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Rain Days and Their Predictability in South-western Region of Nigeria

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KEYWORDS Thermal Contrast. Sea Surface Temperatures. Inter–annual Variability. Rainfall Prediction

ABSTRACT This study was able to determine the rainy days of the first two months in the rainy season and the last two months to the end of rainy season including their annual totals in South-western Nigeria. To be able generate models for their prediction, the study used composite effect of the rainfall – engendering factor of the sea surface temperature of the tropical Atlantic Ocean, Land-sea thermal contrast between Southwestern Nigeria and the tropical Atlantic Ocean, surface location of Inter-tropical Discontinuity and the land surface temperature in Southwestern Nigeria. The specific locations over which rainfall data were collected to represent Southwestern Nigeria include Ikeja, Benin City, Ibadan and Ilorin. Stepwise multiple regression analysis was used to construct the model. The analysis shows that the hypothesized rain-engendering factors are adequate in predicting rainy days in Southwestern Nigeria. Out of the four rainfall engendering factors, two of them (sea surface temperature and land-sea thermal contrast) dominate the explanatory factors in the model, constituting 87% of total explanatory factors found significant in the models generated. The study also show that all of the areas of the tropical Atlantic, right from the Gulf of Guinea, through the St. Helena and Ascension Island, up to the Benguela current region have significant bearing to the inter-annual variability in the rainy days in Southwestern Nigeria. It was also noted that the direction of relationship between sea surface temperature, land-sea thermal contrast and rainy days in Southwestern Nigeria is not simple and straightforward, but the sea surface temperature anomalies experience changes in location, extent and time of the year.

INTRODUCTION

In the recent past, in Africa and Nigeria in particular, the emphasis of many scholars in the study of tropical climatology has been the consideration of rainfall characteristics, such as rainfall amount, duration and intensity. The various rainfall characteristics have been studied in terms of their distributions over space and time, trends, periodicities, onset, retreat, probabilities (Ayoade 1974; Ilesanmi 1972a; Ayoade and Akintola 1982; Adejuwon et al. 1990; and Odekunle 1997). The highly variable nature of the rainfall in the region as compared with the relatively stable nature of the temperature, appear to have imbued more relevance to the former as the major component in the study of climate in the region (Adejuwon 1988; Kane 1999; Gbuyiro et al. 2002).

However, as comprehensive as the various research works on rainfall characteristics of the various tropical lands are, the literature indicates that little attention has been paid to rainy days characteristics, most especially, its predictability. Except for the works of Garbutt et al. (1981), Stern and Coe (1999), Ayoade and Akintola (1982), most studies on tropical rainfall climatology were overly concerned with rainfall amounts rather than rainy days. Whereas, with respect to agricultural practices in terms of water requirement by various crops, rainy days appears to be relatively more important than the amount. This is so because relatively smaller storm sizes but numerous rainy days, for instance, should benefit crop establishment, development and growth more than relatively larger storm sizes but scanty rain days. Two rainy days within a month cannot be as beneficial as ten rainy days, to crop development. Thus, rainfall amount cannot be the best measure of crop requirement for its development. Thus, the need for spread of the amount over time through rainy days predictability becomes important.

The established concepts of factors which promote or inhibit rainfall precipitation in West Africa and Nigeria in particular is the progression or regression of the zone of influence of the tropical maritime air mass (MT) and it's associated zone of discontinuity.

The Inter-Tropical Discontinuity (ITD) is the most popularly accepted medium that influence rainfall distribution in Nigeria (Clackson 1960; Obasi 1965; Mbele-Abong 1974; Ayoade 1988; Ilesanmi 1981; Lamb 1983; Adejuwon et al. 1990). It is established that to the southern part of ITD, varying degrees of convective activity and precipitation takes place, whereas, little or no cloud development or precipitation occur to the northern part. In other words, rain falls mostly when an area is overlain by the MT air mass and ceases when the area is overlain by the Conti-nental Tropical (CT) air mass. This makes the position of ITD a great determinant of most rainfall attributes in the region. Prominent among these attributes are the length of the rainy season. It, thus, appears as if the ITD is a rain – producing phenomenon in itself, but in reality, weather zones occur in a latitudinal spatial relationship to it (Ilesanmi 1981).

