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ON DETERMINING EFFECTIVE ONSET RAINFALL AND ITS VARIABILITY OVER SOKOTO, NIGERIA (1971-2015)

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ABSTRACT

Peasant crop farming is the major economic activity especially in the Sahel and sub-humid area of Africa whose fortunes can easily be affected by fluctuations in the rainfall regime. In the light of the above this study investigated the historical record rainfall data to determine effective onset rainfall and its variability over Sokoto. Daily rainfall data of 1971-2015 were acquired from Environmental Management Programme Federal University of Technology Minna. A drought monitoring and Early Warning (EW) methodology based on an Intra-seasonal Rainfall Monitoring Index (IRMI) were adopted. The findings revealed that effective onset rainfall have been variable with the mean onset date at 40th pentad (20th July). The years with an early onset date were found to have higher rainfall distribution and intensity (figure $3a - i$). Of the two rainfall extreme (flood and drought), the result revealed a prevalence of drought (table 2). The mild drought ($0.1 < IRMI \leq 1$) revealed 28%, severe drought ($0.010 < IRMI \leq 0.1$) 8% and very severe drought ($IRMI \leq 0.01$) representing 7%. Owning to variability in the inter-seasonal onset rainfall we recommend a continue monitoring of the rainfall scenarios to effectively communicated it exact effective date to rain-fed farmers for proper agricultural planning in the region.

Keywords: Onset Rainfall, Inter-Seasonal Variability, Intra-Seasonal Variability, Drought

1 Introduction

Rainfall onset is defined as the period, at the beginning of the rainy season, when rainfall distribution has become adequate for crop development (Odekunle, *et al* 2005). Of all the climate parameters, rainfall is said to be a major input which significantly impacts on socio-economic wellbeing of the population who depend on rain-fed agriculture (Recha, et al., 2012). The rainfall over Sokoto is understood to show high temporal and spatial variability on a wide range of scales. The implication of this is that the large rural population of the area, who mainly depend on rain-fed agriculture, are greatly influenced by climate variability.

It is noted generally that considerable studies exist on onset rainfall in marginal and sub-humid areas of West Africa (Recha, et al., (2012), Hachigonta, *et al*, (2008), Odekunle *et al* (2005), Camberlin and Okoola, (2003), Omotosho, *et al*, (2000), and Usman (2000)). Most of the methods adopted to determined onset rainfall in marginal and sub-humid areas of West Africa employed cumulative percentage mean rainfall to generate the rainfall onset when the value exceeds a given threshold. These methods only consider cumulative totals, with little or no consideration for the spread over time, which is the most important stress factor for plants. Similarly, most of these methods has been mainly concerned with onset and cessation date. Other methods within this study area have used cumulative rainfall and defined the onset of rains as the end of a 30-day period within which one decade with at least 25 mm of rain is followed by two consecutive decades where at least 20 mm of rain falls. The weakness of this scheme is that after the first rainfall event, the farmer may need to wait another 30 days to know whether the onset of the rains has occurred. This may be worrisome as it is understood that in rain-dependent farming regimes, time is of critical essence and this period of indecision is one farmer can ill afford (Tadross et al. 2003).

The pertinent issues remain as to what happen to the rainfall in between the onset and the cessation. This worth investigating as it has been revealed that a high frequency of damaging dry spells within the growing season can set in (Mugalavai, *et al*, 2008). In addition, the onset date of the rainy season as well as other characteristics such as the number of dry spells within it are understood to be typically of more interest and applicability than seasonal rainfall totals to user groups such as farmers, water resource managers and health and tourism officials (Hachigonta, *et al*, 2008).

In this study, we determine the onset date, it's inter-seasonal and intra-seasonal variability within the growing seasons of 1st May to 30th October each year.

2 Materials and Methods

2.1 Data Used

The daily rainfall data for the period of 1971-2015 from globally reference meteorological stations of Sokoto were acquired from Environmental Management Programme of Federal University of Technology Minna.

