall than the farmers have been accustomed to [2]. To make matters worse, the amount of rainfall for a given period can no longer

be predicted accurately. Consequently, farmers are bound to suffer heavy losses due to either inadequate or excessive rainfall. In the case of inadequate rainfall, a well-planned irrigation intervention could be used as an alternative; unfortunately, excessive rainfall is difficult to remedy and it is accompanied by environmental degradation and devastation [3].

In addition, torrential rains that cause flooding does not only destroy crops, livestock and other land resources, they also destroy homes and valuable infrastructure especially roads and bridges. This on the long run hinders the farming populations from markets, which their produce could be sold out to, and also blots access to education and healthcare facilities. The resulting effect is that agricultural growth and farmers' living standards would be seriously compromised. [4] reported that extreme and unusual weather events, resulting in loss of life and property, and disruption of socio-economic activities, are being experienced all over the world. The increasing frequency and intensity of these events constitute a major challenge to socio-economic development, particularly in developing countries. Nigeria is not exempted from this global phenomenon, because wet season is characterized by thunderstorms, strong winds and turbulence at the onset and cessation phases of any wet season therefore timely weather and climate information are vital tools for planning.

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 [5]. 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 [6]. 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 2 weeks or more may be critical to plant germination and/or growth [7].

Several approaches have been developed over the years for analysing the onset, cessation and the length of growing season; according to [8], the techniques used can be broadly grouped into two, namely the direct and indirect methods. The direct methods define growing season using rainfall threshold criteria [9][1][10]. The indirect methods involves the use of rainfall-evapotranspiration model [11], upper wind data [12] and equivalent potential temperature [13]. [14] also proposed a combination of rainfall amount and Normalised Difference Vegetation Index (NDVI) which proved to be effective in south west Nigeria.

The ease of application of the techniques differ in terms of data requirement and depth of analysis; [2] reports that the rainfall-evapotranspiration model pioneered by [3] is by far the easiest to apply.

The approach defined the onset of the rainy season as the date after which mean rainfall amount over any given period of time interval is consistently greater than half of the mean ET over the same period under consideration. The agronomic importance here is that more than 50% of field moisture lost through evapotranspiration can be replenished by rainfall for successful crop growth and development.

This study aims at analysing recent onset and cessation of rainfall in some important agrarian centres in south west Nigeria using the rainfall – evapotranspiration model approach and to determine specific length of growing season for the centres.

2. Materials and Methods

The study area is south west Nigeria, which consist of Lagos, Oyo, Osun, Ondo and Ekiti states. The area lies between lat. 60 32' N – lat. 80 57' N and long. 20 31' E – long. 50 48' N [15], with a total land area of 77, 818 km2. The study area is bounded in the east by Edo and Delta states, in the north by Kwara and Kogi states, in the west by the republic of Benin and in the south by the gulf of Guinea. The climate of southwest Nigeria is tropical in nature and it is characterized by wet and dry seasons.

The mean temperature ranges between 19 °C and 30 °C, while the annual rainfall ranges between 924 mm and 2016 mm; the wet season is associated with the southwest monsoon wind from the Atlantic Ocean while the dry season is associated with the northeast trade wind from the Sahara desert. Figure 1 shows the map of the southwest states of Nigeria.

The meteorological data required for the analysis were sourced from the Nigerian Meteorological Agency (NIMET). A total five synoptic stations in the south west region of Nigeria were selected, namely: Ibadan, Lagos, Abeokuta, Ondo and Osogbo for year 2001 – 2014. Table 1 shows the characteristics of the stations used and the available data for the study. The data set was made up of time series of daily rainfall, daily minimum and maximum temperatures, daily relative humidity and daily solar radiation. The selected stations had continuous records for the years considered (2001 – 2014). Quality control checks were carried out for homogeneity of data set and outliers were removed, missing values were estimated from the mean values obtained from three neighbouring stations. Daily evapotranspiration data were synthesized using the Blaney–criddle model according to [16]:

$$ET_o = P(0.46T + 8.13) \quad (1)$$

Where, ET_0 is known as potential or reference evapotranspiration

P is known as mean daily percentage of annual daytime hours in (%)