However, a new climatic phenomenon of global influence, the El Nino/Southern Oscillation is being invoked as a significant cause of rainfall variability over space and time in West Africa (Adedokun 1978; Rasmusson 1985; Burroughs 1992; Kripalani and Kulkani 1997; Kane 2000; Change 2002). ENSO teleconnection is defined in two ways, namely in association with the sea– level pressure (SLP) and also in association with the sea surface temperature (SST) (Bjerknes 1966, 1969). Today, SST appears to be the most widely accepted parameter, by which ENSO is investigated (Adedokun 1978; Barnett 1988).

In West Africa, low sea surface temperature is experienced (Adedokun 1978). The unusually low SST is recognized in the Gulf of Guinea (Bjerknes 1969; Krueger and Winston 1975; Adedokun 1978; Hougton and Colin 1987). The low SST experienced is a result of the upwelling of cold water at the coast. The upwelling is believed to be affected by the combined action of cold under current – the Benguella current and a two – sided divergence of the Ekman transport found within the Guinea Coast (Flohn 1971). In West Africa in general, and Nigeria in particular, this ENSO phenomenon produces a number of effects on the nature of rainfall.

It, thus, appears from the literature that rainfall – engendering factors which can serve as explanatory factors in the prediction of rainy days distribution in Nigeria include sea surface temperatures of Atlantic Ocean from the Gulf of Guinea, southward up to the Benguella current region of Southern Atlantic Ocean, land/sea thermal contrast between the SST locations and rainfall stations in south-western Nigeria, surface location of ITD and land surface temperature of rainfall stations in south-western Nigeria.

The aim of this paper is to generate models that can predict rainy days in south-western Nigeria. The most important rainy days parameters and for which the models would be developed include

i. The rainy days of the first two months after the onset of rains.
ii. The rainy days of the last two months to the end of rainfall retreat.
iii. The total annual rainy days.

STUDY AREA

The study area is south - western region of Nigeria (Fig. 1). The area lies between longitude 30^0 and 7^0E and latitude 4^0 and 9^0N and thus, west of the lower Niger and south of the Niger Trough. This area includes the whole of Kwara, part of Kogi, Osun, Oyo, Ogun, Lagos, Ondo, Ekiti, Delta and a little part of Western Bayelsa States. The total land area is about 191,843 square kilometers (Iloeje 1981).

As in the other parts of the country, the climate of south-western Nigeria is dominated by the influence of three major wind currents, namely: the maritime tropical (mT) air mass, the continental tropical (cT) air mass and the equatorial easterlies (Ojo 1977; Iloeje 1981). The mT air mass originates from the southern high-pressure belt located off the coast of Namibia, and in it trajectory, picks up moisture from over the Atlantic Ocean, crosses the Equator and enters south-western Nigeria. The cT air mass originates from the high-pressure belt North of the Tropic of Cancer. It picks up little moisture along its path and is thus dry. The two masses (mT and cT) meet along a slanting surface called the InterTropical Discontinuity (ITD). The equatorial easterlies are rather erratic cool air masses, which come from the East and flow in the upper atmosphere along the ITD. Occasionally however, the air mass dives down, undercuts the mT or cT air mass and give rise to line squalls or dust devils (Iloeje 1981).

The specific locations where data were collected are Ikeja, Benin City, Ibadan and Ilorin, to represent south-western Nigeria. Each of the four locations was selected as representative of zones comprising areas of similar climatic tendencies in West Africa. For instance, while Ikeja represents the coastal climatic zone, Benin City, Ibadan and Ilorin represent rain forest; southern and northern Guinea climatic zones respectively.

