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Statistical Estimation of Onset, Length and Cessation of Rainfall in Selected Locations in South West, Nigeria.

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Abstract: *Without quantitative data, agro-meteorological planning, forecasting, and services cannot properly assist agricultural practitioners to optimally meet the ever-increasing demands for food and agricultural by-products. This study was carried out to compare several proposed estimation methods and to identify the best method for determining the rainfall variables in Southwest States of Nigeria. Rainfall variables (rainfall onset, rainfall period and rainfall cessation) were estimated from the data obtained from Nigeria Meteorological Training (NIMET) and using 3 different models of Cocheme and Franquin (CAF), Walter and Kowal and Knabe. The estimates of these 3 models were compared with the control (NIMET data) and the results revealed that mean rainfall period ranged between 213.938 and 257.875mm (for Osogbo and for Ikeja) while the variance ranged between 400.706 and 598.71 (for Osogbo and for Ado Ekiti). Generally the variance as well as the mean of the rainfall on-set was lesser than those of the rainfall period. Similarly the descriptive statistics reveal that Cocheme and Franquin's estimates is closer to the control (The NIMET observed value) while M_3 estimate is farther away. The correlation analysis of the relationship between the estimates and the control (the observed data from the NIMET) consistently returned positive/direct correlation values for all the bivariate pair and none of the bivariate correlation was negative. It was observed that M_1 has the highest relationship (0.695) with the control hence could be adjudged the most similar. The general linear model (glm) analysis of rainfall on-set across the sites showed that there exists significant difference in the rainfall on-set across the sites because $F_{(5;168:0.05)} = 43.02$ obtained for rainfall on-set is statistically significant ($p<0.05$). Also, the glm analysis of both rainfall period and rainfall cessation across the sites indicated that the $F_{(5;168:0.05)} = 57.11$ and 22.36 (for rainfall period and rainfall cessation) were both significant. The results of the analysis of the consistency and efficiency of the estimator indicated that for all the estimators, $V(\hat{\mu})$ approaches zero as $n \rightarrow \infty$ and there exist insignificant exception to the cases where the variance tends to jump up again..*

Keywords: *Prediction, disparate, consistence, parsimonious, evapotranspiration and prediction*.

INTRODUCTION

Rainfall estimation is important due to farmers' dependency on rain-fed agriculture and it also has impact on domestic and international economies (Chandrasekar and Cifelli, 2012). Crops that are grown for food, animals that are reared, mode of dressing, and type of shelter of any place on earth are usually determined by weather and climate characteristics of such place. Indeed weather and climate shape the way of life of people and affect their socio – economic activities. Without quantitative data, agro-meteorological planning, forecasting, and services cannot properly assist agricultural practitioners to optimally meet the ever-increasing demands for food and agricultural by-products. The data are also essential for assessing the impacts of agricultural activities and processes on the environment. Such information is used for strategic planning and for climate-smart decisions and practices which could bring about reduction of losses from adverse weather, minimize disasters and maximize output. Seasonal Rainfall Prediction (SRP) is the forecast of rainfall conditions for a period or season ranging from about three months to one year (Anyadike, 1992). The prediction is done annually and usually presented to stakeholders in policy implementation relating to weather and disaster management (Hargreaves and Zamani, 1982). The SRP is released early in the year so as to create good lead-time for policy makers to factor into their decision making processes. Rainfall predictions are meant to contribute significantly in ensuring food security by providing valuable information that would enhance optimum food production and processing.

Onset-date of rainy season is the date at which the available water content of the root zone at the beginning of the cropping season reaches 50%. Onset of rainfall is a reliable prediction of start of rains for growing season and it contributes immensely to the planning of farm operations. The onset time is a key variable on which all other seasonal rainfall characteristics depend (Jolliffe and Sarris-Dodd, 1994).

Cessation date of rainy season is determined when the available water content at the root zone has dropped to 50%. Cessation of rainfall is a reliable estimate of end of rains is of considerable interest to agriculture as it signals the approaching end of growing season. It is very essential in defining the length of rainy/growing season, as it aids in selection of crop varieties or cultivars for increased food production. Length of rainy season is the number of days between the onset and cessation dates of the rainy season while annual rainfall amount is the total amount of rainfall observed and recorded in the year under reference. Comparison of rainfall variable estimators is justified from the need to adopt a robust model that is capable of predicting accurately the rainfall variables. Early establishment of crops in the season means higher yields and it is based on accurate prediction (Rosenzweig *et al,* 1995). It is taken as the receipt of sufficient rain for survival of seedling after sowing as bogus rainfall onset prediction poses serious problem against crop production (Hess *et al,* 1995).

