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A Markov Chain Analysis of Wet and Dry Spell for Agricultural Crop Planning in the Middle Belt Region of Nigeria

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Abstract

The frequencies of dry and wet spells and probabilities of dry and wet spell weeks were analysed from 1981 – 2010 in the Middle Belt region (MBR) of Nigeria. Daily rainfall (mm) data were obtained from eight synoptic weather stations spread across the region. A wet (dry) spell is defined as a consecutive number or group of days each with at least 1.2mm rainfall (<1.2mm rainfall), and a wet week is defined as a week with an accumulated rainfall amount of at least 8.4mm. Markov Chain probability model was used to analyse the probabilities of occurrences of dry and wet weeks. The result showed that the mean regional onset, cessation and duration of the rainy season were week 15th (9th – 15th April), week 42nd (15th – 21st October) and 29 weeks (203 days) respectively. The observed frequencies generally agreed with the estimated frequencies for wet spells for the entire region compared to dry spells. The initial and conditional probabilities of wet spell week were more than 50% from the week 22nd for all the stations at 8.4mm per week threshold. The study concludes that land preparation for crop planting should commence from week 20th - 22nd whereas crop irrigation farming should start after week 42nd in the Middle Belt region.

Keywords: Dry spell, Wet spell, Markov chain, probability, rainy season, crop

1. Introduction

There has been a growing operational demand for modelling daily rainfall data using various stochastic models. This is because the models provide prior knowledge of the structural characteristics of varying rainfall systems which are very much essential for agricultural and hydrological planning, industrial and water resource management, and climate change studies (Mangaraj, Sahoo and Sukla, 2013).

Such prior knowledge like the probability or chances of occurrence of dry and wet spells at given periods is increasingly important, especially given the global impact of climate change. For instance, the knowledge of rainfall probability analysis could be useful in adjusting crop sowing dates in such a way that critical stages of crop production coincide with the period of higher rainfall probability. If a dry spell coincides with critical moisture requiring stages of crop production such as grain filling, it may be damaging but during ripening stage, it may be beneficial. On the other hand, if wet spell coincides with the critical moisture requiring stages of crop production, it will be most beneficial for increasing crop productivity (Kingra, Gill and Singh, 2013).

Practically, in a crop growing season, many times decisions have to be taken based on the probability of receiving certain amounts of rainfall during a given week [$P(w)$], which is called "initial probability," then the probability of rain next week if we had rain this week [$P(w/w)$], which is called "conditional probability" (Dabral et al., 2014), both of which are very important. Under initial probabilities, the probability of any given week being wet or dry is estimated, whereas in the case of conditional probabilities, if a given week 'i' is wet, then the chances of (i+k)th period as wet, wet/wet or dry/dry are estimated (Senthilvelan, Ganesh and Banukumar, 2012). The initial and conditional probabilities form the basis for the analysis of rainfall using Markov Chain process (Dabral et al., 2014).

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Using the Markov Chain approach, Kingra, Gill and Singh (2013) computed weekly rainfall probabilities for crop planning for the Sub-Mountainous Punjab area of India. The week-wise analysis was done for initial and conditional probability at different rainfall limits (10, 20, 30, 40 and 50mm). Senthilvelan, Ganesh and Banukumar (2012) also employed the Markov Chain model to compute the initial and conditional probabilities of weekly rainfall for two threshold limits (10 mm and 20 mm) in Orathanadu Taluk, Thanjavur District, Tamil Nadu.

Dabral *et al* (2014) studied dry and wet spell probabilities in North Lakhimpur (Assam), India using weekly rainfall data for a period of 24 years, based on the weekly rainfall threshold of 20 mm, with the objectives of forecasting dry and wet spell using Markov Chain model and finding out the exact time of onset and termination of monsoon. They found the probability of occurrence of dry week to be higher from week 1st - 14th and also from week 41st - 52nd. The range of probability of occurrence of dry week in those weeks varied from 41.67% to 100%. For wet week, the probability of occurrence was higher from week 17th to 40th. The range of probability of wet week in those weeks varied from 66.67% to 100%.

Mangaraj *et al.* (2013) analysed daily rainfall occurrence at Western Orrisa of India using rainfall data from Jharsuguda, Sambalpur, Titilagarh and Bolangir meteorological stations for 29 years (1977 to 2005). They used the Markov Chain model to estimate conditional and unconditional spell probabilities on monthly basis from June to November, and reported a satisfactory fit of the model to the rainfall data for computing probabilities of dry or wet spells.

Using rainfall data for four stations in four States in Nigeria (Katsina, Borno, Lagos and Rivers) for a period of 41 years (1971–2011), Eze *et al*, (2016) applied the Markov Chain model to simulate the probability of wet and dry spells at given annual intervals for the semi-arid (BSh) and the Equatorial (Af) climatic zones in southern and northern parts of Nigeria using Katsina and Borno States (in the BSh climatic zone) and Lagos and Rivers States (in the Af climatic zone).

More recently, Manikandan *et al.* (2017) analysed wet and dry spells for agricultural crop planning using Markov chain probability model at Bhavanisagar for a period of 47 years (1969 – 2015). They determined the weekly spell probabilities for the area based on 20mm threshold of rainfall.

Probabilities of dry and wet spells have been investigated by several other researchers (e.g. Caskey, 1963; Reddy *et al.*, 2008; Oduwole, Bonboland and Shawulu, 2011; Sharahki et al., 2012; Fitsume and Desalegn, 2013; Admasu *et al.* 2014). Fitsume and Desalegn (2013) also estimated the probabilities of dry and wet spells of given lengths (equal to or greater than a specified duration), and noted that the distribution of the spells by length or duration was geometric.

2 Materials and method

2.1 Data need and sources

The data used in this study were daily rainfall records (≥0.3mm) covering a period of thirty years (1981-2010). Available data were found to cover this period for the eight selected synoptic meteorological stations, namely Bida, Ibi, Ilorin, Jos, Lokoja, Makurdi, Minna and Yola, of which choice relates to their geographical spread, hence fair spatial representation of the study area (Figure 1).The daily rainfall records for thirty years (1981-2010) were obtained from the Nigerian Meteorological Agency (NIMET) Operational Headquarters, Oshodi, Lagos. Climate data from NIMET stations are usually quality controlled and were the only data used in the study.

