Effect of Breaks and Dry Spell Occurrence on Moisture Effectiveness in Minna, Niger State.

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Abstract

The performance of any rainfall season depends on not just the amount of rainfall received, but also on the seasonal distribution which signify the need categorize moisture stress (breaks and dry spell) and its on moisture effectiveness in such season. This study examined the effects of break occurrences on the intra-seasonal characteristics of rainy seasons in Minna, Niger State. Daily rainfall records of fifteen (15) years (2000-2014) were analyzed using Intra-seasonal Rainfall Monitoring Index (IRMI) to derived onset and cessation dates, break frequencies, dry spell and drought. The result showed that the average number of break occurrence per each rainy season in Minna is 7 breaks per season with the highest record of 12 breaks in the year 2005 while the least recorded occurrence within the period under review is 4 breaks which occurred in 2011 and 2012. The frequency of breaks occurrence within the 15 years period produced a total of 6 dry spells, with the year 2005 accounting for 3 of the dry spells and a single record of mild drought was recorded in May the same year. Also, the result signals the potential of IRMI in capturing breaks, dry spell and drought during the growing season. Generally, breaks and dry spell plays significant role in the seasonal moisture effectiveness as prolonged cases of breaks and dry spell constitute seasonal hazard to crops development as soil moisture will decline and may eventually dry up which could lead to crop failure. This is an indication for the development and adoption of crop species that are resistance to moisture stress for sustainable crop production and enhance livelihood.

Keywords: Rainfall, Breaks, Dry spell, Drought and Moisture Effectiveness

Introduction

The impact of erratic moisture on crop and animal is a threat to sustainable agriculture and attainment of food security across Niger State because of the predominance of rain-fed agriculture which is highly sensitive to inconsistency in rainfall. The livelihoods of rural communities across the state are usually at risk of water-deficits/surplus impact due to little/prolong breaks that may result to dry spell, drought and flood in severe cases. Climate change cannot be totally avoided; hence, adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts is of

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paramount importance (Asnake 2015). Fundamentally, the short-term variability of rainfall is a major risk factor to rain-fed agriculture as insufficient and unreliable rainfall have continued intensify soil moisture deficits while surplus moisture escalate flood thus, increasing seasonal rainfall-related hazard in recent times.

Rainfall is a renewable natural resource, highly variable in space and time and subject to depletion or enhancement due to both natural and anthropogenic causes (Abaje, 2010). Smallholder farmers (including herders and fishers) which are mainly the rural poor depend on moisture effectiveness to make a living thus, its uncertainty will aggravate rural poverty. Climate is, with particular reference to rainfall, known to be changing worldwide and there has been growing concern as to the direction and effects of these changes on settlement and infrastructures (Chaponniere and Smokhtin, 2006). The effect of these variations is not just restricted to changes in settlement and infrastructures alone, food security as well as water supply which are part of the major fundamental needs of a man is also on the threat list. Thus, rain-fed activities and processes such as agriculture, hydrological resources such as streams, rivers and ponds that are mainly rain-fed; are adversely affected by variations in rainfall (Onyenechere *et al.* 2011).

Recent short-term climatic variability and most particularly rainfall fluctuations are becoming increasingly of concern to the government and the people. This is because rainfall variability determines the planning horizons of agriculture, water resources and many government and judicial processes (Yusuf, 2011). Previous studies and researches have also proven that rainfall intensity is very high between the months of July and August. As a result, even though the environment is generally dry, crops are frequently lost through too much rain. It also results in rapid surface run-off, soil erosion and water-logging (Ati *et al.*, 2009). The study of rainfall variability in relation to the quality of rainfall received in a particular location over a given period of time is quite complex justifying the need for a critical in-depth study of the intra-seasonal characteristics of the rainy seasons. Intra seasonal rainfall variability refers to the in-depth study of the quantity and quality of rainfall received in a particular geographical location within a specific growing season. On the other hand, the much-needed information on inter-/intra-seasonal variability of rainfall in the region is still inadequate despite its critical implication on soil-water distribution, water use efficiency (WUE), nutrient use efficiency (NUE), and final crop yield (Oscar, 2015). This Identify the internal variations that may be experienced within a given rainy season and it examines the nature and occurrence of rainfall parameters within the particular given rainy season as well as their interplay in determining the quality of moisture available in the soil to sustain effective crop growth.