The objective of this research is thus to compare several proposed estimation methods for determining the rainfall on-set, cessation and period of rainfall in Southwest States of Nigeria and to identify the best method of estimating rainfall variables for agricultural improvement.

RESEARCH METHODOLOGY

Several methods of determining the onset and retreat of the rains in West Africa and Nigeria in particular, have been formulated. Inter-tropical Discontinuity (ITD) – rainfall model, (e.g. NIMET, Ayoade JO 2004; Kowal and Knabe, 1972), rainfall-evapotranspiration relation model (Cocheme and Franquin, 1967; Benoit, 1977), percentage cumulative mean rainfall model – based on rainfall data alone (Ayoade JO 2004; Adejuwon, 2005), wind shear model (Burke *et al* 2009) and the theta – E technique (Porter *et al*, 2010) are some of the adopted estimators. Nigeria Meteorological Agency (NIMET) prediction model is based on the strong tele-connection between El Nino/Southern Oscillations (ENSO), Sea Surface Temperature (SST) anomalies and rain-bearing weather systems over Nigeria (NIMET, 2010). ENSO is a recurrent abnormal shift in winds and Ocean currents centred in the South Pacific Ocean region. It produces extreme weather and climate conditions in many parts of the world and it serves as control. The model also incorporates phenological and soil information. Historical daily weather data from meteorological stations spatially distributed over Nigeria for 23 ENSO – Neutral years and 10 El Nino years is also used in the model for calculation of onset, cessation, length of rainy season and annual rainfall amount for the different areas in the country.

Cocheme and Franquin, (1967) – This model is rainfall potential evapotranspiration (PET) relation model and it (PET) is a parameter that depends solely on meteorological factors. It is the rate of water loss from a short green crop completely covering the ground and amply supplied with water. It is helpful to compare estimates of PET with mean rainfall total, when the latter exceed the former, crop growth is not usually hampered by shortage of water. The mean monthly rainfall amount obtained is plotted against the mean monthly potential evapotranspiration values including plots of 0.5 PET and 0.1 PET to determine the onset, duration and duration of rainfall. This method was tagged M_1 in our present study and its determination is by empirical formulae (e.g. Modified Penman-Monteith) which are defined as:

$$PET = \left[\frac{\left\{ \left((0.75 Ra(a + b\, n/N) - \sigma T^4 (0.56 - 0.79\sqrt{E_d}) \right\} \left\{ 0.1 + 0.9\, n/N \right\} + 0.26(E_a - E_d)(0.54_u + 1) \right)}{\frac{P_0^k}{P} \cdot \frac{\Delta}{\gamma}} \right]$$

Where PET = Potential Evapotranspiration
σT4 = Black body radiation
⊿ = the rate of change with temperature of the saturation vapor pressure
γ = the psychometric coefficient
0.75 = factor expressing the reduction in the incoming shortwave radiation on the evaporation surfaces and corresponding to an Albedo of 0.25
a and b = coefficient for the estimation of total radiation from the sunshine duration

N = sunshine duration astronomically possible for the given period.
n = sunshine duration for the period considered in hour
Ra = shortwave radiation received at the limit of the atmosphere
Ea = saturation vapor pressure
Ed = vapor pressure for the period under consideration.
T = air temperature measured in the station
U = mean wind speed at an elevation of 2m for the given period.

Walter (1967) - The methods based on accumulated rainfall totals assume that rainfall started when a particular amount is reached and the probability of a long dry spell that leads to crop failure. This method, propounded by Walter (1967) was labeled M_2 in our study and the relationship is given as:

ER = D (51-F)/R

Where ER = date of effective rainfall. D is the number of days in the first month when the accumulated rainfall total is more than 51 mm while F is the accumulated rainfall total in previous months while R is the total rainfall of the peaked month.