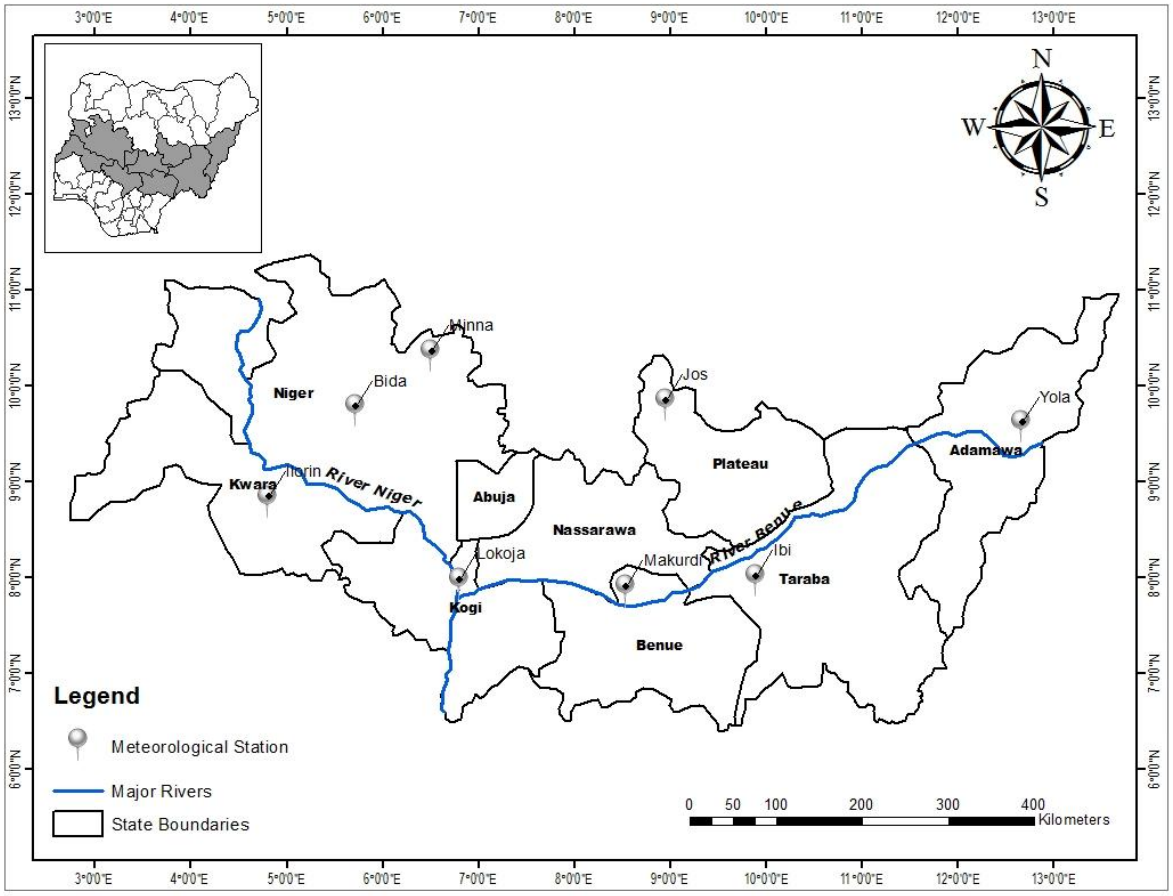

Figure 1: Location of study area and meteorological stations.

2.2 Definition of a spell and a wet week

A spell is defined, in the study, as a consecutive number or group of days each with at least 1.2mm of rainfall (wet spell) or less than 1.2mm rainfall (dry spell). As Hernaeze and Martin-Vide (2011) noted, the definition of thresholds is important because it plays a key role later on in the outcomes of the study. Fisher et al. (2013) specifically pointed out that for agricultural applications a threshold of 1mm day^{-1} may be more appropriate. This study, however, uses 1.2 mm as threshold for description of dry/wet days, which translates to a weekly threshold of 8.4 mm. These thresholds relate more closely to the weekly crop water requirement for Nigeria, which is 8 mm (Adefisan and Abatan, 2015; Omotosho, Balogun and Ogunjobi, 2000). The 1.2 mm daily threshold also takes care of measurement errors associated with light rains due to direct evaporation at manual rain gauges (Tarhule & Woo, 1998; Barring et al., 2006). Thus, a day is considered as wet if it has rainfall equal to or more than 1.2mm, while days with less than 1.2 mm are considered as dry. Similarly, a wet week is one with rainfall equal to or more than 8.4 mm, and a dry week has less than 8.4 mm.

2.3 Determination of onset, cessation and duration of the rainy season

Gitau (2010) made a useful suggestion that the actual onset and cessation dates of the rainy season should be determined before the frequency distribution of wet and dry spells are derived. Since the scope of this study is limited to the rainy season, onset and cessation of the season have been defined and empirically determined from daily rainfall data. Based on Tarhule and Woo (1998) method, onset of the rainy season is taken to be the first wet day of the year after which there is no dry spell longer than 12 days in-between the subsequent four wet days, while the cessation of the rainy season is considered to commence on any wet day after which there occurred a dry spell longer than 12 days during the last four wet days of the year. The condition of having no dry spell of more than 12 days in-between four consecutive wet days following the onset date is to eliminate the possibility of including a false onset of the rainy season. The duration of the season is the number of days between the onset and cessation dates.

To determine the onset date of the rainy season for a given year, the daily rainfall data were observed from the beginning of the year to identify a wet day, then the next four consecutive wet days were also identified, ensuring that no dry spell of duration longer than 12 days occurred between them. The first wet day, after which no dry spell longer than 12 days occurred before the next four consecutive wet days were counted, marked the onset of the rainy season. On the other hand, cessation of the rainy season was determined by observing the daily rainfall data backward from the end of the year to identify the wet day after which a dry spell longer than 12 days occurred during the last four wet days of the year.

2.4 The Markov Chain probability model

The Markov Chain probability model, which is shown to fit sequences of wet or dry days in records of varying lengths and for several climatically different areas (Weiss, 1964; Mangaraj *et al.*, 2013), has been used to compute the dry and wet spell frequencies and probabilities. The first order (two-state) of the model has been applied to determine the initial and conditional probabilities of dry and wet spell weeks, with dry and wet as the two states.

Before application, the goodness of fit of the model to the Middle Belt data was tested. The empirical or observed frequencies of dry and wet spells of an exact length and greater than a given length were manually counted from the data sheets, while their corresponding theoretical frequencies were computed from the first order (two-state) Markov Chain model. The computation involved determining the basic parameters of the model (P_0 and P_1) for each station, which were then used to calculate probabilities of the various spell lengths.

In line with Berger and Goossens (1983), El-Seed (1987), Sukla *et al.* (2012), Fitsume and Desalegn (2013), the probabilities of dry spells of length x and greater than x were, respectively, calculated using the expressions:

$$P(D=x) = P_0 (1-P_0)^{x-1}, \quad x = 1,2,\ldots \tag{1}$$

and

$$P(D>x) = (1-P_0)^x \tag{2}$$

Similarly, the probabilities of wet spells of length n and greater than n are respectively

$$P(W=n) = (1-P_1) P_1^{n-1} \tag{3}$$

and

$$P(W>n) = P_1^n \tag{4}$$

Where P_0 is the probability of a wet day following a dry day; $1-P_0$ is the probability of a dry day following another dry day; P_1 is the probability of a wet day following another wet day, and $1-P_1$ is the probability of a dry day following a wet day.