T is known as mean air temperature in (°C)

The FAO rainfall–evapotranspiration model [3] was used to analyse onset and cessation of rainfall. The model presented in Eq. (1) defines the onset of rain as the date after which mean rainfall amount over any given period of time interval is consistently greater than half of the mean evapotranspiration over the same period under consideration. It also defines the growing season as any week in the initial period of a wet season within which rainfall amounts totals to at least 25 mm or any 10 day period in the initial period of the wet season with a total amount of at least 30mm and followed by the continuity of rain for good emergence and vegetative of crops. The analysis was carried out using monthly, weekly and daily time step to determine the most appropriate approach.
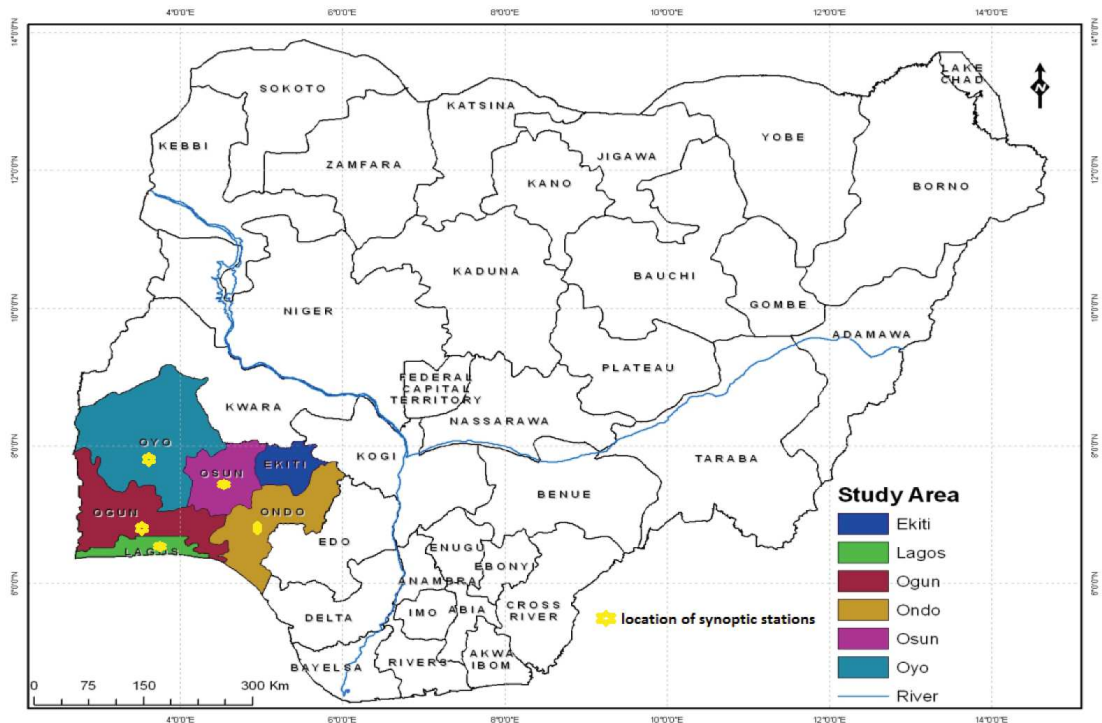
Figure 1. Study locations in Nigeria

Table 1. Characteristics of selected synoptic stations [4]

Station name	Station No.	Latitude	Longitude	Elevation a.m.s.l. (m)	Record (years)	Available Data
Lagos	65203	6^0 27' N	3^0 24' E	14	10	R, T_{min}, T_{max}, RH,
Ondo	65222	7^0 6' N	4^0 50' E	287.3	10	R, T_{min}, T_{max}, RH, SR
Ibadan	65208	7^0 26' N	3^0 54' E	229.2	10	R, T_{min}, T_{max}, RH, SR
Abeokuta	65213	7^0 10' N	3^0 20' E	104	10	R, T_{min}, T_{max}, RH, SR
Oshogbo	65215	7^0 47' N	4^0 29' E	302	10	R, T_{min}, T_{max}, RH,