Kowal and Knabe, (1972) – Kowal and Knabe, (1972) defined onset of rainfall as the when 10-day rainfall total early in the year is equal or more than 25mm, but where the subsequent 10-day rainfall is greater than 0.5 of the potential evapotranspiration. It has been allotted M_3 while the direct observation from the NIMET was taken as control. These models were used to estimate the rainfall variables from the real data obtained from the NIMET.

Data obtained were analyzed using descriptive statistics (Mean, standard error and variance) and mean difference of the estimates. Mean differences between estimated rainfall on-set as well as rainfall period and that of the actual were obtained using;

$$\bar{x}_d = \frac{\sum (x_i - x_a)}{n}$$

Where $\bar{x}_d$ = mean difference, x_i = estimated rainfall on-set or rainfall period and x_a= the actual rainfall on-set and rainfall period as obtained from the National Institute of Meteorological Study (NIMET). The correlation analysis of the estimation methods and the general linear model (glm) analysis of the estimation across the site (with 5 degree of freedom - df) and estimation methods (with 3 df) were computed. The quality of the estimation methods were evaluated using Minimum variance unbiased Estimator (MVUE) principle. An estimator $\hat{\theta}(X)$ is said to be minimum unbiased estimator (MVUE) if and only if ( );

1. $E(\hat{\theta}) = \theta_0$
2. $\text{var}(\hat{\theta}) \leq \text{var}(\hat{\theta}_i)$ for all i satisfying (1)

The analysis was done using SAS (version 9) and Kye plot.

RESULTS AND DISCUSSION

The summary statistics of the rainfall on-set of different locations indicated that Ikeja gave the earliest rainfall on-set of 78.719 (±1.602) days while the rainfall on-set for Ikeja was the least rainfall on-set. The variance of the rainfall on-set ranged between 22.015 for Ikeja and 146.418 for Ado-Ekiti (Table 1). The disparity between the highest rainfall on-set and the next rainfall on-set portends a scenario of difference in the rainfall patterns of these areas. Also, M_1 gave the nearest mean rainfall on-set estimate of 88.563 relative to the control which is 83.667 while M_3 estimate was the most distinct mean (98.708) from the control (Table 1). The mean rainfall period ranged between 213.938 and 257.875mm (for Osogbo and for Ikeja) while the variance ranged between 400.706 for Osogbo and 598.71 for Ado Ekiti. All the rainfall period irrespective of the method were lesser than the actual of 247.229 (Table 1). M_1 gave the closest rainfall period of 231.792 while M_3 estimated 202.458 ranged was the widest (Control – M_3 estimates). Generally the variance as well as the mean of the rainfall on-set were lesser than those of the rainfall period. Similarly the descriptive statistics reveal that M_1 estimates is closer to the control (The NIMET observed value) while M_3 estimate is farther away. Rainfall cessation ranged between 307.75 (± 2.684) for Abeokuta and 330.594 (± 3.207) for Ikeja while the variance fall between 214.241 for Osogbo and 329.023 for Ikeja. The estimated mean rainfall cessation for the Control (NIMET data) was 330.896 and was followed by the rainfall cessation for M_1 (320.354). The variance of the rainfall cessation however ranged between 106.861 and 259.036 (for the control and for the Kowal and Knabe, 1972). This indicated that the mean and the variance of the rainfall cessation followed different pattern.

Mean difference between estimated rainfalls on-set were negatively skewed except in few cases when it became random (Figure 1). The implication of this is that the models overestimated the rainfall on-set. The mean difference of the rainfall periods however were random and positively skewed for all the sites except Ikeja where some values fell below zero (Figure 2). The variability pattern differs across different sites for the estimated rainfall period. The descriptive statistics of the rainfall variables indicated that the M_1 is the closest of the estimates. The sum of the difference in the estimation $(\sum_{i=1}^{n=3} DM_i)$ followed;

$$\sum DM_1(-235) > \sum DM_2(-686) > \sum DM_1(-722)$$

This implies that the M_1 estimates gave the closest estimation of the rainfall variables. Lastly, the results of the analysis of the efficiency of the estimators indicated that M_2 is the most efficient estimator followed by M_1 while M_3 is the least efficient for any of the rainfall variables (Table 2). The goal of estimation in our present study has been to approximate the value of the rainfall variables on the basis of some available models. This approach is different from the one proposed by both krichner (2009) and Brocca et al., (2013). Simple approach of rainfall accumulation estimation from soil moisture was proposed by the duo (krichner, 2009 and Brocca et al., 2013) while our work utilized available rainfall data to estimate the rainfall variables. The estimation in the present study followed the point estimation types as against interval estimation. Similarly, our works can be categorized as physical science aspect of rainfall estimation. The physical science aspect of rainfall estimation according to Chandrasekar and Cifelli (2012) essentially represents the tracking of the microphysical properties of rainfall