The maximum likelihood estimates of P_0 and P_1 are given by:

$$P_0 = \frac{n(W/D)}{n(W/D) + n(D/D)} \tag{5}$$

$$P_1 = \frac{n(W/W)}{n(W/W) + n(D/W)} \tag{6}$$

Where n(W/W), n(D/W), n(W/D) and n(D/D) are respectively, the observed frequencies of wet day preceded by wet day, dry day preceded by wet day, wet day preceded by dry day and dry day preceded by dry day.

Subsequently, the expected or theoretical frequencies of the respective spell lengths were obtained by multiplying the probability values (results of equations 1- 4) by the total number of spells (including single days) of the corresponding state (dry or wet).

To finally determine the agreement between the observed and theoretical spell frequencies, the Chi-square test (χ^2) was applied at 95% level of significance. The Chi-square (χ^2) determines whether the observed frequencies of a given phenomenon based on a stated hypothesis, such as the null hypothesis, differ significantly from the expected frequencies (Anyadike, 2009). The chi-square test is expressed as (Agawal, 1998, Anyadike, 2009, Sukla et al, 2012):

$$X^2 = \sum_z (O_z-E_z)^2/E_z \tag{7}$$

Where χ^2 is chi-square value, Oz and Ez are respectively, observed and expected frequencies of wet or dry spell. The degrees of freedom are V=n-1 (V is number of variables).

When the calculated value of χ^2 is less than the critical (table) value, the null hypothesis is accepted, but when the calculated value is more than the table value, H_o is rejected (Agawal, 1998, Anyadike, 2009).

2.5 Determination of dry and wet spell week probabilities

Initial or independent probability refers to the probability of any given week being wet or dry regardless of the weather of the preceding week, while the probability of a dry (wet) week following a dry (wet) week is the conditional probability. To calculate the wet and dry week probabilities, the year was divided into 52 standard meteorological weeks of seven days each, from 1st January to 31st December. Weekly rainfall values were summed up from the daily records, and a threshold limit of 8.4mm was used to distinguish between dry and wet weeks. Using the first order Markov Chain model, both initial and conditional probabilities of dry and wet spell weeks were determined using the following expressions (Admasu *et al.*, 2014; Dabral et al., 2014; Manikandan *et al,* 2017):

For initial Probabilities:

$$Pd = Fd/N \quad (8)$$

$$Pw = Fw/N \quad (9)$$

For conditional Probabilities:

$$Pdd = Fdd/N \quad (10)$$

$$Pww = Fww/N \quad (11)$$

$$Pwd = 1 - Pdd \quad (12)$$

$$Pdw = 1 - Pww \quad (13)$$

Where, Pd is probability of a week being dry; Pw is probability of week being wet; Fd is number of dry weeks, Fw is number of wet weeks, N is number of years of data (30 years), Pdd is probability of dry week preceded by a dry week, Pww is probability of a wet week preceded by a wet week, Pwd is probability of a wet week preceded by a dry week, Pdw is probability of a dry week preceded by a wet week, Fww is number of wet weeks preceded by a wet week, Fdd the number of dry weeks preceded by a dry week.

3. Results and discussion

3.1 Characteristics of the rainy season

The result of characteristics of the rainy season in the Middle Belt region is presented in Table 1. The earliest onset and latest onset of the rainy season in the Middle Belt region occurred on week 9th (26th February-4th April) at Ilorin and on week 21st (21st-27th May) at Bida and Yola, with a regional mean onset date on week 15th (9th-15th April). The season remained active up to week 38th (17th-23rd September) when the earliest cessation occurred at three stations (Jos, Minna and Yola), while the latest cessation was on week 46th (12th-18st November) at Lokoja. This showed a mean cessation on week 42nd (15th-21st October) over the whole region.

The longest duration of the rainy season was 36 weeks (252 days), which occurred at Ilorin, while the shortest duration of 21 weeks (147 days) occurred at Yola. Therefore, the mean duration of the rainy season that could be expected in the region is 29 weeks (203 days). The pattern of spatial variation of onset, cessation and duration of rainy season in the Middle Belt region comforms with the observed zonal pattern of spatial distribution of daily and extreme daily rainfall characteristics in the region (Tyubee, 2005; Mage and Tyubee, 2019).

3.2 Dry and wet spell frequencies

The result on goodness of fit of the first order Markov Chain model to the empirical data, which is achieved by comparing the observed frequencies (Obs) with predicted frequencies (Prd) for wet and dry spells, is presented in Tables 2 - 3.

Table 1: Characteristics of the rainy season in the Middle Belt region (1981-2010)

Attribute	Station							
	Bida	Ibi	Ilorin	Jos	Lokoja	Makurdi	Minna	Yola
Onset of the rainy season								
Earliest	Week 14th (Apr 2-8)	Week 11th (Mar 12-18)	Week 9th (Feb 26-Mar 4)	Week 11th (Mar 12-18)	Week 11th (Mar 12-18)	Week 11th (Mar 12-18)	Week14th (Apr 2-8)	Week 14th (Apr 2-8)
Latest	Week 21st (May 21-27)	Week 20th May 14-20	Week 16th (Apr 16-23)	Week 19th (May 7-13)	Week 18th (Apr 30-May 6)	Week 19th (May 7-13)	Week 20th (May 14-20)	Week 21th (May 21-27)
Mean	Week 18 (Apr 30-May 6)	Week 19th (May 7-13)	Week 13th (Mar 26-Apr1)	Week 15th (Apr 9-15)	Week 14th (Apr 2-8)	Week 15th (Apr 9-15)	Week 17th (Apr 23-29)	Week 18th (Apr 30-May 6)
Cessation of the rainy season								
Earliest	Week 39th (Sep 24-30)	Week 39th (Sep 24-30)	Week 40 (Oct 1-7)	Week 38 (Sep 17-23)	Week 41th (Oct 8-14)	Week 39th (Sep 24-30)	Week38th (Sep 17-23)	Week 38 (Sep 17-23)
Latest	Week 45th (Nov 5-11)	Week 45th (Nov 5-11)	Week 45th (Nov 5-11)	Week 45th (Nov 5-11)	Week 46th (Nov 12-18)	Week 45th (Nov 5-11)	Week 45th (Nov 5-11)	Week 45th (Nov 5-11)
Mean	Week 42nd (Oct 15-21)	Week 42nd (Oct 15-21)	Week 43th (Oct 22-28)	Week 42 (Oct 15-21)	Week 44th Oct 29-Nov 4)	Week 42th (Oct 15-21)	Week 42th (Oct 15-21)	Week 41 (Oct 8-14)
Duration of the rainy season								
Longest	32 weeks (224 days)	33 weeks (231 days)	36 weeks (252 days)	33 weeks (231 days)	33 weeks (231 days)	33 weeks (231 days)	32 weeks (224 days)	31 weeks (217 days)
Shortest	21 weeks (147 days)	24 weeks (168 days)	27 weeks (189 days)	22 weeks (154 days)	24 weeks (168 days)	22 weeks (154 days)	23 weeks (161 days)	21 weeks (147 days)
Mean	27 weeks (189 days)	29 weeks (203 days)	32 weeks (224 days)	28 weeks (196 days)	29 weeks (203 days)	28 weeks (196 days)	28 weeks (196 days)	26 weeks (182 days)