R indicates rainfall, T_{min} is minimum temp., T_{max} is maximum temp., RH is relative humidity and SR is solar radiation

3. Result and discussions

Characteristics of rainfall in south west Nigeria

Figures 2 and 3 shows the annual trend and distribution of rainfall at the five stations, close observation revealed that rainfall has a marked variability within the period. Annual total rainfall ranged between 849 mm (Abeokuta) to 2,207 mm (Lagos), further analysis show that year 2001 presented the least rainfall while 2010 has the highest rainfall. The implication of this is that year 2010 presented an opportunity for increased food

production and at the same time has the highest risk for flooding and environmental degradation. The fact that Abeokuta has the least rainfall in the region is a surprise despite its proximity to the station with the highest rainfall (Lagos) and its low elevation (130 m above mean sea level). The reason for this is largely unknown but it is suspected that this might be due to the evolving derived savannah vegetation status of the area; however, this claim needs to be investigated. Local experience has shown that rainfall in Abeokuta and environ has been largely orographic in nature owing to the numerous granitic rock outcrops wide spread in the town. This point to the fact that rainfall will be highly variable, erratic and unevenly distributed.
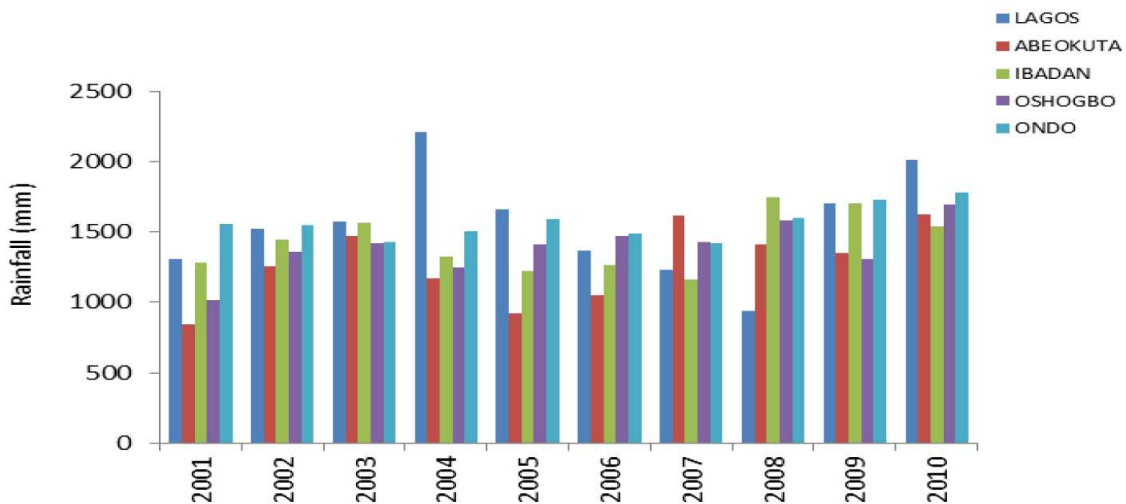