METHODLOGY

The climatic data required for this study

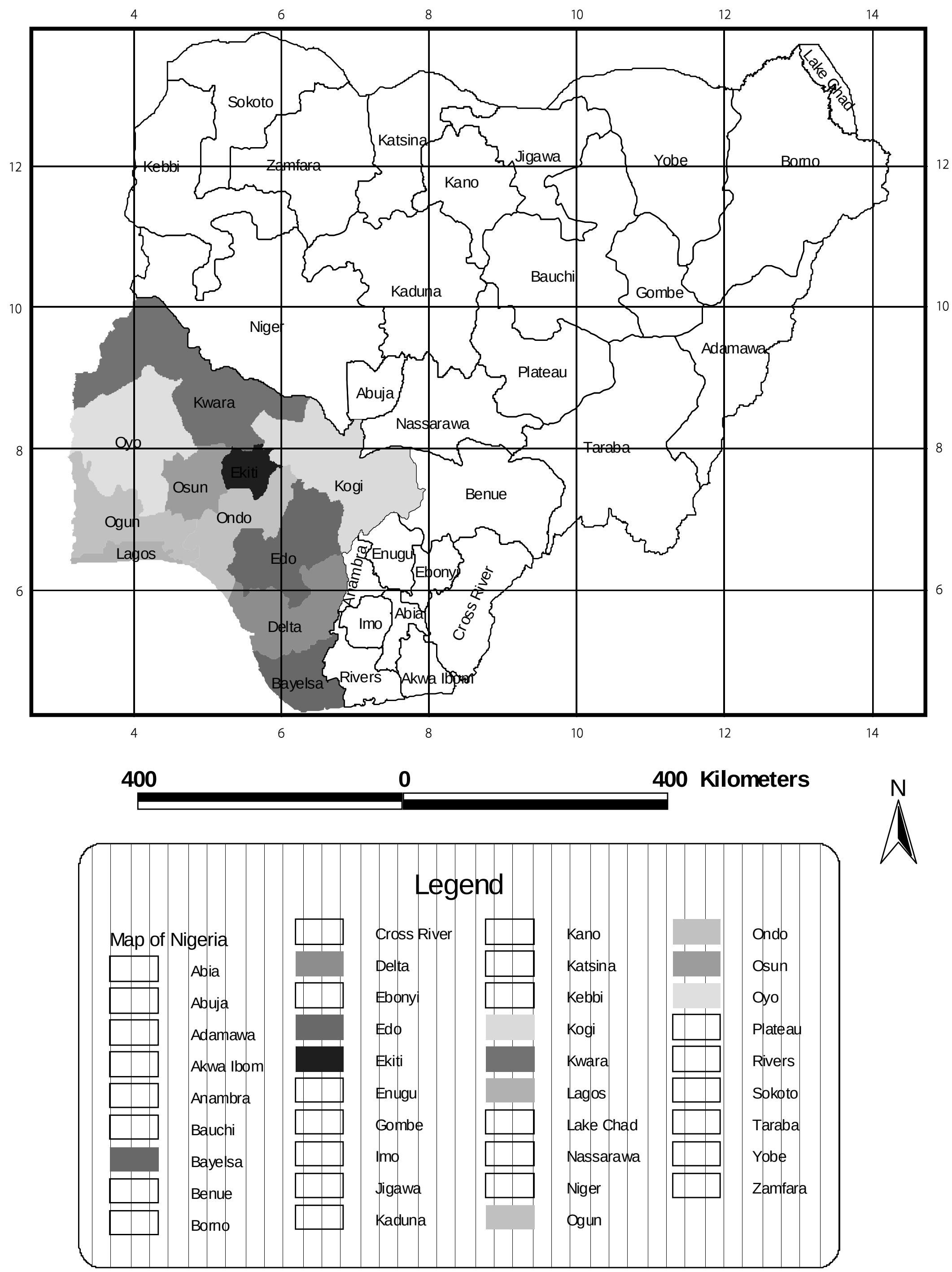

Fig. 1a. Map of Nigeria showing states in the study area

includes: daily rainfall totals, the surface location of the ITD, sea surface temperatures at locations off shore of south-western Nigeria and land surface temperature in south-western Nigeria. Data availability on sea surface temperature and ITD's surface location appear to be the two main factors that constrained the length of the data used in this study. The available SST data during the period of data collection of this study is from 1945 to 2006, while the available surface location of ITD data is from 1970 to 2006. Thus, for the purpose of uniformity in the length of the data, this study made use of 36 years data (1970 – 2006). However, two years (2005 and 2006) were set aside for testing the scheme, thus left with 34 years for developing the required model for the rainy days predictability in the sub-region.