For wet spells, the observed frequencies generally agree with the estimated frequencies by the first order Markov Chain model over the entire region since the critical values exceeds the calculated chi-square values (χ^2) at 95% significance level across the eight stations (Table 2). This result indicates that the theoretical frequencies of wet spells have agreed with the observed frequencies suggesting that wet spell persistence in the Middle Belt region is a Markovian process.

Notwithstanding the general agreement, cases of slight overestimation (when Obs<Prd) and underestimation (when Obs>Prd) of spell frequencies by the model are observed. The over estimated frequencies include spells lasting 2 days (Bida, Ilorin, Jos, Minna and Yola), 3 days (Ilorin), 4 days (Jos, Minna and Yola) and >5 days (Ibi). Some of the under estimated frequencies include spells lasting 2 days (Ibi and Makurdi), 3 days (Makurdi), 4 days (Bida and Minna), 5 days (Jos, Lokoja and Makurdi) and > 5 days (Ilorin, Jos, Lokoja and Minna).

In case of the dry sequences, the model satisfactorily approximated observed frequencies for only three stations, namely Bida, Ibi and Yola (37.5%), but fails to successfully fit those of the remaining stations (Ilorin, Jos, Lokoja, Makurdi and Minna) at 95% significant level (Table 3). For the 2 days dry spell, frequency was overestimated by the model at only one station (Jos), while for the rest of the spell lengths and study locations, overestimated cases by the model involved more stations than underestimated cases (Table 3).

Table 2: Observed and predicted frequencies of wet spells of various lengths at eight stations in MBR, 1981-2010.

Length	Bida		Ibi		Ilorin		Jos		Lokoja		Makurdi		Minna		Yola	
(Days)	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd
2	262	287	254	234	297	318	303	336	293	294	291	262	289	310	233	241
3	106	109	79	79	111	124	170	172	95	97	92	87	131	132	70	73
4	58	42	28	26	50	48	82	88	33	32	30	28	49	56	15	23
5	16	16	9	9	18	18	41	46	17	11	13	9	22	24	9	7
>5	8	10	1	5	20	12	57	48	9	5	7	5	26	18	5	3
X^2	8.76		5.06		8.17		5.90		6.55		6.28		6.03		5.08	
Critical Value	9.49		9.49		9.49		9.49		9.49		9.49		9.49		9.49	

The result suggests that, in the Middle Belt region, the performance of the simple Markov Chain model in predicting spell frequencies is better for wet spells than for dry spells. This is in conformity with the findings of previous researchers (Berger and Goossens, 1983, Deka *et a*l. 2010, Sukla *et al.*, 2012, Sonnadara and Jayewardene, 2015) who reported better performance of the model for wet spells relative to the dry sequences. According to Sukla *et al.,* (2012), one of the probable reasons for the failure of the first order Markov Chain model in replicating dry spell frequency may be due to the fact that during the study period, dry spells persisted for longer periods in comparison to the wet spells. Therefore, the adequacy of the first order Markov Chain model to compute probabilities may not be satisfactory for prolonged sequences when different meteorological forcings are in operation.

Table 3: Observed and predicted frequencies of dry spells of various lengths at eight stations in MBR, 1981-2010.

Length	Bida		Ibi		Ilorin		Jos		Lokoja		Makurdi		Minna		Yola	
(Days)	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd	Obs	Prd
2	306	287	259	229	309	285	310	324	369	286	342	290	305	305	272	261
3	190	181	155	158	178	199	126	187	186	199	178	195	193	186	169	175
4	103	115	81	109	116	139	67	107	129	139	134	131	86	114	101	117
5	64	46	82	79	76	97	41	63	72	97	70	88	60	69	71	65
6	36	73	52	53	39	68	28	36	53	67	49	59	31	42	47	52
7	25	28	39	35	31	47	16	21	40	47	35	40	20	26	30	35
8	12	18	20	26	37	32	14	12	24	33	29	26	13	15	23	24
9	9	11	22	17	20	23	6	7	19	23	14	18	12	9	14	15
10	8	7	10	12	15	16	5	4	12	16	6	12	6	6	14	11
11	5	5	8	9	15	10	5	3	5	11	9	8	6	4	5	7
>11	13	8	22	19	37	27	20	3	42	26	27	17	11	6	18	14
X^2	12.19		15.54		37.84		144.50		53.34		27.12		19.01		7.25	
Critical Value	18.30		18.30		18.30		18.30		18.30		18.30		18.30		18.30	

3.3 Dry and wet spell week probabilities

The result of initial and conditional probabilities for the rainy season weeks is presented in Tables 4 to 11. Though the mean duration of the rainy season for the entire region is from week 15th to week 42nd, the presented result however covered week 14th - 45th in order to have a wider time period.

The probability of occurrence of dry week (Pd) at Bida is high from week 14th - 19th and week 41st - 45th (Table 4). During these weeks, the occurrence probability of dry week ranged from 30% to 93%. Between weeks 32nd and 38th, Pd is 0.00%. Similary, the probability of occurrence of dry week preceded by another dry week (Pdd) is higher from week 14th-16th and week 43rd- 45th, ranging from 30% to 83%. For dry week preceded by wet week (Pdw), probability is 100% on week 14th and 45th, and decreases towards the middle of the season to 0% on week 35th and 36th. Conversely, the probability of a wet week (Pw) attained consequential values from week 16th - 43rd, ranging in these weeks, from 30 % to 100%. The 100% occurred during weeks 34th - 38th (excluding 37th). For wet week preceded by another wet week and wet week preceded by dry week (Pww & Pwd), probabilities were high from weeks 17th and14th to week 42nd and 44th, and ranged from 40% to 100% and 37% to 100% respectively.