Correlation analysis, General Linear Model (glm) and Mean separation of the Rainf all variables

The correlation analysis of the relationship between the estimates and the control (the observed data from the NIMET) consistently returned positive/direct correlation values for all the bivariate pair (Table 3). None of the bivariate correlation was negative and it ranged between 0.855 (M_1 and M_3) and 0.334 (M_2 and control) for the rainfall on-set (Table 3). It is observed that M_1 has the highest relationship (0.695) with the control hence could be adjudged the most similar. Also the bivariate correlation analysis of the estimation of the rainfall periods by different methods returned similar trends. The bivariate correlation values ranged from 0.833 (relationship between M_3 and M_2) to 0.513 (relationship between M_3 and the control). M_1 had the highest correlation value (0.725) with the control in term of rainfall period estimation. (Table 3). The correlation analysis of the rainfall cessation showed that the bivariate correlation ranged between 0.736 (for M_1 and M_2 relationship) and 0.405 (for the relationship between M_3 and Control – Table 3). The M_1 returned the highest relationship with the control while M_3 has the least bivariate correlation (0.405) values with the control.

The general linear model (glm) analysis of rainfall on-set across the sites showed that there exists significant difference in the rainfall on-set across the sites. The $F_{(5;168\ :0.05)} = 43.02$ which was obtained for rainfall on-set for the sites is statistically significant ($p<0.05$ – Table 4). Also, the glm analysis of both rainfall period and rainfall cessation across the sites indicated that the $F_{(5;\ 168\ :0.05)} = 57.11$ and 22.36 (rainfall period and rainfall cessation obtained are both significant ($p < 0.05$ – Table 4). Duncan Multiple Range Test (DMRT) partitioned the mean rainfall on-set into 2 distinctively significant class. The mean rainfall on-set obtained for Ikeja was significantly earlier than all other sites that are not significantly different from one another. Similarly, the rainfall periods for all the sites were not significantly different from one another but significantly less than that of Ikeja (Table 4). The rainfall cessation was however differs from both rainfall on set and period in term DMRT partitioning. Rainfall cessation obtained for Ikeja (330.594) is statistically higher than that of Ibadan (313.656). Rainfall cessation for Ibadan is statistically higher than the rainfall cessation for Abeokuta (307.75) while other sites have rainfall cessation forming intermediary class between that of both Ibadan and Abeokuta estimates (Table 4).

The glm analysis of the estimation methods showed that there exists significant difference in the estimated rainfall on-set by each of the methods. The $F_{(3; 168 :0.05)} = 78.57$ returned for the rainfall on-set is significant ($P < 0.05$ - Table 4) for the estimate methods. Also, there is significant different in the estimates by difference methods (Table 4). The F- Statistics ($F_{(3; 168 :0.05)} = 179.9$) returned for rainfall period is statistically significant ($P< 0.01$) for the rainfall period. Mean rainfall on-set were partitioned into 3 significant classes. The observed rainfall on-set (as obtained from NIMET) was statistically lower than the M_1 estimates which is in turn lower than both M_2 and M_3. The glm analysis of the rainfall cessation estimates indicated that there is significant difference in the rainfall cessation of different sites. Similarly, there exists significance difference among the rainfall cessation estimates of different methods. The $F_{(3; 168 :0.05)} = 95.17$ obtained for the estimates methods are significant ($P < 0.01$ – Table 4). The rainfall cessation by the control is statistically later that the M_1 estimates and was followed by both M_3 and M_1 which are not statistically different from each other. The results of the analysis of the consistency and efficiency of the estimator indicated that for all the estimators, $V(\hat{\mu})$ approaches zero as $n \to \infty$ (that as n increases to infinity, the variance reduces towards zero –Table 5). There is insignificant exception to the cases where the variance tends to jump up again and the M_1 estimator returned the most consistent of the estimators. Similarly, for all the estimators, the variance $V(\hat{\vartheta}_i)$ of the M_1 is the least (Table 5).