Data on daily rainfall, land surface temperature, and surface location of ITD were sourced from the archives of the Nigerian Meteorological Services, Oshodi, Lagos. Data on rainfall and land surface temperature were collected for the four selected Nigerian synoptic meteorological stations, Ikeja, Benin City, Ibadan and Ilorin. Data on the surface location of ITD were collected along three longitudinal positions across the Gulf of Guinea, West Africa, and the selected Nigerian long-term synoptic meteorological stations. The three longitudinal positions which give the average position of the ITD's WNW – ESE orientation include 5^0W, 0^0 and 5^0E. The data were collected at 0600Z chart, with the aid of dew point temperature of 15^0C. Data on sea surface temperature were collected for twelve locations over the Atlantic Ocean. The locations for which the data were collected include: 22.5^0S; 7.5^0E, 22.5^0S; 2.5^0E and 22.5^0S; 2.5^0W in the Benguela current region of South Atlantic, 17.5^0S; 2.5^0W and 17.5^0S; 7.5^0W, near St. Helena, 7.5^0S; 2.5^0E and 7.5^0S; 12.5^0W, near Ascension Island and 2.5^0S; 2.5^0E, 2.5^0S; 2.5^0W, 2.5^0S; 7.5^0W, 2.5^0N; 2.5^0E and 2.5^0N; 2.5^0W to represent the Gulf of Guinea. The SST data were sourced from the archives of the Hadley Centre for Climatic Prediction and

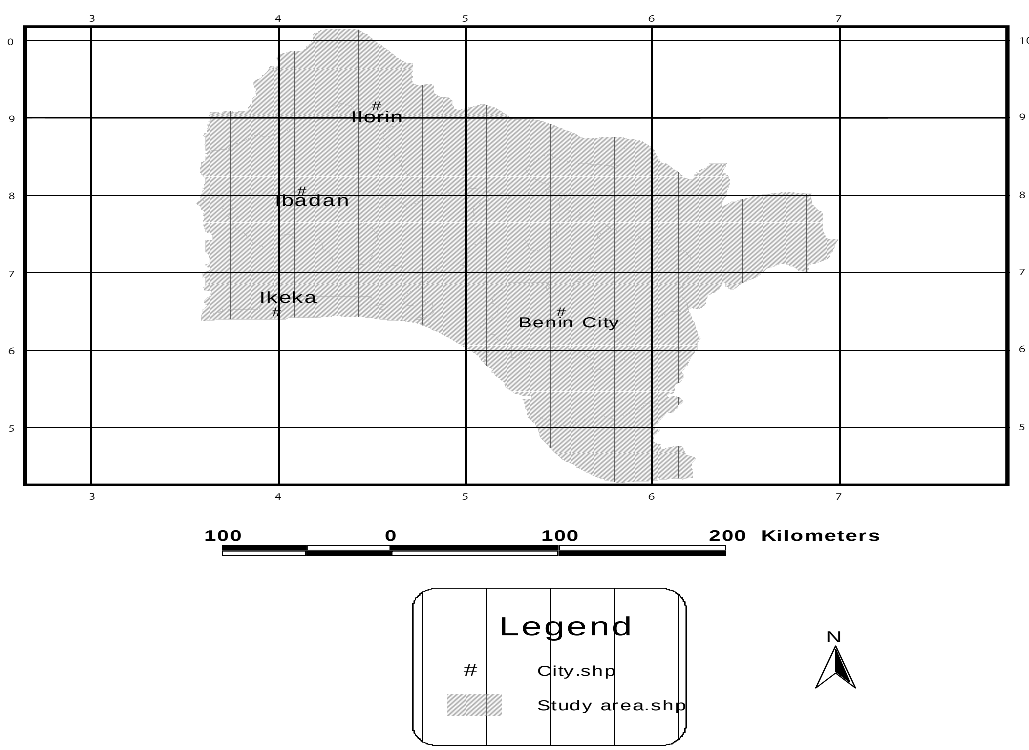

Fig. 1b. Map of study area showing Ilorin, Ibaban, Ikeja and Benin City.

Research, UK. The data were extracted from MOHSST6 (Meteorological Office Historical Sea Surface Temperature 6) file format. The measurements were taken at 1m depth and the data were stored as counts x 100 in degree Celsius. The MOHSST6 observed database was analyzed on a 5 x 5 degree grid (resolution). The data on all explanatory factors of all the months preceding the rainfall onset and retreat months are used in the construction of the predictability models for the two consecutive months following rainfall onset and retreat dates. The months of January, February and March were employed for the total annual rainy days.