The performance of any rainfall season depends on not just the amount of rainfall received, but also on the seasonal distribution which brings about the role of breaks and dry spell in the effectiveness of such a season. It is also important to note that the subject of seasonal rains constitute the most important modulator of socio-economic activities in semi-arid and dry sub-humid areas of Nigeria. In Minna, peasant crop farming is a major economic activity whose fortune can easily be affected by fluctuations in the rainfall regime. Thus, the socio-economic wellbeing of the inhabitants is largely a function of the performance of the seasonal rains (Usman and Abdulkadir 2013).

The Study Area

Minna is the headquarters of Chanchaga Local Government area and the capital city of the state respectively. It lies between Latitude 09^{0} 40^{1} 7.63^{II} N to Latitude 09^{0} 39^{1} 59.72^{II} N and longitude 06^0 30^I 0.32^{II} E to Longitude 06^0 36^1 34.05^{II} N. Minna lies on a valley bed (i.e. lowland) bordered to the east by Paida hill stretching eastwards towards Maitumbi and essentially savannah and quite conducive for farming. It bordered by Wushishi and Gbako to the west, Shiroro to the North, Paikoro to the East and Katcha to the south (Fig 1.2). Minna possesses the tropical continental wet and dry climate based on the Koppen classification scheme and is characterized with two distinct seasons, namely the wet season which begins around March and runs through October and as well as a dry season which begins from October to March. Minna has a mean annual rainfall of 1334mm with September recording the highest rain of close to 330mm on the average while the least amount of rainfall occurs in December and January which can be as low as 1mm.

The monthly rainfall is often intensified during the months of July, August and September. The variation in precipitation between the driest and the wettest month is averaged around 259mm, temperature also varies by 5.2^0 C throughout the year (climate-data.org). In terms of ethnicity and culture, the three principal ethnic groups of the state are the Nupe, the Gwari and Hausa. Other groups include the Koro, Kadara, Kamuku, Pangu, Bauchi, Fulani, Dukawa, Gade, Godara, Ganagana, Dukawa, Mauchi, Ayadi, Ingwai, Dibo, Kadanda, Gulengi, Abishiwa and Shigini (Aminu, 2010).

Materials and Methods

Daily rainfall records of fifteen years (2000-2014) were obtained from the Nigerian Meteorological Agency, Minna Synoptic Office and Geography Department, Federal University of Technology, Minna. From this record, the rainfall effectiveness for minna and the environs was computed using the Intra-seasonal Rainfall Monitoring Index (IRMI) Usman and Abdulkadir (2013) to identify breaks and dry spell and its possible effect on moisture effectiveness. The onset dates as well as the cessation dates were first determined for each seasons followed by the number of breaks occurrence within each season as well as dry spell and drought occurrence as the case may be.

Intra-seasonal Rainfall Monitoring Index (IRMI)

This rainfall-only scheme is effective in observing the performance of rainfall right from its effective onset to the cessation which makes it suitable for monitoring the seasonal spread of rain within a particular rainy season (Usman and Abdulkadir 2013). Observed daily rainfall totals (2000-2014) were aggregated into pentad totals for computation of IRMI at pentad level. This scheme comprises of three basic elements, the cumulative pentad total which is calculated at each pentad starting from the 25th pentad, the highest pentad total noted at every pentad which is the highest from previous estimation and lastly the number of break occurrence within the rainy season after the estimation of onset and cessation dates. All the three elements were combined to compute the index using the expression below:

$$\textbf{IRMI} = {(\boldsymbol{Cpt^2})} \Big/ {(\boldsymbol{hpt\ X\ Nb\ X\ 100})} \qquad \textbf{(1.1)}$$

Where Cpt = cumulative pentad rainfall since April 1,
hpt = highest pentad total rainfall since April 1,
Nb = number of breaks in rainfall,
100 = a factor.