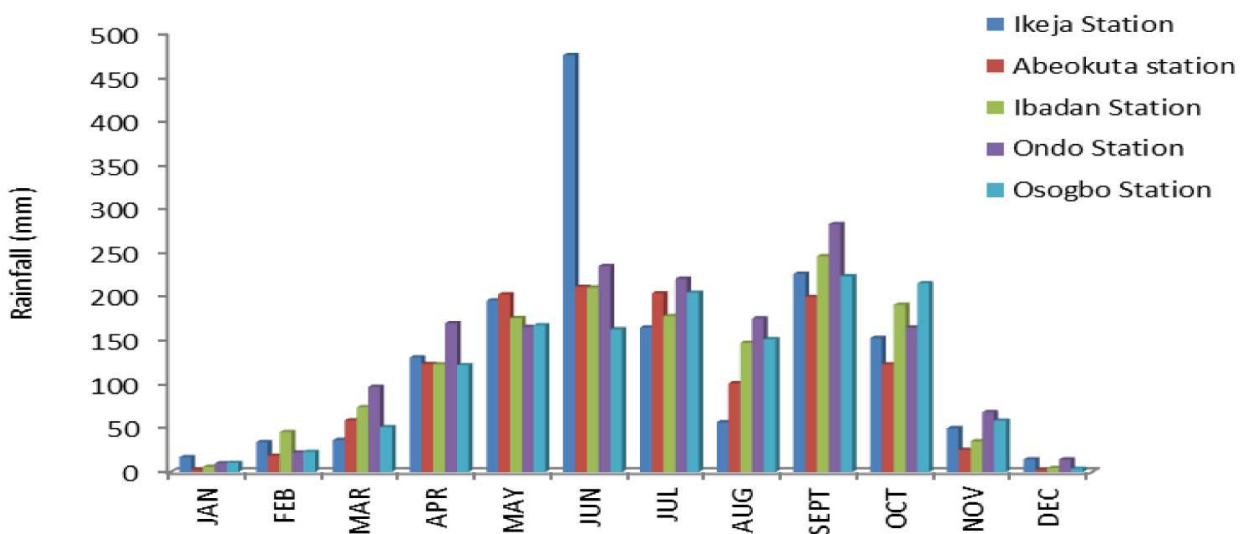Figure 2. Annual totals of Rainfall in the Southwest

Figure 3. Monthly Rainfall distribution in southwest Nigeria (2001-2014)

The rainfall regime in the region within the decade was found to still follow the traditional double maxima characteristics, it should however be noted that the marked short dry spell usually experienced in the month of August is fast disappearing owing to climate change, this can easily be seen in figure 3. The analysis of rainfall occurrence in the month of August shows that Lagos has the lowest rainfall values followed by Abeokuta, other stations show evidence of appreciate rainfall values revealing that the August break is already cancelling out in the region. The month of June experienced more rainfall than any other month at Lagos station with a maximum rainfall of 475 mm. In the month of January, Abeokuta has the lowest rainfall of all the stations followed by Ibadan, Ondo, Osogbo and Lagos respectively. The second rainfall maxima occurred in the month of September across the region. It was also noticed that the amount of rainfall in November and December dropped sharply due to the dry season.

Onset and Cessation of Rainfall

Daily analysis of the rainfall data did not produce any significant result of the dates of onset and cessation of rainfall, showing that precise identification of the point where rainfall amount will be greater than half of the mean evapotranspiration is not feasible; this suggest that applying daily rainfall and evaporation data for the FAO model is impracticable. Monthly data analyses on the other hand produced useful results but do not lend itself to accurate estimation of onset and cessation dates as can be seen in Figure 4; when weekly analysis was implemented, the results were very satisfactory as the days when onset and cessation of rainfall occured were clearly identified. The onset and cessation dates varied across the five locations that were considered; Ibadan and Ondo had an early onset while Ondo and Oshogbo had a late cessation of rain. Other stations had similar onsets and cessation days as shown in Table 2, it is however surprising that Lagos being the closest to the Atlantic ocean and the most southern location had its onset date falling on April 2 behind Ibadan and Ondo.