From these results, it is noteworthy that different estimation methods gave different results and across the sites. Also, the different statistical tools pointed to the same results of M_1 producing a closer estimate to the observed data. The disparity in the rainfall variable estimation across the sites is consistent with the rainfall characteristics of the South West Nigeria and the entire country. The overestimation of the rainfall on-set by the estimators obtained in our study contrast with Dembele and Zwart (2016) where the precipitation variables were underestimated. Similarly, the estimation methods in the present study were strongly correlated unlike in Dembele and Zwart (2016) where weak correlation values were reported for different estimation methods. The disparate results between the 2 studies (Dembele and Zwart, 2016 and the current research) could be linked to the sources of the data. The data for Dembele and Zwart (2016) were from satellite while the current study obtained the data from direct observation.

Direct comparison among techniques of rainfall variable estimation is possible in our present work due to availability of the control (which is the NIMET data) and this is in consonant with Fernando *et al.,* (2014). According to Fernado *et al.,* (2014), direct comparison of techniques of average rainfall estimation is not feasible due to non-availability of the real values. The direct comparison of estimates has been employed for Sub Sahara Africa in the past (Elias and Drake, 2009). However, this research is able to identify the best estimates (M_1) for the rainfall variables. This is in line with Fernando et al., (2014) who identified ME and RDS as given great results. Similarly, M_1 estimation method is also found to fulfil the statistical properties of estimation including unbiasedness, consistency and efficiency.

CONCLUSIONS AND RECOMMENDATION

This study has evaluated estimation of the rainfall variables using different approaches/methods. Estimation is one of the two types of statistical inference with the other one being hypothesis testing. It can be concluded that rainfall variable estimation is best predicted when data is available using M_1 and that complex model may not be needed to avoid bogus results. It is thus recommended that more rainfall variable estimator be included in future study.

REFERENCES

Adejuwon, J.O. (2005). Food crop production in Nigeria: Present effects of climate variability, *Climate Research, Inter-Research, Germany.*

Anyadike, R.N.C. (1992) Regional variation in flunctuations of seasonal rainfallover Nigeria. Theoretical and Applied Climatology 45: 285-292.

Ayoade, J.O. (2004) *Introduction to Climatology for the Tropics*. Spectrum Book Limited, Ibadan.

Benoit, P (1997) The start of growing season in northern Nigeria. Agricultural Meteorology 18: 91-99.

Burke, M. B., Lobell, D. B. and Guarino, L. (2009) Shifts in African crop climates by 2050, and the implications for crop improvement. *Global Environmental Change,* 19**,** 317-325.

Brocca, L., Moramarco, T. Melone, F. and W. Wagner (2013) A new method for rainfall estimation through soil moisture Observations. Geophysical Research Letters, 40: 853–858.

Chandrasekar, V. and Cifelli, R. (2012) Concepts and Principles of Rainfall Estimation from Radar: Multi Sensor environment and data fusion. India Journal of Radio and Space Physics. 41:389 – 402.

Hess, T.M., Stephens, W. and Maryah, U.M. (1977) Rainfall trends in the north east arid zone of Nigeria 1961-1990. *Agriculture and Forest Meteorology* 74: 87-97.

Hargreaves, G.H. and Zamani, Z.A. (1982) Estimating potential evapotranspiration. Journal of Irrigation and Drainage Division, Proceedins of American Society of Civil Engineers 108: 225-230.

Jolliffe, I.T. and Sarris-Dodd, D.E. (1994) Early detection of the start of wet season in tropical climate. *International Journal of Climatology.* : 71-76.

Kirchner, J. W. (2009). Catchments as simple dynamical systems: catchment characterization, rainfall-runoff modeling, and doing hydrology backward. Water Resources Research, 45, W02429.

Kowal, J.M. and Knabe, D.T. (1972) An Agroclimatological Atlas of the Northern States of Nigeria with Explanatory Notes. Ahmadu Bello University, Zaria, Nigeria.