As described by Usman (1999), any pentad with less than 5mm of rainfall from the first of May of each year after effective onset was taken as a break. The first of May (the 25th pentad of the year from first of January) was taken as the pentad of reference for this research. This choice was in line with the views of Sultan & Janicot, (2000) and Usman & Abdulkadir, (2013). As for dry spell, there are several methods for deriving dry spell; some are 5, 10 or 15days. For the purpose of this research, dry spell was taken as any two consecutive breaks within a growing season after the onset of rain till its cessation that is 10 days dry spell. A drought condition was recorded as any scenario where there are more than 3 consecutive breaks within a growing season.

The intra-seasonal rainfall monitoring index (IRMI) values were used for the analysis of the intra-seasonal rainfall variability from year 2000 – 2014, these were also plotted graphically and the 15 years IRMI values were grouped into 3 categories of 5 years each for simplicity. Furthermore, IRMI values and Cumulative pentad total (Ogive) were plotted graphically to determine and compare their effectiveness in capturing breaks and dry spell efficiently, timely and adequately. Number of breaks and dry spell occurrences per each rainy season were determined from the computed IRMI. Consecutive occurrences of breaks during the growing season were used to determine dry spell.

Results and Discussion

The intra-seasonal rainfall monitoring index graph for year 2000-2004 reveals that most of the growing seasons were characterized with breaks which could adversely affects germination and growth of crops (figure 1). This is supported by findings of Solomon et al. (2013) which shows that precipitation effectiveness indices are the major control of crop yield in the West African savannah region. It is evident from the graph that IRMI capture breaks adequately, the points at which the line drops from onset to cessation are indication of breaks which are as result of drops in IRMI values. These depicted the effect on moisture effectiveness particularly, in 2002 before cessation and 2004 after effective onset with sharp drops when compared to the pattern observed from the other years.

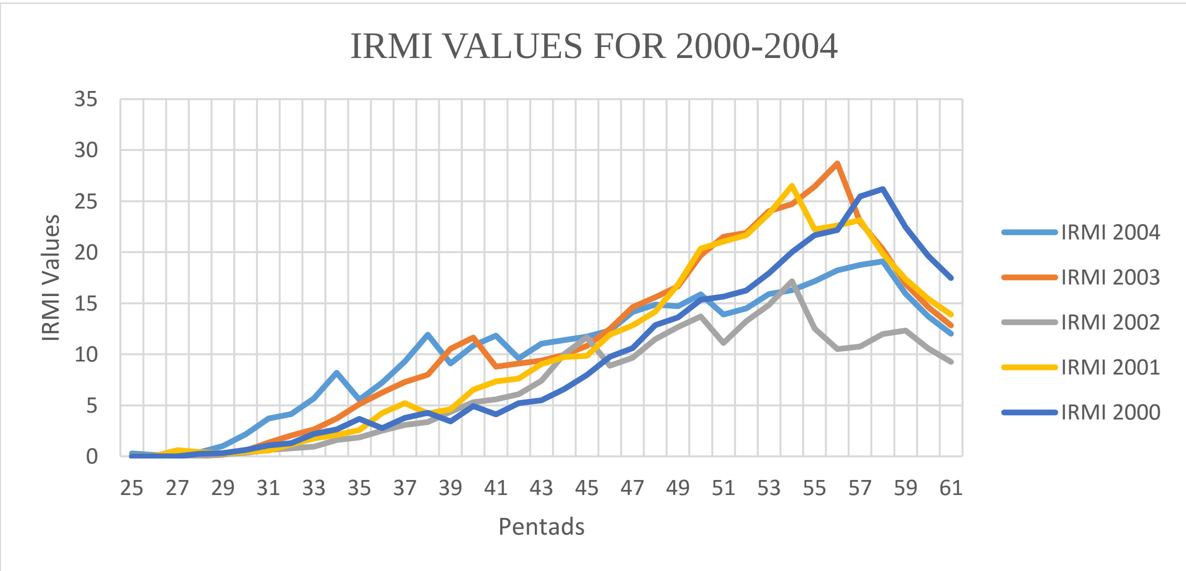

Figure 1: Intra-seasonal Rainfall Monitoring Index value plot for year 2000-2004.