2.2 Data Analysis

To achieve objective of this study, a drought monitoring and Early Warning (EW) methodology based on an Intra-seasonal Rainfall Monitoring Index (IRMI) developed by (Usman & Abdulkair, 2013) were adopted. IRMI is a tool for determining the real onset date of the summer monsoon rains. IRMI were computed on a pentad-by-pentad basis from the beginning of May using the expression here under:

$$IRMI = \frac{(Cpt)^2}{(hpt \times Nb \times 100)}$$

Cpt = Cumulative pentad rainfall since May 1

hpt = The highest pentad total rainfall since May 1

Nb = Number of breaks in rainfall (pentads with less than 5mm of rainfall) and

100 = a factor

The 'actual' or 'real' onset of rains is taken as the pentad within which the index is ≥ 1 for the first time. IRMI is classified to indicate abundant, adequate, deficient, very deficient and extremely deficient moisture conditions (see table 1). Similarly the inter-seasonal variability were calculated by subtracting the succeeding onset date from the previous. The value is negative if the preceding onset rainfall date were earlier to succeeding onset date and the reverse is true if the succeeding

onset date were earlier. In addition the average onset pentad value were subtracted from the actual onset pentad to give the deviation from the mean.

Table 1 IRMI based drought-monitoring scheme

On set classification categories		Rainfall receipt (moisture supply condition)	Hazard
IRMI ranges		IRMI classes	
IRMI>10	1	Abundant (high rainfall total within short time spans)	Flood
1<IRMI≤10	2	Adequate	No drought, No flood
0.1<IRMI≤1	3	Deficient	Mild drought
0.010.01<IRMI≤0.1	4	Very deficient	Severe drought
IRMI≤0.01	5	Extremely deficient (low rainfall totals over long time spans)	Very severe drought

Sources: *Adopted from Usman and Abdulkadir (2014)*

3 Results and Discussion

3.1 Effective Onset Date

The effective onset date is depicted in figure 1. The average onset date within the considered period is 40 pentad (20th July). The best onset date is found in 1997 (27 pentad corresponding to 15th May). The worst onset date is found in 1987 (49 pentad corresponding to 5th September). The pattern of the onset date reveal high rate of variability between seasons. The general onset pattern in the study area is reveal to be poor as Usman & Abdulkadir, (2014) noted that **"if rainfall is not effective before pentad 36 (30 June), it should be an indication of a problem of some sort as this will impact negatively on the length of the growing season and should be used to issue an advisory statement to farmers and similarly if effective onset of rain is at about pentad 41 (25 July), this should be an indication of deficient moisture conditions".**