The fact that Lagos received the largest amount of rainfall in the decade makes this discovery a subject of further research.
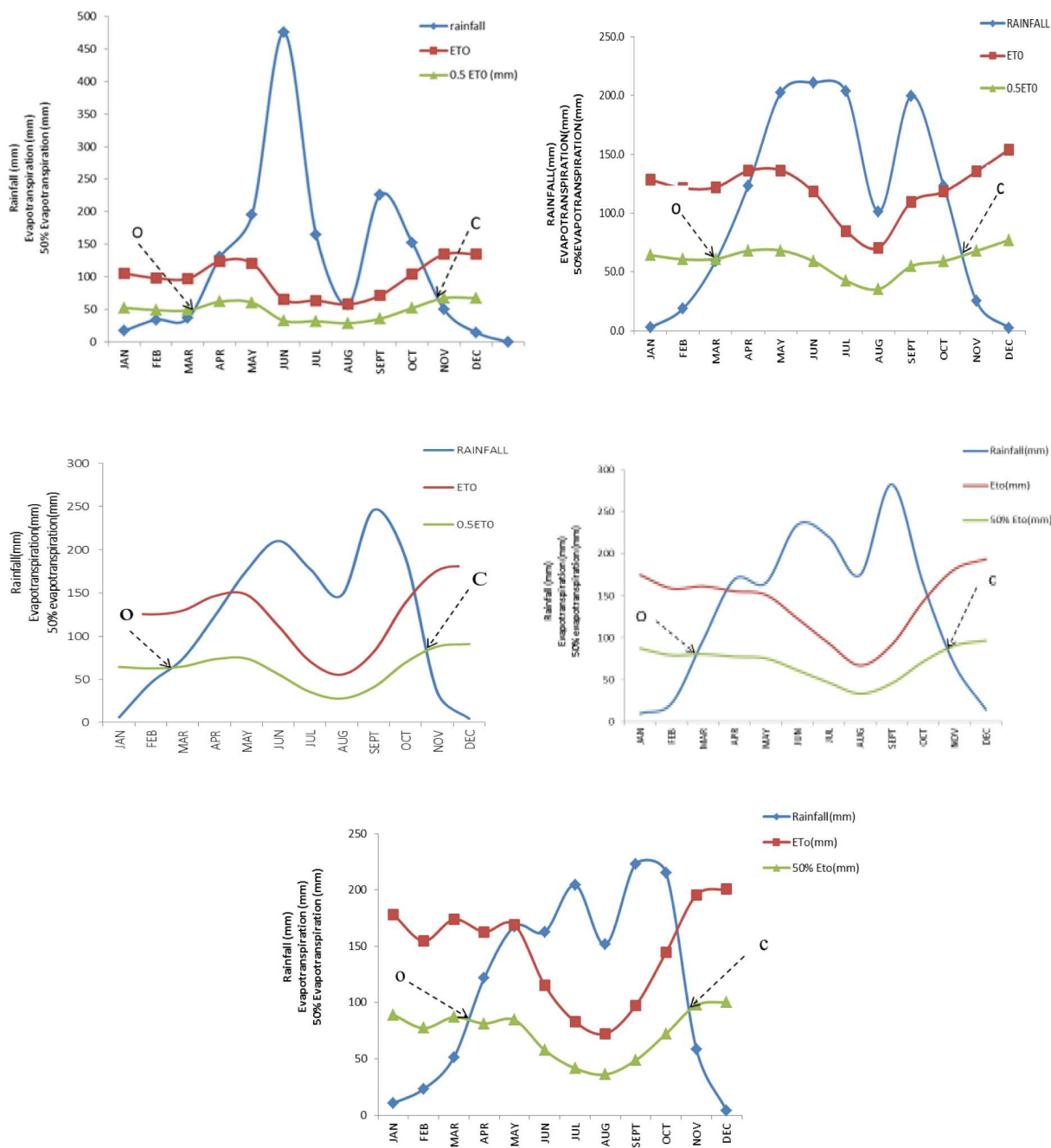

Figure 4: Onset and cessation of rainfall at selected stations in south west Nigeria

The length of the growing season was found to range between 219 – 228 days within the period of study, indicating the types of crops that could be sown and the number of cycles of such crops that can be accommodated in the season.

Food security impact of variability in the length of growing season

Sub Saharan Africa have been reported to be one of the most susceptible and vulnerable region to variability in the length of growing season; the sub region have large populations of the poor with very low access to basic resources such as irrigation water and productive land [17]. Projections show that by 2020, between 75 and 250 million people in Africa will be exposed to increased water stress and in some countries, yields from rainfed agriculture could be reduced by 50 percent.