Figure 2 shows that 2005 had early onset as early as at 26th pentad the same as 2007. Although rainfall became effective early enough in 2005 but shortly after this onset was concurrent breaks that hinder effectiveness of rainfall received before finally gaining stability after the 42nd pentad. This decline in effectiveness after the effective onset is a threat to the sustainability of relevant socio-economic sector such as agriculture. More serious impacts of global climate change will be felt by smallholder farmers in the developing countries who are depending on small farm sizes, low technology and capitalization, poor infrastructure and institutional support (Mustapha and Adzemi 2014).

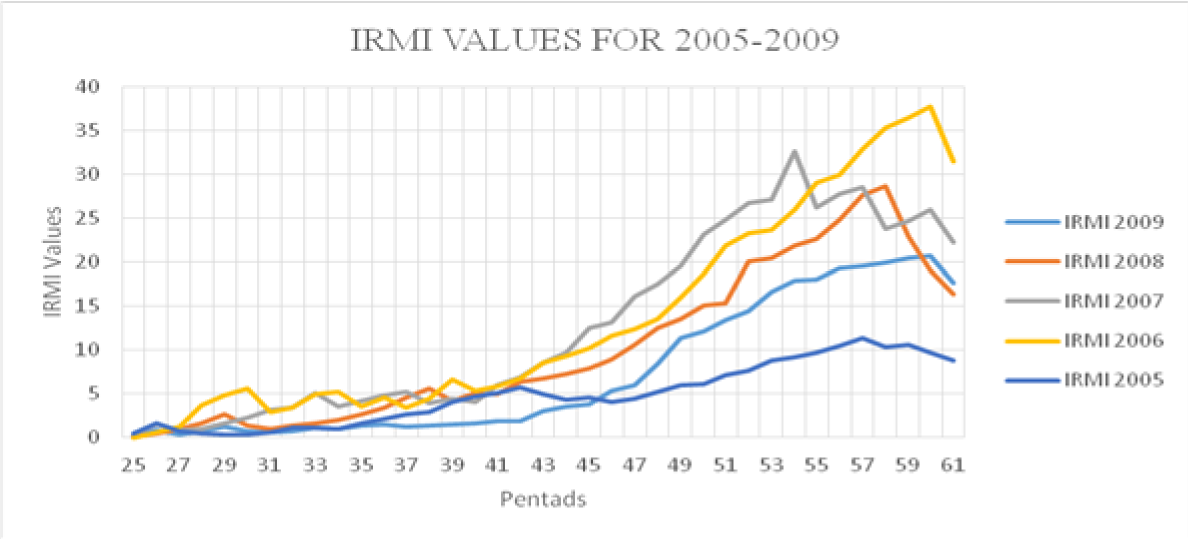

Figure 2: Intra-seasonal monitoring index value plot for year 2005-2009.

From the record, 2005 received a total of 1076.5mm of rainfall which is clearly represented on the graph as the lowest IRMI graph while 2006 recorded the highest rainfall in the category with a total of 1423.2mm; this also explains why the IRMI values plot for 2006 has the highest peak of values as displayed on figure 2. Similarly, 2006 and 2009 were the years with record of late cessation on the 60^{th} pentad which is an indication of effective moisture distribution during the growing season.