Nigeria Meteorological Agency (2011-2018) Yearly Seasonal Rainfall Prediction.

PORTER, C. H., JONES, J.W., ADIKU, S., GIJSMAN, A. J., GARGIULO, O. and NAAB, J. B. (2010). Modeling organic carbon and carbon-mediated soil processes in DSSAT V4.5. Operational Research 10, 274–278.

Rosenzweig, N.J., Ritchei, J.T., Jones, J.W., Tsuji, G.Y. and Hildebrand, P. (1995) Climate change an Agriculture: Analysis of potential impacts. American Society of Agronomy. Madison, WI.

Sahu, P.K., Pal, S.R. and Ajit, K.D. (2015) Estimation and Inferential Statistics. Springer Publisher, 315pp

1: Summary Statistics for Both Rainfall on-set and Rainfall period

		Rainfall on-set		Rainfall period		Rainfall Cessation	
		Mean ± S.E	Variance	Mean ± S.E	Variance	Mean ± S.E	Variance
Locations	Abeokuta	93.688 ± 1.662	88.415	214.063 ± 3.788	459.157	307.75 ± 2.684	230.516
	Ado-Ekiti	95.031 ± 2.139	146.418	216.750 ± 4.325	598.71	311.781± 2.772	245.854
	Akure	95.500 ± 1.606	82.516	215.406 ± 4.145	549.733	310.906± 2.702	233.701
	Ibadan	95.563 ± 1.602	82.125	218.094 ± 4.094	536.217	313.656± 2.956	279.523
	Ikeja	78.719 ± 0.829	22.015	251.875 ± 3.587	411.661	330.594 ±3.207	329.023
	Osogbo	94.844 ± 1.110	39.426	213.938 ± 3.539	400.706	308.781± 2.588	214.241
Methodology	Control	83.667 ± 1.213	70.61	247.229 ± 2.005	192.989	330.896± 1.492	106.861
	M1	88.563 ± 1.228	72.379	231.792 ± 2.442	286.339	320.354± 1.736	144.617
	M2	97.958 ± 1.202	69.317	205.271 ± 2.423	281.861	303.229 ± 1.605	123.627
	M3	98.708 ± 1.269	77.275	202.458 ± 3.286	518.424	301.167 ± 2.323	259.036

M_1 = Cocheme and Franquin, (1967)'s method, M_2 = Walter (1967)'s method and M_3 = Kowal and Knabe, (1972)'s method

Table 2. Efficiency of the Estimations.

Methods	Rainfall on-sets	Rainfall Periods	Rainfall cessation
M1	0.976	0.674	0.739
M2	1.019	0.685	0.864
M3	0.914	0.372	0.413

M_1 = Cocheme and Franquin, (1967)'s method, M_2 = Walter (1967)'s method and M_3 = Kowal and Knabe, (1972)'s method

Table 3. Correlation analysis of the different estimation methods

		M1	M2	M3	Control
	M1	72.37899	47.1516	54.50798	49.65957
Rainfall on set	M2	0.665685	69.31738	62.54078	23.39007
	M3	0.728844	0.854522	77.27482	27.62411
	Control	0.694646	0.334332	0.37397	70.60993
	M1	286.3387	232.6746	313.2677	170.4105
Rainfall Period	M2	0.819014	281.8613	318.5966	127.9579
	M3	0.81308	0.833453	518.4238	162.2544
	Control	0.72492	0.548635	0.512965	192.9889
	M1	144.6166	98.3852	129.9823	87.69725
Rainfall Cessation	M2	0.735807	123.6272	129.1738	49.51374
	M3	0.671576	0.721835	259.0355	67.44326
	Control	0.705451	0.430783	0.405367	106.8613

NB . M_1 = Cocheme and Franquin, (1967)'s method, M_2 = Walter (1967)'s method and M_3 = Kowal and Knabe, (1972)'s method, Control = actual estimates as recorded by the NIMET.

Table 4: General Linear Model and Mean Separation for location and Estimation Methods for both Rainfall on-set and Rainfall periods.