The information above is stagerring and require pragmatic efforts to address the expected shortfall in food production. [18] reports that crop yield is more sensitive to the precipitation than temperature, hence the need to give adequate attention to the length of growing season in all affected areas; the observed variability in the length of the growing season cannot be modified in any way but can be adapted to by the practice of climate smart production systems and strategies. One of such strategies lies in the choice of crops to plant; because of the reducing length of growing season, certain crops may no longer be supported by rainfed production, necessitating a change in the cropping calendar.

For example, for a hypothetical choice of a crop like maize which is commonly grown in sub saharan Africa and with days to maturity ranging from 80 – 90 days depending on variety; the observed length of the growing season in southwest nigeria will only be able to accommodate two production cycles of maize conveniently unlike what obtains in the past when three cycles were possible. Obviously, the climate has changed and its effects on our agricultural production systems are very evident and will have its toll on food security.

Another strategy is to enhance irrigation development; this will provide supplemental water to crops and increase the growing season. At present, irrigation practice is not well developed in the study area in sharp contrast with the northern parts of Nigeria, despite the fact that the area is water rich. State governments in the region needs to harness the water resources of the region and invest in irrigation so as to engage the army of jobless youths in the region and enhance food security.

Table 2. Summary of Rainfall onset and cessation dates in southwest Nigeria (2001 – 2014)

Station Name	Location	Onset Date	cessation Date	Length of growing Season (days)
Lagos	Lat. 6^0 27' N, Long. 3^0 24' E	April 2	November 7	219
Abeokuta	Lat. 7^0 10' N, Long. 3^0 20' E	April 1	November 8	222
Ibadan	Lat. 7^0 26' N, Long. 3^0 54' E	March 30	November 9	224
Ondo	Lat. 7^0 6' N, Long. 4^0 50' E	March 30	November 13	228
Osogbo	Lat. 7^0 47' N, Long. 4^0 29' E	April 3	November 10	221

In low-rainfall areas where moisture stress is expected to remain a primary constraint on plant growth, [19] suggested planting faster-maturing crop varieties that avoid drought or heat stress during sensitive stages of plant growth, such as flowering or grain filling.

Developing faster-maturing varieties of crops for areas with short and highly variable rainy seasons should be the goal of crop breeding programs, and such a strategy would seem promising anywhere climate change is expected to shorten the length of growing seasons.

It is equally advisable to promote crop switching by farmers in order to plant crop varieties that are more tolerant to the new climate regime, this might be a little difficult but must be promoted. Farmers in Sub Saharan Africa do not easily yield to changing old, unprofitable ways for the new; much persuasion need to be done through extension services and incentives.

4. Conclusion

The onset and cessation of rainfall in the South western region of Nigeria was evaluated using the FAO rainfall – evapotranspiration model. Results revealed that the onset dates range from March 30th – April 3rd, while cessation of rain occurs between November 7th – 13th across the region. The length of the growing season was found to range from 219 – 228 days for the period of study, this suggest the types of crops can be supported by a rain fed system and the number of growing cycles that can be accommodated

in the region. The implication of these is that the climate in the region has actually changed as projected by IPCC; south western part of Nigeria is located within the rain forest vegetation belt where rain falls for at least nine months in the past, but appreciable rainfall that could support crop cultivation is now limited to seven months within the year. This occurence has substantial implication for food security in the region. The results obtained are of inestimable value for the planning, organization and execution of agricultural activities; timely preparations can now be made to mobilise man power, seed and other relevant agricultural inputs in order to achieve effective crop yield. The results also underscores the need for enhancing irrigation development in the region; at present, irrigation development is at a sub optimal level. If the desired food security must be achieved, then appropriate measures must be implemented to enhance irrigation of crops that will suite the small holder farming commonly practiced in the region and to increase the length of growing season. The new rainfall regime observed would also warrant farmers to be encouraged to switch to crops that could be accomodated by the present growing season; government has a great role to play in order to achieve this, if food security must be achieved in the region.

Acknowledgement

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