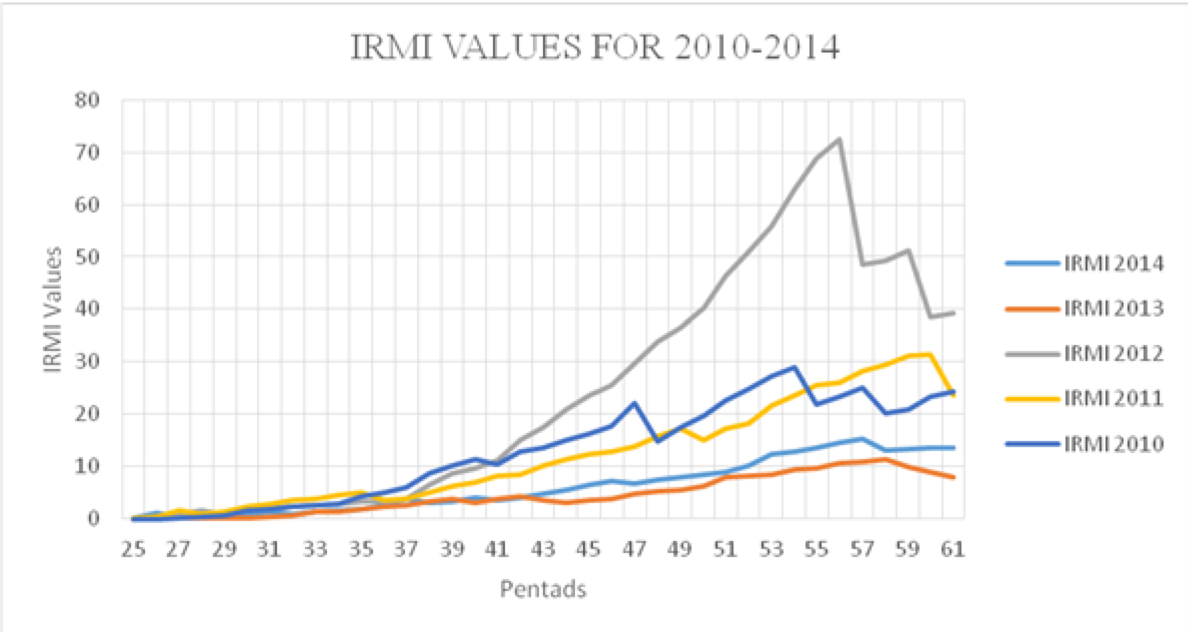

Figure 3: Intra-seasonal monitoring index value plot for year 2010-2014.

Similarly, the year 2012 has the highest IRMI value of 72.39 and sharp rise signal surplus moisture which resulted to one of the worst flood disaster recorded in recent time. In addition, changes in the amount of 1540.35mm rainfall received in 2012 is not as drastic as IRMI value when compare to 2006 annual total rainfall. This is an indication that the IRMI values are crucial in determining moisture surplus and deficit during the growing season. Mustapha and Adzemi,(2014) states that shortage of soil moisture in the dry rainfed areas often occurs during the most sensitive growth stages of flowering and grain filling of the crops resulting in poor growth and consequent low yield.

Furthermore, 2011 recorded the least rainfall amount within the 15 years analysis with a value as low as 992.2mm of rainfall, but 2013 has the lowest IRMI values within the category. This is due to the effect of the much breaks from 4 breaks witnessed in 2011 to 10 breaks. This is equivalent to having little or no rainfall for 50 solid days within a rainy season! The highest value of IRMI recorded within the 15years period was the year 2012 which also confirms why it was a year with the most devastating flood across the country. Changes in the magnitude and intensity of precipitation and the timing of runoff will increase riverine flooding (Brian et.al, 2007). This is not simply because of the amount of rainfall received alone for the year but because of the distribution and timing of rainfall (Figure 3) as there was no break after the 40th pentad. By implication, this implies that the soil was frequently flooded with much rain without a break to give room for effective infiltration and percolation.

Comparison of IRMI and Ogive Method

The effectiveness of IRMI over the Ogive method in capturing rainfall break efficiently, timely and adequately is apparent in figure five. The Ogive method which is a function of cumulative rainfall from the same 25th pentad (1st of May), is inadequate to identify breaks timely and efficiently within the rainy season compared to the IRMI graphs which measures fluctuation in rainfall performance at every occurrence of a break. The 2004 IRMI graph vividly visualized the first break after the effective onset at the 35th pentad; this also shows the subsequent breaks at every time the graph drops till cessation pentad.