Location				Methodology			
Variable	**Rainfall on set**	**Rain Period**	**Rainfall Cessation**	**Variable**	**Rainfall on set**	**Rain period**	**Rainfall Cessation**
F-Statistics	43.02**	57.11**	22.36**	**F-Statistics**	78.57	179.9	95.17**
Df	5	5	5	**Df**	3	3	3
Ibadan	95.563[a]	218.094[b]	313.656[b]	**M1**	88.563[b]	231.792[b]	320.354[b]
Akure	95.500[a]	215.406[b]	310.906[bc]	**M2**	97.958[a]	205.271[c]	303.229[c]
Ado-Ekiti	95.031[a]	216.75[b]	311.781[bc]	**M3**	98.708[a]	202.458[c]	301.167[c]
Osogbo	94.844[a]	213.938[b]	308.781[bc]	**Control**	83.667[c]	247.229[a]	330.896[a]
Abeokuta	93.688[a]	214.063[b]	307.75[c]				
Ikeja	78.719[b]	251.875[a]	330.594[a]				

M_1 = Cocheme and Franquin, (1967)'s method, M_2 = Walter (1967)'s method and M_3 = Kowal and Knabe, (1972)'s method

Table 5. Analysis of the consistency and efficiency of the Estimators

No of items	Rainfall on-set			Rainfall Period			Cessation		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
12	44.811	112.811	79.455	149.182	217.242	174.697	67.902	64.568	69.242
18	46.810	120.134	101.595	138.029	308.353	280.536	78.840	134.095	162.379
19	44.719	118.322	97.386	131.192	364.603	373.731	62.188	155.808	196.577
21	44.500	114.748	107.157	150.333	307.948	334.214	93.733	159.633	201.814
24	40.737	108.862	101.636	153.259	331.036	328.303	93.326	187.188	205.906
28	37.602	100.258	91.878	140.476	289.720	293.231	90.004	181.433	204.036
33	40.280	102.104	97.570	151.320	268.746	472.047	85.610	173.017	299.905
37	39.488	102.743	98.422	142.559	256.743	452.021	79.008	165.333	288.977
41	40.580	103.205	98.600	135.220	245.805	428.044	74.751	149.370	264.494
44	46.000	98.063	94.245	144.977	231.393	406.725	78.326	142.577	249.731
48	43.670	93.147	92.637	138.507	218.934	386.904	76.083	131.461	231.010

M_1 = Cocheme and Franquin, (1967)'s method, M_2 = Walter (1967)'s method and M_3 = Kowal and Knabe, (1972)'s method