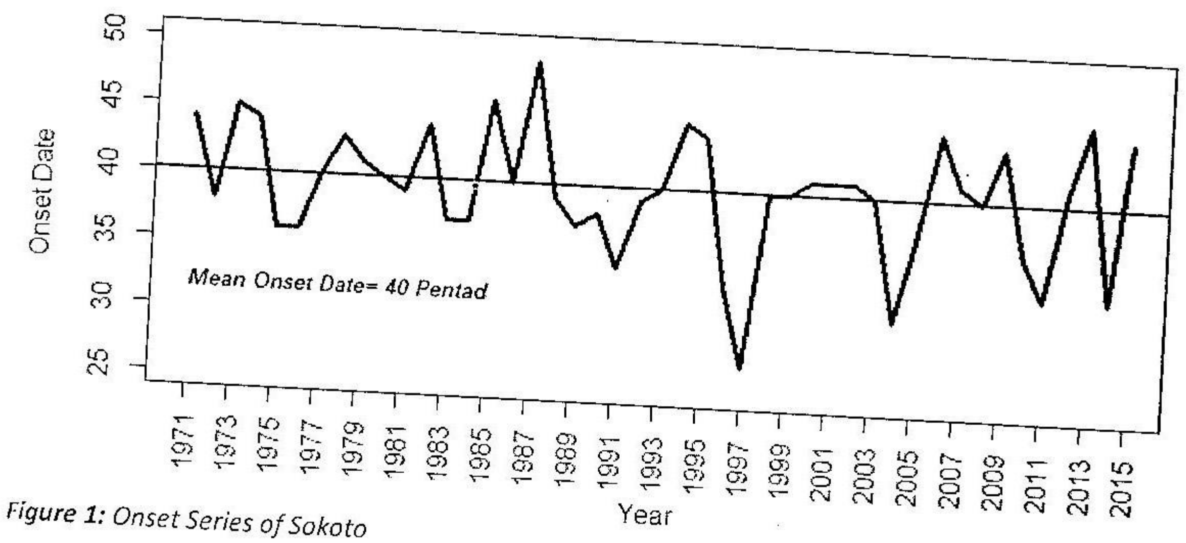


Figure 1: Onset Series of Sokoto

3.2 Deviation and Inter-seasonal Differences

The uncertainty to which rain-fed farmers are exposed to seasonal wise is depicted in Figure 2. The figure shows both the inter-seasonal variability as well as deviation from mean of onset date. Years with negative value indicated that the onset date were earlier compare to the preceding years. The year 1973, 1977, 1978, 1982, 1985, 1987, 1990, 1992, 1993, 1994, 1998, 2000, 2005, 2006, 2009, 2012, 2013 and 2015 all demonstrated this. The remaining years within the considered period show the reverse.

The figure 2 also indicated positive and negative deviation of onset rainfall date from the mean. The negatives value in year 1996, 1997, 2004, 2005, 2006, 2010, 2011 and 2014 indicated below the mean onset rainfall date while remaining positive values reveal above the mean onset rainfall date. Generally, the Figure 2 show high uncertainty in the onset of rainfall between seasons. The implication of this is that inter-seasonal variability (degree of uncertainty) got progressively worse and it is believed to have caused tremendous difficulties to the farmers.