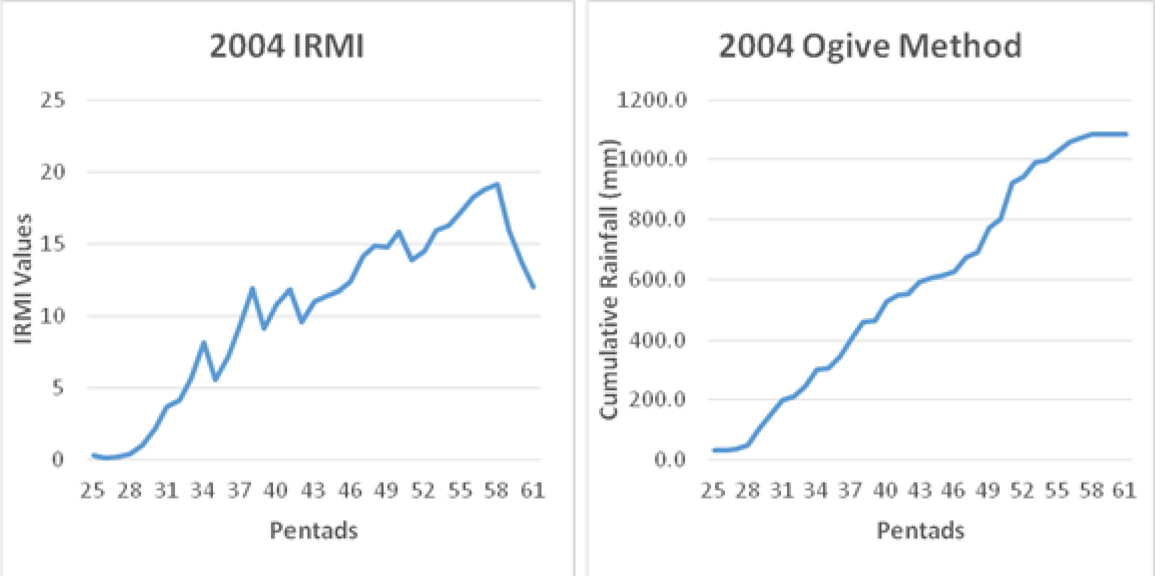

Figure 5: Comparison of IRMI and Ogive method in determining breaks for 2004 rainfall season.

The index is very efficient in determining real monsoon onset dates, breaks dry spell and cessation which are of prime important to farmers, agro-meteorologist and other major stakeholders in hydrology. IRMI is more effective in the study of the intra-seasonal variability of rainfall especially in the semi-arid zones of Sub-Saharan African countries (Usman and Abdulkadir, 2013). It also is efficient in the in-depth study of changes in rainfall pattern and performance within the growing season.

Breaks

The fifteen years analysis reveals that breaks characterized intra and inter-annual variability as the occurrence of breaks varies within the growing season and from one year to the other (Figure 6). Furthermore, it shows an estimated average break occurrence of 7-8 breaks per growing season and years with number of break occurrence higher than the average include; 2000, 2005 and 2013 while, the years with least breaks like 2011 and 2012 which were characterized by flood.