For Ibi, the probability of occurrence of dry week (Pd) was higher from the beginning of the season (week 14th - 20th) and ending of the season (week 42nd - 45th) ranging, in these weeks, from 30% to 87% (Table 5). Also chances of dry week preceded by dry week (Pdd) were high from week 14th - 16th and week 44th - 45th ranging, during these weeks, from 43% to 73%. However, the probability of dry week preceded by wet week (Pdw) was generally high throughout the rainy season (30% to 100%), except on weeks 31st, 33rd, and 37th - 40th when lower chances in the range of 20% to 27% occurred. For initial probability of wet week (Pw), chances were high from week 16th - 43rd, ranging from 37% to 93% during the period.

For wet week preceded by another wet week, and wet week preceded by dry week, chances were high from weeks 17th - 42nd and 14th - 44th, with a range from 43% to 87% and 33% to 100% respectively.

Table 4: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4mm threshold limit of rainfall for Bida

Weeks	Initial Probabilities		Conditional Probabilities				
	Pd	Pw	Pdd	Pww	Pwd	Pdw	
14	0.80	0.20	0.70	0.00	0.30	1.00	
15	0.73	0.27	0.67	0.13	0.33	0.87	
16	0.43	0.57	0.30	0.13	0.70	0.87	
17	0.43	0.57	0.27	0.40	0.73	0.60	
18	0.37	0.63	0.27	0.43	0.73	0.57	
19	0.33	0.67	0.17	0.47	0.83	0.53	
20	0.23	0.77	0.07	0.47	0.93	0.53	
21	0.17	0.83	0.03	0.60	0.97	0.40	
22	0.23	0.77	0.00	0.63	1.00	0.37	
23	0.13	0.87	0.03	0.67	0.97	0.33	
24	0.07	0.93	0.03	0.87	0.97	0.13	
25	0.10	0.90	0.00	0.83	1.00	0.17	
26	0.10	0.90	0.00	0.80	1.00	0.20	
27	0.13	0.87	0.00	0.77	1.00	0.23	
28	0.23	0.77	0.00	0.70	1.00	0.30	
29	0.07	0.93	0.00	0.70	1.00	0.30	
30	0.10	0.90	0.00	0.83	1.00	0.17	
31	0.17	0.83	0.00	0.73	1.00	0.27	
32	0.17	0.83	0.07	0.73	0.93	0.27	
33	0.03	0.97	0.00	0.80	1.00	0.20	
34	0.00	1.00	0.00	0.97	1.00	0.03	
35	0.00	1.00	0.00	1.00	1.00	0.00	
36	0.00	1.00	0.00	1.00	1.00	0.00	
37	0.03	0.97	0.00	0.97	1.00	0.03	
38	0.00	1.00	0.00	0.97	1.00	0.03	
39	0.07	0.93	0.00	0.93	1.00	0.07	
40	0.17	0.83	0.00	0.77	1.00	0.23	
41	0.30	0.70	0.10	0.63	0.90	0.37	
42	0.47	0.53	0.13	0.40	0.87	0.60	
43	0.70	0.30	0.40	0.23	0.60	0.77	
44	0.90	0.10	0.63	0.03	0.37	0.97	
45	0.93	0.07	0.83	0.00	0.17	1.00	

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

Table 5: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4mm threshold limit of rainfall for Ibi

Weeks	Initial Probabilities		Conditional Probabilities			
	Pd	Pw	Pdd	Pww	Pwd	Pdw
14	0.80	0.20	0.67	0.03	0.33	0.97
15	0.77	0.23	0.67	0.10	0.33	0.90
16	0.50	0.50	0.43	0.17	0.57	0.83
17	0.30	0.70	0.27	0.47	0.73	0.53
18	0.43	0.57	0.17	0.43	0.83	0.57
19	0.30	0.70	0.17	0.47	0.83	0.53
20	0.37	0.63	0.17	0.53	0.83	0.47
21	0.13	0.87	0.13	0.67	0.87	0.33
22	0.23	0.77	0.03	0.67	0.97	0.33
23	0.30	0.70	0.03	0.53	0.97	0.47
24	0.17	0.83	0.03	0.57	0.97	0.43
25	0.17	0.83	0.07	0.73	0.93	0.27
26	0.23	0.77	0.07	0.67	0.93	0.33
27	0.27	0.73	0.10	0.60	0.90	0.40
28	0.17	0.83	0.03	0.60	0.97	0.40
29	0.23	0.77	0.03	0.63	0.97	0.37
30	0.13	0.87	0.03	0.67	0.97	0.33
31	0.13	0.87	0.03	0.77	0.97	0.23
32	0.17	0.83	0.00	0.70	1.00	0.30
33	0.10	0.90	0.00	0.73	1.00	0.27
34	0.20	0.80	0.00	0.70	1.00	0.30
35	0.17	0.83	0.03	0.70	0.97	0.30
36	0.17	0.83	0.03	0.70	0.97	0.30
37	0.07	0.93	0.03	0.80	0.97	0.20
38	0.10	0.90	0.03	0.87	0.97	0.13
39	0.10	0.90	0.00	0.80	1.00	0.20
40	0.17	0.83	0.00	0.73	1.00	0.27
41	0.20	0.80	0.07	0.70	0.93	0.30
42	0.43	0.57	0.07	0.43	0.93	0.57
43	0.63	0.37	0.27	0.20	0.73	0.80
44	0.87	0.13	0.53	0.03	0.47	0.97
45	0.87	0.13	0.73	0.00	0.27	1.00

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

The probability of occurrence of dry week (Pd) for Ilorin was high from week 14th to 19th (excluding 15th &17th), 30th to 32nd, and week 42nd to 45th (Table 6). The Pd in these weeks ranged from 30% to 87%. For dry week preceded by dry week (Pdd), chances were high from week 14th - 22nd (excluding weeks 17th, 18th and 21st), and week 43rd - 45th, ranging in these weeks, from 30% to 73%. Also high chances of having a dry week following a wet week (Pdw) were high from weeks 12th - 20th, 30th - 35th and 42nd - 45th respectively. In these weeks, Pdw ranged from 30% to 93%. The probability of a week being wet (Pw) was over 40% from week 14th - 43rd, ranging from 43% to 97%, while similar chances for wet week preceded by wet week (Pww) occurred from week 16th - 42nd (excluding week 31st). In addition, 53% to 100% probability of wet week to be preceded by dry week (Pwd) occurred throughout the rainy season except on the last week (45th), which had a lower value of 27% (Table 6).

For Jos, both initial and conditional probabilities of dry week were relatively low except weeks 14th-15th and 41th - 45th (Table 7). From week 16th - 40th, the probability of dry week ranged from 0% - 37%, with most of the weeks skewed to the minimum, while the probability of dry week following dry week ranged from 0% to 17%. On the other hand, initial and conditional probabilities of wet week (Pw, Pww & Pwd) were over 50% from weeks 16th - 41st, 16th - 40th and 15th - 42nd respectively. In these weeks, the initial and conditional probabilities ranged from 53% to 100% (Table 7).