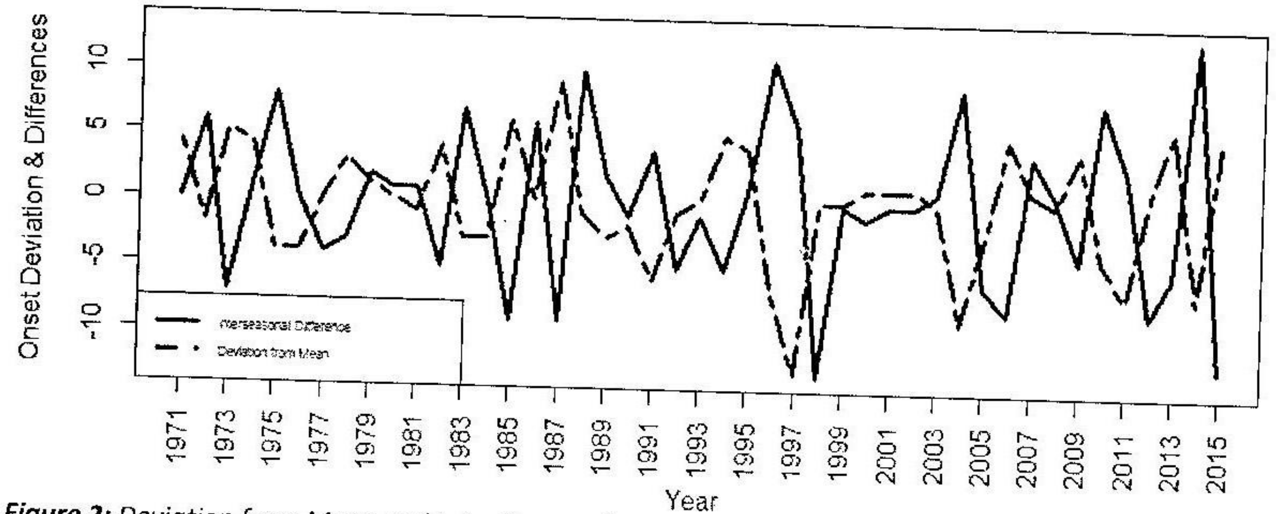


Figure 2: Deviation from Mean and Inter-Seasonal Variability of Onset

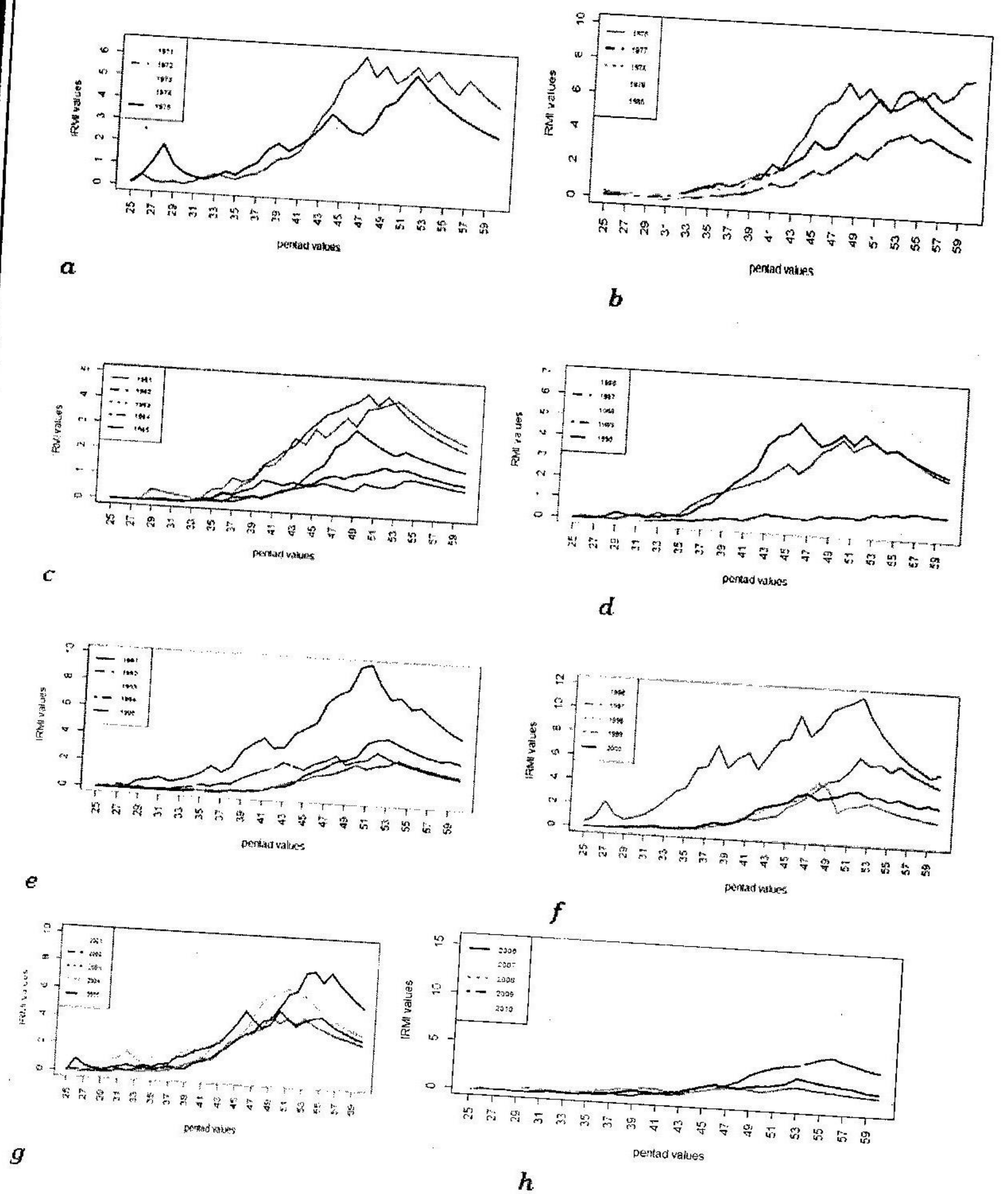
3.3 Intra-Seasonal Variability

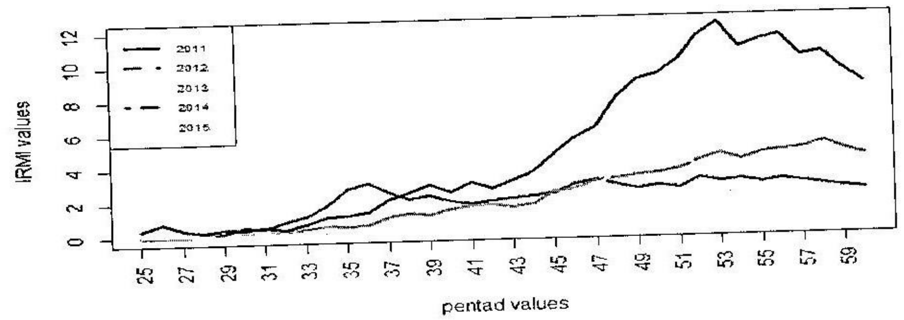
The intra-seasonal variability of each season are depicted in figure 3 $-i$. From figure 3 $a-i$ it is clear that those years with early onset in comparison with others tend to have higher rainfall in term of distribution and intensity seasonal wise. Thus, this confirm other studies (Omotosho 2002, Sivakumar 1988) that the length of the rainy season is more dependent on the rainfall onset than its cessation. The year 1972, 1983, 1991, 1987, 2010 and 2014 demonstrated the above statement.

Table 2 showed the hazard classification of the entire seasonal rainfall. On seasonal basis the study area has not witnessed many flood event as the index value must be greater than 10. However year 1991, 1997, 2010 and 2014 witnessed flood within a short span. This represent 2% of the entire seasonal rainfall within the historical period of 1971-2015. Incidentally, 1997 coincided with the best onset rainfall date within the considered years. The table 2 indicated the seasonal rainfall of the study area have been generally normal (No drought, No flood 1<IRMI≤10). This represent 55% of the seasonal rainfall. Of the two hydrological extremes (flood and drought), drought appear to be more prevalence within the study area. Within the

drought categories, mild drought (0.1<IRMI≤1) is the highest with 28%. This is followed by severe drought (0.010<IRMI≤0.1) 8% and very severe drought (IRMI≤0.01) representing 7%.