Studies have been carried out extensively on the onset and retreat of rainfall in Nigeria (Ilesanmi 1972a, 1972b; Olaniran 1983; Adejuwon 1988; Odekunle 1997, 2003). Central to the various explanations is that rainfall begins in earnest in most stations in south-western Nigeria between March ending and early April. Rainfall retreats truly towards the end of October and early November. Thus, the months of April and May qualify as the first two months into the rainy season, while the last two months to the end of rainy season in the sub-region are September and October. Therefore, this study would determine the rainy days for the months of April, May, September, October and the annual totals, for the selected four station (Ikeja, Benin City, Ibadan and Ilorin) in south-western Nigeria, and generate models for their prediction.

There is need to define the threshold value of rainfall amount required for a day to be counted as rainy. The most important factor to be taken into consideration is the selection of the threshold value of rainfall to be used for the purpose to which the data would be put and the geographical location over which the data would be used. For agricultural purposes and for West African countries, several thresholds have been tried by Garbutt et al. (1981) and 0.85mm was found appropriate. It implies that all the rainy values below 0.85mm is assumed to be zero. It is on the basis of this threshold value that the rainy days are obtained in this study.

The method chosen for the construction of the prediction models in this study is multiple regression analysis. The statistical procedure employed in the selection of significant explanatory variables among the hypothesized set of explanatory variables is stepwise regression procedure. Diraper and Smith (1966) have evaluated this procedure of regression analysis as the best among others. The most important feature of the stepwise regression is that a significant variable, which has been added at an earlier stage, may later be considered insignificant and thus deleted. At the end of the search, it is only the most significant variables which account for the largest portion of the total variance in Y that are retained in the regression equation (Ayeni 1979). The F-level for accepting into or deletion from the equation is set before the analysis. The level of significance chosen for accepting into or deletion from the regression equation in this study is set to " = 0.05. Here, in this study, rainy days is the dependent variable, while the surface location of ITD, SST, land/sea thermal contrast and land surface temperate constitute the explanatory variables. Data involving time series tend to move in the same direction because of the trend that is common to all of them. Thus, it has been argued the trend be included among the explanatory variables so as to avoid misleading forecast (Grager and Newbolt 1974). So, time (year) is included among the explanatory variables in this study.

Finally, as observed by Folland et al. (1991) the use of a part of historical data outside that employed in the construction of the model to verify forecasts, is the best way to assess the level of skill such models were likely to achieve in real time forecasting. This assessment, which can be referred to as the actual "goodness of fit" and thus, the reliability of the prediction models would be assessed by comparing the predicted values of the rainy days, modeled with the observed values using some threshold values. On the basis of this, comments would be made on the relative accuracy of the prediction skill. The skill performance is rated in three categories, namely, "skill high", "skill moderate" and "skill low" if the difference between the actual and predicted rainy days is within 10%, 25% and above 25% of the mean rainy days respectively, Table 1 shows the mean rainy days of the various parameters of the various stations that were assessed.

RESULTS AND DISCUSSION

Modeling

Five rainy day parameters are modeled for the prediction of rainy days in each of the four stations studied. The parameters are rainy days of the

Table 1: The mean rainy days in south-western Nigeria (Between 1970 and 2006).

Stations	*Month*	*Mean rainy days*
Ikeja	April	8 days
Benin	April	9 days
Ibadan	April	10 days
Ilorin	April	11 days
Ikeja	May	13 days
Benin	May	10 days
Ibadan	May	11 days
Ilorin	May	12 days
Ikeja	September	20 days
Benin	September	13 days
Ibadan	September	16 days
Ilorin	September	10 days
Ikeja	October	15 days
Benin	October	14 days
Ibadan	October	10 days
Ilorin	October	8 days
Ikeja	Annual total	127 days
Benin	Annual total	91 days
Ibadan	Annual total	91 days
Ilorin	Annual total	82 days

months of April, May, September, October and annual totals. The five parameters for the four stations should give twenty unique prediction models. Eighteen out of the attempted twenty models are found significant at " = 0.05 level significance. It is only the rainy days of the month of April and annual totals of Ilorin that have no significant relationship with the hypothesized causative factors at " = 0.05. In other words, rainy day distribution in the sub-region shows coherent relationship with the hypothesized causative factors. The various relationships obtained between rainy days and the explanatory factors are expressed in the equations.