Similar to the result of Jos, the probability of dry week and dry week following dry week (Pd & Pdd) at Lokoja, in the range of 43% to 100% were limited to weeks 14th - 15th and 43rd - 45th. In between these two periods, the chances of a dry week and dry week preceded by another dry week were low, ranging from 0% to 37% and 0% to 23% respectively, with most of the weeks skewed to the minimum.

For dry week preceded by wet week (Pdw), high chances occurred from weeks 14th - 21st, 26th - 27th, 32nd - 33rd and 41st - 45th. For initial wet week probability (Pw), 57% to 100% chances occurred from week 15th - 41st, while for wet week preceded by wet week, 53% to 100% chances occurred from week 17th - 42nd.

Table 6: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4 mm threshold limit of rainfall for Ilorin.

Week	Initial Probabilities		Conditional Probabilities			
	Pd	Pw	Pdd	Pww	Pwd	Pdw
14	0.53	0.47	0.27	0.17	0.73	0.83
15	0.27	0.73	0.10	0.33	0.90	0.67
16	0.30	0.70	0.03	0.47	0.97	0.53
17	0.27	0.73	0.07	0.53	0.93	0.47
18	0.33	0.67	0.13	0.53	0.87	0.47
19	0.33	0.67	0.10	0.43	0.90	0.57
20	0.13	0.87	0.03	0.57	0.97	0.43
21	0.17	0.83	0.10	0.80	0.90	0.20
22	0.13	0.87	0.03	0.73	0.97	0.27
23	0.03	0.97	0.00	0.83	1.00	0.17
24	0.07	0.93	0.00	0.90	1.00	0.10
25	0.07	0.93	0.00	0.87	1.00	0.13
26	0.20	0.80	0.00	0.73	1.00	0.27
27	0.13	0.87	0.00	0.77	1.00	0.23
28	0.10	0.90	0.00	0.80	1.00	0.20
29	0.13	0.87	0.03	0.83	0.97	0.17
30	0.47	0.53	0.10	0.50	0.90	0.50
31	0.37	0.63	0.17	0.37	0.83	0.63
32	0.30	0.70	0.13	0.50	0.87	0.50
33	0.20	0.80	0.10	0.67	0.90	0.33
34	0.17	0.83	0.03	0.67	0.97	0.33
35	0.03	0.83	0.03	0.70	0.97	0.30
36	0.03	0.97	0.00	0.83	1.00	0.17
37	0.03	0.97	0.00	0.93	1.00	0.07
38	0.03	0.97	0.00	0.93	1.00	0.07
39	0.03	0.97	0.00	0.97	1.00	0.03
40	0.03	0.97	0.00	0.93	1.00	0.07
41	0.13	0.87	0.00	0.83	1.00	0.17
42	0.37	0.63	0.07	0.57	0.93	0.43
43	0.57	0.43	0.30	0.40	0.70	0.60
44	0.77	0.23	0.47	0.13	0.53	0.87
45	0.87	0.13	0.73	0.07	0.27	0.93

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

Table 7: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4mm threshold limit of rainfall for Jos

Weeks	Initial Probabilities		Conditional Probabilities			
	Pd	Pw	Pdd	Pww	Pwd	Pdw
14	0.70	0.30	0.57	0.03	0.43	0.97
15	0.50	0.50	0.47	0.27	0.53	0.73
16	0.33	0.67	0.17	0.40	0.83	0.60
17	0.27	0.73	0.10	0.53	0.90	0.47
18	0.20	0.80	0.07	0.63	0.93	0.37
19	0.13	0.87	0.03	0.70	0.97	0.30
20	0.20	0.80	0.00	0.70	1.00	0.30
21	0.07	0.93	0.00	0.80	1.00	0.20
22	0.03	0.97	0.00	0.90	1.00	0.10
23	0.03	0.97	0.00	0.93	1.00	0.07
24	0.00	1.00	0.00	0.97	1.00	0.03
25	0.00	1.00	0.00	1.00	1.00	0.00
26	0.10	0.90	0.00	0.90	1.00	0.10
27	0.03	0.97	0.00	0.87	1.00	0.13
28	0.03	0.97	0.00	0.97	1.00	0.03
29	0.03	0.97	0.00	0.93	1.00	0.07
30	0.00	1.00	0.00	0.97	1.00	0.03
31	0.00	1.00	0.00	1.00	1.00	0.00
32	0.00	1.00	0.00	1.00	1.00	0.00
33	0.00	1.00	0.00	1.00	1.00	0.00
34	0.00	1.00	0.00	1.00	1.00	0.00
35	0.00	1.00	0.00	1.00	1.00	0.00
36	0.00	1.00	0.00	1.00	1.00	0.00
37	0.07	0.93	0.00	0.93	1.00	0.07
38	0.03	0.97	0.00	0.90	1.00	0.10
39	0.13	0.87	0.03	0.87	0.97	0.13
40	0.37	0.63	0.10	0.73	0.90	0.27
41	0.43	0.57	0.20	0.37	0.80	0.63
42	0.73	0.27	0.30	0.13	0.70	0.87
43	0.87	0.13	0.70	0.10	0.30	0.90
44	0.93	0.07	0.83	0.03	0.17	0.97
45	0.97	0.03	0.93	0.03	0.07	0.97

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

Table 8: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4mm threshold limit of rainfall for Lokoja

Week	Initial Probabilities		Conditional Probabilities			
	Pd	Pw	Pdd	Pww	Pwd	Pdw
14	0.63	0.37	0.53	0.10	0.47	0.90
15	0.43	0.57	0.37	0.30	0.63	0.70
16	0.17	0.83	0.03	0.43	0.97	0.57
17	0.37	0.63	0.07	0.53	0.93	0.47
18	0.27	0.73	0.13	0.50	0.87	0.50
19	0.23	0.77	0.07	0.53	0.93	0.47
20	0.27	0.73	0.03	0.53	0.97	0.47
21	0.10	0.90	0.03	0.67	0.97	0.33
22	0.10	0.90	0.00	0.80	1.00	0.20
23	0.10	0.90	0.00	0.80	1.00	0.20
24	0.07	0.93	0.03	0.87	0.97	0.13
25	0.17	0.83	0.03	0.80	0.97	0.20
26	0.27	0.73	0.00	0.63	1.00	0.37
27	0.10	0.90	0.03	0.70	0.97	0.30