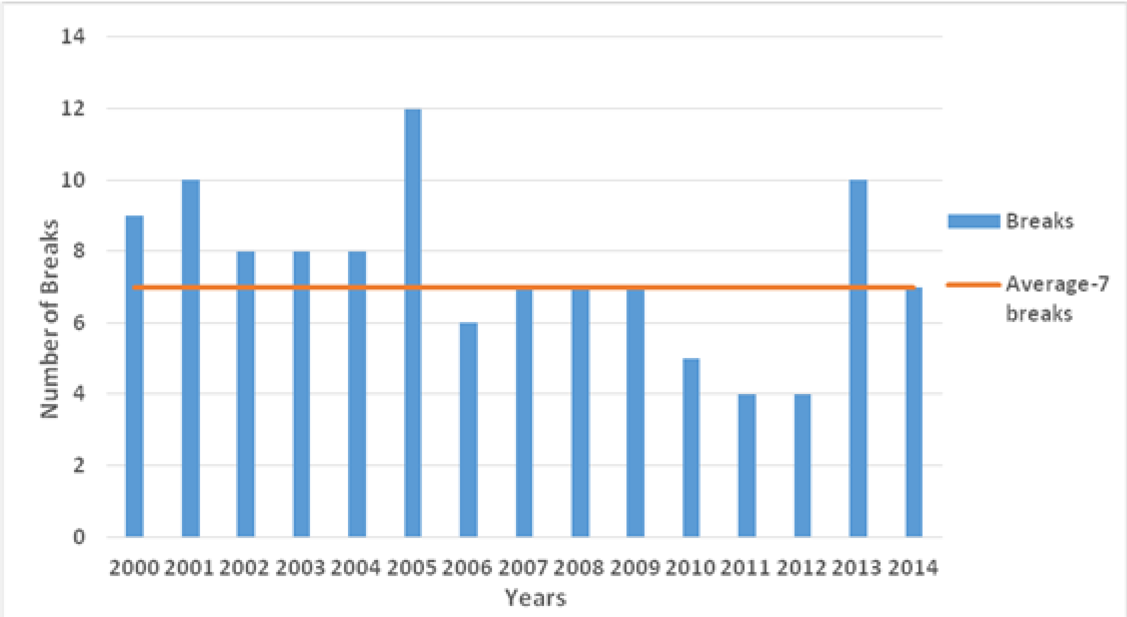

Figure 6: Number of breaks in seasonal rains in Minna (2000-2014).

Dry Spell and Drought Occurrence(s)

The occurrence of breaks in a planting season has implications which are best explained with the aid of moisture effective record (Table 1). The number of breaks in a planting season dictates the extent of moisture stress and effectiveness of rainfall for a particular year. Seasons with high number of breaks do have a devastating effect on the quality of moisture received in such locations especially when such breaks occurred consecutively, they result into cases of dry spells which could eventually lead to drought. And when this happens it leads to low crop yield which will eventually affects the food production in the area. This is also reflected in the submission of Gukurume, (2013) that other socio-economic implications includes failure of crops, death of livestock and low crop yields, all of which have led to declining agricultural productivity in the area.

Table 1: Dry Spell and Drought case occurrence in Minna from 2000-2014

Years	Number of Breaks	Dry Spell	Days of Occurrence	Drought
2000	9	-	-	-
2001	10	-	-	-

2002	8	-	-	-
2003	8	-	-	-
2004	8	-	-	-
2005	**12**	**3**	***11-20th May *21-30th May *30-5th Aug**	***11-30th of May)**
2006		-	-	-
2007	7	-	-	-
2008	7	**1**	***26-4th June**	-
2009	7	**1**	***26-4th June**	-
2010	5	**-**	**-**	-
2011	4	**-**	**-**	-
2012	4	**-**	**-**	-
2013	10	**1**	***30-8th Aug**	-
2014	7	-	-	-

The result shows there were 6 recorded cases of 10days dry spells over the 15years period and dry spell in the study area occurred in May, June and August. Three out of the six dry spells were recorded in year 2005 which happens to be the year with the highest number of breaks (fig 7). This is also reflected in the rainfall total received for the year which in addition has a direct consequence on the year's moisture effectiveness as its an indication of moisture stress due to prolong period of dry spell that resulted to mild drought.