The year 1973, 1978 1987 1988 1994 and 2003 are most significance as they revealed major severe drought events





i.

Figure 3: *$a - i$ Sokoto Seasonal IRMI Pattern (These figures are available in colour online)*

Table 2. . IRMI based seasonal rainfall classification of Sokoto

IRMI ranges	Frequency	Percentages (%)	Hazard
IRMI>10	28	2	Flood
1<IRMI≤10	891	55	No drought, No flood
0.1<IRMI≤1	460	28	Mild drought
0.010.01<IRMI≤0.1	124	8	Severe drought
IRMI≤0.01	117	7	Very severe
Total	**1620**	**100**	

4 Conclusion

The study examine effective onset rainfall, inter-seasonal and intra-seasonal variability over Sokoto. The average effective onset is found to be 40th pentad (20th July). The best and worst case scenarios of onset rainfall were found in year 1997 and 1987. The onset rainfall date demonstrate high variability. The general pattern of the intra-seasonal rainfall indicated that years with early rainfall compare to others had higher rainfall distribution and intensity thus, confirming other study that the length of the rainy season is more dependent on the rainfall onset than its cessation. General findings indicated that mild to severe drought have been common within the study area. To overcome the high variability in the inter-seasonal onset rainfall, we recommend a continue monitoring of the rainfall scenarios to effectively communicated, its exact effective date to rain-fed farmers.

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