28	0.03	0.97	0.03	0.90	0.97	0.10
29	0.13	0.87	0.03	0.87	0.97	0.13
30	0.20	0.80	0.07	0.73	0.93	0.27
31	0.20	0.80	0.10	0.73	0.90	0.27
32	0.20	0.80	0.07	0.67	0.93	0.33
33	0.17	0.83	0.00	0.63	1.00	0.37
34	0.07	0.93	0.00	0.77	1.00	0.23
35	0.10	0.90	0.00	0.87	1.00	0.13
36	0.00	1.00	0.00	0.90	1.00	0.10
37	0.00	1.00	0.00	1.00	1.00	0.00
38	0.00	1.00	0.00	1.00	1.00	0.00
39	0.07	0.93	0.00	0.93	1.00	0.07
40	0.20	0.80	0.00	0.73	1.00	0.27
41	0.13	0.87	0.00	0.70	1.00	0.30
42	0.33	0.67	0.07	0.63	0.93	0.37
43	0.60	0.40	0.23	0.30	0.77	0.70
44	0.90	0.10	0.57	0.07	0.43	0.93
45	1.00	0.00	0.90	0.00	0.10	1.00

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

The probability of having a dry week and dry week following another dry week (Pd & Pdd) for Makurdi was relatively low (Table 9). The highest values of these probabilities, ranging from 30% to 90% and 33% to 77% respectively, were limited to weeks 14th - 16th and 42nd - 45th. However, chances of dry week preceded by wet week were found to be high during most of the weeks including weeks 14th - 22nd, 27th - 32nd and 40th - 45th. The range of probability in these weeks was 30% to 100%. For both initial and conditional probability of wet week (Pw & Pww), over 50% chances occurred from week 17th - 41st, ranging within these weeks from 63% to 100% and 53% to 97% respectively. Furthermore, the probability of wet week preceded by dry week (Pwd) ranged from 50% to100% right from week 15th - 44th.

Table 9: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4 mm threshold limit of rainfall for Makurdi

Week	Initial Probabilities		Conditional Probabilities			
	Pd	Pw	Pdd	Pww	Pwd	Pdw
14	0.60	0.40	0.64	0.60	0.36	0.40
15	0.63	0.37	0.56	0.33	0.44	0.67
16	0.30	0.70	0.32	0.45	0.68	0.55
17	0.20	0.80	0.22	0.76	0.78	0.24
18	0.33	0.67	0.33	0.67	0.67	0.33
19	0.37	0.63	0.50	0.70	0.50	0.30
20	0.20	0.80	0.16	0.79	0.84	0.21
21	0.23	0.77	0.17	0.79	0.83	0.21
22	0.10	0.90	0.14	0.87	0.86	0.13
23	0.07	0.93	0.00	0.93	1.00	0.07
24	0.17	0.83	0.00	0.82	1.00	0.18
25	0.10	0.90	0.20	0.92	0.80	0.08
26	0.20	0.80	0.33	0.81	0.67	0.19
27	0.23	0.77	0.33	0.79	0.67	0.21
28	0.13	0.87	0.00	0.83	1.00	0.17
29	0.17	0.83	0.00	0.81	1.00	0.19
30	0.20	0.80	0.40	0.84	0.60	0.16
31	0.20	0.80	0.17	0.79	0.83	0.21
32	0.17	0.83	0.17	0.88	0.83	0.13
33	0.03	0.97	0.00	0.96	1.00	0.04
34	0.00	1.00	0.00	0.97	1.00	0.03
35	0.03	0.97	0.00	0.97	1.00	0.03
36	0.03	0.97	0.00	0.97	1.00	0.03

37	0.03	0.97	0.00	1.00	1.00	0.00
38	0.03	0.97	0.00	1.00	1.00	0.00
39	0.10	0.90	0.00	0.93	1.00	0.07
40	0.20	0.80	0.00	0.78	1.00	0.22
41	0.23	0.77	0.33	0.75	0.67	0.25
42	0.53	0.47	0.57	0.48	0.43	0.52
43	0.50	0.50	0.50	0.36	0.50	0.64
44	0.83	0.17	1.00	0.27	0.00	0.73
45	0.90	0.10	0.92	0.00	0.08	1.00

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

Table 10: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4 mm threshold limit of rainfall for Minna

Week	Initial Probabilities		Conditional Probabilities			
	Pd	Pw	Pdd	Pww	Pwd	Pdw
14	0.67	0.33	0.57	0.00	0.43	1.00
15	0.70	0.30	0.60	0.23	0.40	0.77
16	0.50	0.50	0.33	0.13	0.67	0.87
17	0.30	0.70	0.13	0.37	0.87	0.63
18	0.43	0.57	0.20	0.47	0.80	0.53
19	0.27	0.73	0.10	0.47	0.90	0.53
20	0.27	0.73	0.07	0.53	0.93	0.47
21	0.17	0.83	0.07	0.60	0.93	0.40
22	0.23	0.77	0.00	0.63	1.00	0.37
23	0.10	0.90	0.03	0.73	0.97	0.27
24	0.10	0.90	0.00	0.80	1.00	0.20
25	0.10	0.90	0.03	0.87	0.97	0.13
26	0.13	0.87	0.03	0.80	0.97	0.20
27	0.07	0.93	0.03	0.87	0.97	0.13
28	0.17	0.83	0.03	0.83	0.97	0.17
29	0.03	0.97	0.00	0.80	1.00	0.20
30	0.07	0.93	0.03	0.93	0.97	0.07
31	0.10	0.90	0.00	0.83	1.00	0.17
32	0.07	0.93	0.00	0.83	1.00	0.17
33	0.07	0.93	0.00	0.87	1.00	0.13
34	0.00	1.00	0.00	0.93	1.00	0.07
35	0.00	1.00	0.00	1.00	1.00	0.00
36	0.03	0.97	0.00	0.97	1.00	0.03
37	0.00	1.00	0.00	0.97	1.00	0.03
38	0.00	1.00	0.00	1.00	1.00	0.00
39	0.07	0.93	0.00	0.93	1.00	0.07
40	0.03	0.97	0.00	0.93	1.00	0.07
41	0.13	0.87	0.00	0.83	1.00	0.17
42	0.37	0.63	0.10	0.57	0.90	0.43
43	0.67	0.33	0.27	0.20	0.73	0.80
44	0.87	0.13	0.67	0.13	0.33	0.87
45	0.93	0.07	0.80	0.00	0.20	1.00

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

The initial dry week probability (Pd) at Minna was high, from week 14th - 18th (excluding week 17th) and week 42nd to 45th, ranging from 37% to 93%, while equivalent values for the conditional probability (Pdd) were limited to weeks 14th - 15th and 44th - 45th (Table 10). High chances of having a dry week following a wet (Pdw) occurred on more weeks, from week 14th - 22nd and week 42nd - 45th. The range of probability within these weeks was 37% to 100%, with most of the weeks skewed to the maximum. The probability of wet week (Pw), 50% to 100%, occurred from week 16th - 42nd, while wet week preceded by wet week (Pww) attained equivalent values from week 20th - 41st.