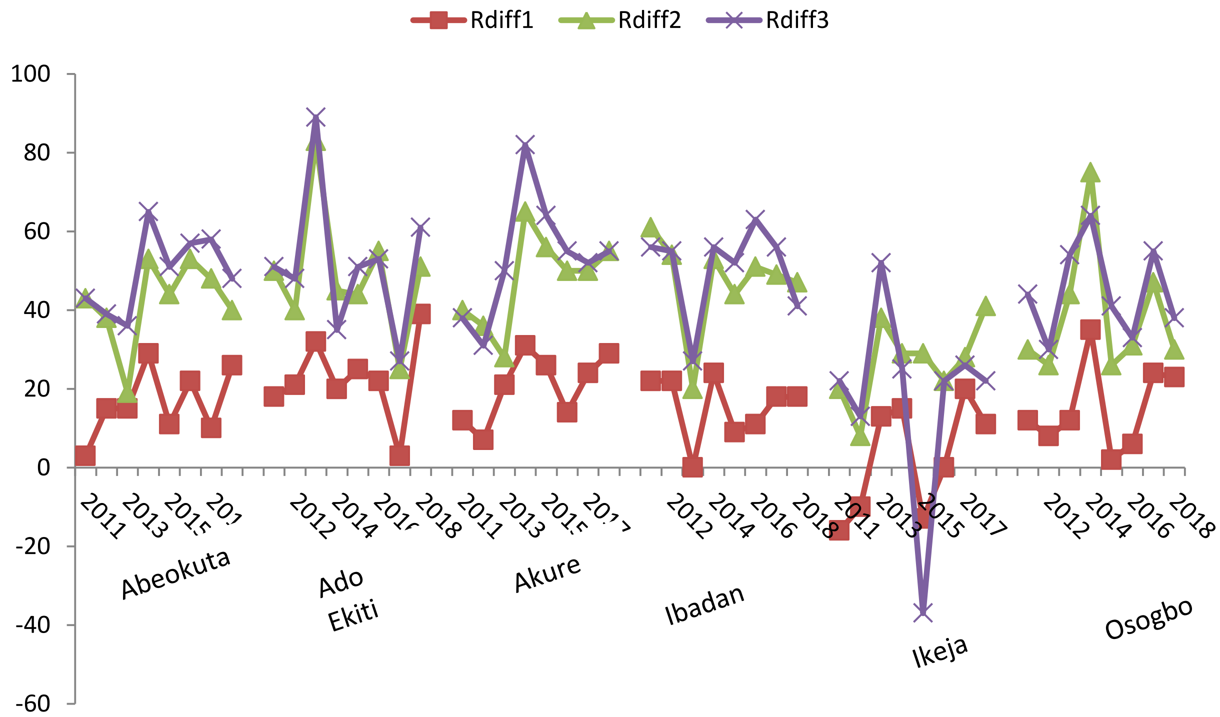

Figure 1. Difference between the Control and the 3 Model estimations.

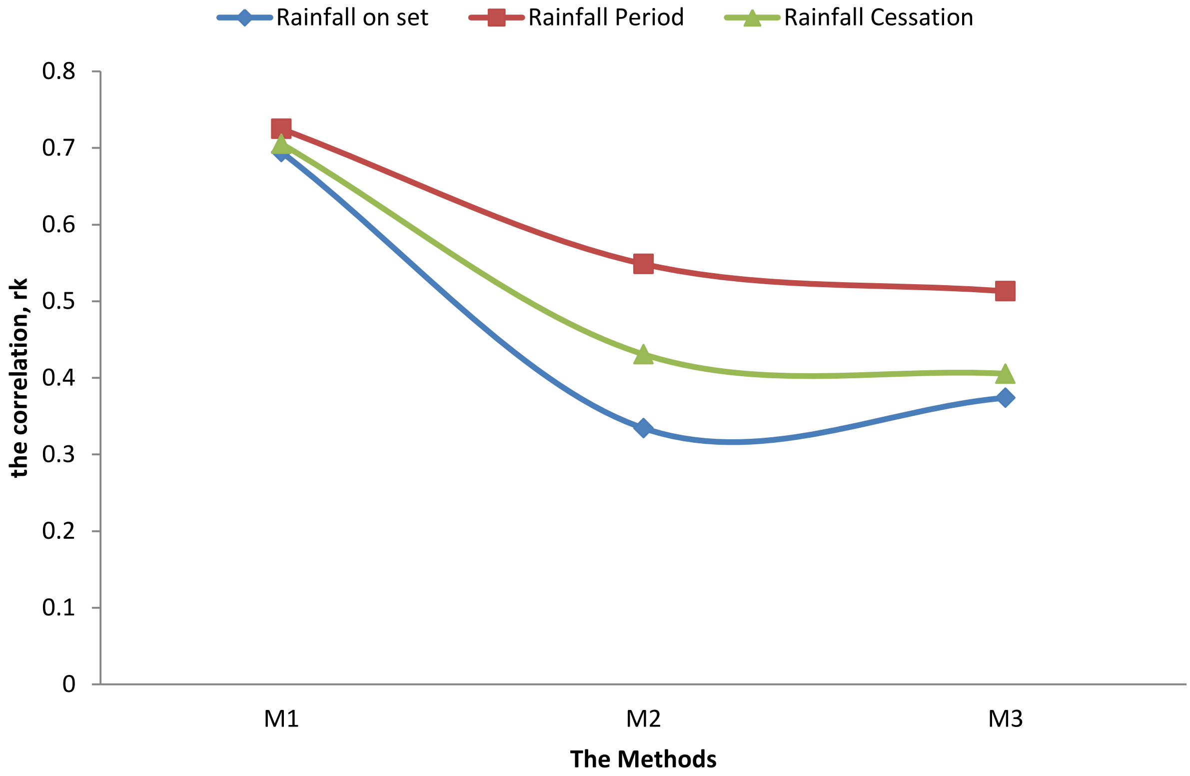

Figure 2. The Correlation trend across difference Methods.

M_1 = Cocheme and Franquin, (1967)'s method, M_2 = Walter (1967)'s method and M_3 = Kowal and Knabe, (1972)'s method