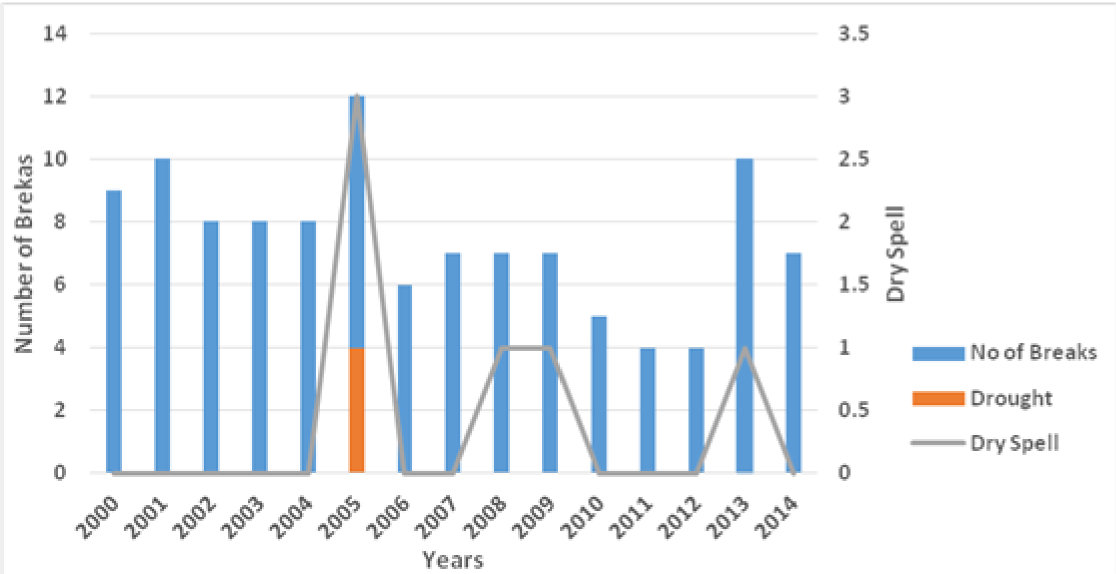

Figure 7: Number of breaks, dry spells and drought case record (2000-2014)

According to the result on the table 1 and figure 7, the first 2 consecutive dry spells for the year 2005 occurred in May from 11th – 30th May (20days) totaling 4 breaks while the other case was recorded from 30th July to 8th of August (table 2). The significant long term increased trend of drought and dry spells has exacerbated water shortages thereby undermining agriculture and threatening livelihood (Mustapha and Adzemi 2014). The first case gave rise to a mild drought condition as seen in figure 6 because by definition it was a record of 4 consecutive breaks. The drought was mild due to the fact that there were no enough breaks to sustain its duration. While 2008, 2009 and 2013 had a single record of dry spells each (fig 7) which occurred on 26th May – 4th of June 2008, same period for 2009 and 30th July – 8th of August.

Generally, the result indicates that dry spell and drought case were function of the number of breaks. The misidentification of recurring temporary dry spells as droughts, which implies an extreme abnormal situation, can result in societies becoming maladapted and increasingly vulnerable because of unnecessary asset depletion or inappropriate mitigation measures (Smakhtin and Schipper 2008).The constant condition here is that the breaks must be consistent and consecutive enough to give rise to cases of drought and dry spell. Oloro (2013) concluded that grain production shortfalls in northern Ethiopia are commonly associated with occurrence of intra-seasonal dry spells or droughts and rapid land degradation which adversely impact crop yields. The occurrence of break, dry spell and drought scenarios has a lot of implication on the overall rainfall effectiveness as well as the crop performance in Minna and its environs. The interplay of these parameters dictates that moisture effectiveness is crucial for sustainable crop growth and it is a vital tool in developing an early warning system for both dry spell and drought occurrence as opined by Usman and Abdulkadir (2013).

The occurrence of breaks, dry spells and drought has several implications especially on rainfed agricultural practices because consecutive occurrence of two or more breaks in a month could lead to wilting of the crops which stagnates the growth of such crops. Any further prolonged cases of breaks into more dry spell cases will eventually lead to the drying up of soil moisture which could lead to crop failure (Sawa and Adebayo, 2011). It is also important to note here that the occurrence of break is not totally disastrous; it is also needed within a rainy season to give room for percolation and infiltration which allows the moisture to sink down into the soil before subsequent heavy downpours. The absence of break occurrence after 40th pentad and cessation period in year 2012 escalated the devastating flood that wrecked most farms, destroyed lives and property among other havoc recorded.

Conclusion

Breaks, dry spells, droughts and floods are common hydro-meteorological hazards across Nigeria that should be identified and characterized promptly using efficient, adequate and accurate indices to minimize its impact on vulnerable population. The study demonstrates the role of breaks and dry spell in hindering the usefulness of seasonal rainfall directly and indirectly for crop production which is not only a function of total number of break occurrences but rather the spread and frequency of it occurrence that leads to dry spell, drought and flood thereby intensifying rainfall-related hazard. The index employed also displayed its efficiency and simplicity making it more suitable index for an in-depth analysis for identification of seasonal rainfall-related hazards. Consequently, in a State that is natural resource-dependent, it should be used to monitor seasonal rainfall, inform farmers and stakeholders of the anticipated seasonal rainfall-related hazard and capacity building as pathway towards disaster risk reduction.

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