The probability of wet week preceded by dry week (Pwd) was also high from week 16th - 43rd, ranging from 67% to 100%.

For Yola, considerable chances of a week being dry (Pd) extended from the week 14th - 20th and week 39th - 45th, ranging from 33% to 97% (Table 11). For dry week preceded by dry week (Pdd), 43% to 90% chances occurred from week 14th - 16th and week 43rd - 45th. Similar to all other stations except for Jos, the probability of dry week preceded by a wet week (Pdw) attained consequential values (33% to 100%) during most weeks, from week 14th - 24th and week 39th - 45th, with majority of the weeks skewed to the maximum. The initial probability of wet week (Pw), ranging from 50% to 97%, occurred from week 17th - 41st week, while for wet week preceded by wet week and wet week preceded by dry week (Pww & Pwd), over 50% chances of occurred from week 22nd - 39th and week 16th - 43rd, ranging from 63% to 90% and 57% to 100% respectively.

Generally, for the Middle Belt region, the probabilities of a week being dry (Pd) and dry week preceded by dry week (Pdd) were higher at the early and later parts of the rainy season. In addition, the initial probability of a dry week (Pd) ranged from 30% to 97%, between week 14th - 16th and week 41st - 45th, while chances of a dry week preceded by dry week ranged from 30% to 93% between week 14th - 16th and week 43rd - 45th. On the other hand, chances of wet week (Pw) were low at the beginning and end of the season but high in the middle of it, in all the stations. This conforms to the findings of Kingra et al., (2013), Admasu *et al.,* (2014) and Dabral *et al.,* 2014, Manikandan *et al*, 2017). Initial and conditional probabilities of wet week (Pw and Pww) reached 50% to 100% from the week 21st to 41st across the entire region except at Yola, where in the case of Pww, 63% to 90% were attained from week 22nd - 39th.

3.4 Implications of the finding on agriculture planning in the study area

The Middle Belt region covers an area of 333, 814km^2, representing 36% of the total land mass of Nigeria. Rain-fed agriculture has has been a common practice in the region and until recently, irrigation agriculture has gained prominence due largely to the abundant surface water resources of rivers Niger and Benue that drain the region. The significance of the Middle Belt region with regards to agricultural productivity is well acknowledged in Nigeria. This is partly because the region falls within both grain and root crops zones of the country where *Dioscorea rotumdata* (yam), *Manihot esculenta* (cassava), *Sorghum bicolor* (guinea corn), *Ipomoea batatas* (sweet potato), *Oryza sativa* (rice), *Zea mays* (maize), Pennisetum typhoides (millet), Solanum tuberosum (irish potato), Arachis hypogaea (ground nut), Glycine max (soya bean) and Sesamum indicum (beniseed) are produced in commercial quantitatives (Akinbode, 1978).

The ideal time of land preparation for rain-fed crops is prior to week 17th - 18th for Ilorin, Jos, Lokoja and Makurdi, while other areas including Bida, Minna and Yola, it could be extended to week 20th - 21st when the conditional probability of wet week at these areas reaches over 50%. Ploughing and planting of rain-fed crops at the respective locations could be carried out as from the periods (weeks) pointed out above. For long duration or lately planted crops, supplementary irrigation will be required after week 41st over most of the locations, while at Yola, supplementary irrigation should be practiced as from week 39th - 40th when the conditional probability of wet week declines to below 50%.

4. Conclusion

The mean regional onset, cessation and duration of the rainy season were 15th week (9th – 15th April), 42nd week (15th – 21st October) 29 weeks (203 days).The probabilities of a week being dry (Pd) and dry week preceded by dry week (Pdd) were higher at the early and later parts of the rainy season than in the middle of it. Across the entire region, the initial probability of a dry week (Pd) ranged from 30% to 97%, between week 14th - 16th and week 41st - 45th, while chances of a dry week preceded by dry week ranged from 30% to 93% between week 14th - 16th and week 43rd - 45th. The initial and conditional probabilities of wet week (Pw and Pww) reached 50% to 100% from the week 21st to 41st across the entire region except at Yola, where in the case of Pww, 63% to 90% were attained from week 22nd - 39th. The study concludes that land preparation for crop planting should commence from week 20th - 22nd (i.e. three weeks after onset of the rainy season week) and irrigation farming should start after the week 42nd (i.e. a week after cessation of the rainy season week) in the Middle Belt region.

Table 11: Initial and Conditional Probabilities of Dry and Wet Weeks at 8.4mm threshold limit of rainfall for Yola.

Week	Initial Probabilities		Conditional Probabilities			
	Pd	Pw	Pdd	Pww	Pwd	Pdw
14	0.90	0.10	0.83	0.00	0.17	1.00
15	0.80	0.20	0.70	0.03	0.30	0.97
16	0.53	0.47	0.43	0.10	0.57	0.90
17	0.37	0.63	0.23	0.33	0.77	0.67
18	0.50	0.50	0.20	0.30	0.80	0.70
19	0.37	0.63	0.20	0.33	0.80	0.67
20	0.47	0.53	0.17	0.33	0.83	0.67
21	0.20	0.80	0.13	0.47	0.87	0.53
22	0.17	0.83	0.00	0.63	1.00	0.37
23	0.20	0.80	0.03	0.67	0.97	0.33
24	0.13	0.87	0.00	0.67	1.00	0.33
25	0.23	0.77	0.07	0.70	0.93	0.30
26	0.13	0.87	0.03	0.70	0.97	0.30
27	0.10	0.90	0.03	0.80	0.97	0.20
28	0.10	0.90	0.03	0.83	0.97	0.17
29	0.20	0.80	0.03	0.73	0.97	0.27
30	0.07	0.93	0.03	0.77	0.97	0.23
31	0.07	0.93	0.00	0.87	1.00	0.13
32	0.03	0.97	0.00	0.90	1.00	0.10
33	0.10	0.90	0.00	0.87	1.00	0.13
34	0.03	0.97	0.00	0.87	1.00	0.13
35	0.07	0.93	0.00	0.90	1.00	0.10
36	0.13	0.87	0.03	0.83	0.97	0.17
37	0.10	0.90	0.03	0.80	0.97	0.20
38	0.03	0.97	0.03	0.90	0.97	0.10
39	0.33	0.67	0.03	0.67	0.97	0.33
40	0.37	0.63	0.17	0.47	0.83	0.53
41	0.43	0.57	0.17	0.37	0.83	0.63
42	0.60	0.40	0.30	0.27	0.70	0.73
43	0.73	0.27	0.43	0.10	0.57	0.90
44	0.93	0.07	0.67	0.00	0.33	1.00
45	0.97	0.03	0.90	0.00	0.10	1.00

Source: Computed from the rainfall data of the Nigerian Meteorological Agency (1981-2010)

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