Equation (1) to (18) (Appendix 1) showed that large proportion of the inter-annual variations observed in the frequency distribution of rain days in south-west Nigeria can be explained using the rainfall-engendering factor of the SST of the tropical Atlantic ocean, land/sea thermal contrast, land surface temperature and the surface location of ITD. All of the relationships established are statistically significant at 95% level of confidence. Except for the Ikeja April rainy days where the proportion of the variance explained by its explanatory variable 19% ($R^2 = 0.19$) is low, all other relationships established between rainy days and their hypothesized causative factors show that the latter accounts for a very large proportion of the variations observed in the rainfall-engendering factors is more that 60% in most cases and approaches or even above 90% in many instances.

A careful observation of the various equations also reveals the order of importance of the various rainfall-engendering factors. It was observed the SST alone constitutes 57% of the factors found to be significantly related to rainy days variation in southwestern Nigeria. The land/sea thermal contrast constitutes 30%, while the land surface temperature and the surface location of ITD constitute 6 and 7% respectively. The result show the rainy days in the sub-region can be predicted mainly in terms of the SST and land sea thermal contrast, as the only two factors constitute 87% of the total explanatory factors.

Another observation is that all of the rainfall – engendering factors indicates dual direction relationship with rain days frequency distribution. In other words all the explanatory factors rainy day frequency distribution indicate both positive and negative relationships at different locations at different time.

Assessment of the Rainy Days Predictability Models

Table 2 shows the performances of the prediction models of rainy day frequency distribution in 2005 and 2006, using the criteria outlined earlier for the actual "goodness of fit" assessment of the rainy days predictability models, the skill is rated high in 47% of the cases tested. The skill is assessed moderate and low in 25% and 28% of the cases respectively. Thus, the "high skill" and "moderate" skill category together constitute 75% of all the cases assessed. Generally, the model is suitable for the south-western region of Nigeria.

As clearly demonstrated by both the statistical "goodness of fit" (R^2 value of the regression output) and actual goodness of fit (by comparing the observed rainy days with the predicted values, using 2005 and 2006 data) of the results obtained in this study, the hypothesized causative factors to rainy days frequency distribution proved adequate in the predictability modeling of rainy days in south-western Nigeria. The contribution of the various rainfall-engendering factors to the modeling of the rainy days frequency distribution is however at variant. The results show that the models are overwhelmingly contributed to by the factors of the SST and land/sea thermal contrasts (87%).

Table 2: Model's "Goodness of Fit" assessment of rainy days prediction in south-western Nigeria (2005 and 2006)

Year	Rainy day Parameters	Ikeja rainy days			Benin rainy days			Ibadan rainy days			Ilorin rainy days		
		Obser-ved	*Predic-ted*	*Skill level*	*Obser-ved*	*Predic-ted*	*Skill level*	*Obser-ved*	*Predic-ted*	*Skill level*	*Obser-ved*	*Predic-ted*	*Skill level*
2005	Total annual	119	112	High	149	121	Moderate	93	85	High	94	-	-
2006	Rainy days	87	91	High	139	121	Moderate	93	96	High	69	-	-
2005	April rainy	9	6	Low	10	10	High	9	3	Low	5	-	-
2006	Days	9	9	High	8	8	Low	10	11	High	6	-	-
2005		13	13	High	14	14	Moderate	10	9	High	12	12	High
2006	Nat rainy days	10	11	High	7	1	Low	9	7	Moderate	10	10	High
2005	September	14	24	Low	25	25	Moderate	10	13	Moderate	14	14	High
2006	Rainy days	7	14	Low	14	14	Low	15	12	Moderate	12	25	Low
2005	October rainy	13	14	High	18	18	Moderate	12	5	Low	11	9	Moderate
2006	Days	7	8	High	11	11	High	10	9	High	5	8	Low

The contribution of ITD and surface temperature was relatively low, accounting for only 7% and 6% respectively. This pattern of result is not unexpected because, as noted earlier SST is a new climatic phenomenon of a global influence that determines rainfall characteristics of most places around the world. Adedokun's (1978) study over the sub-region explains rainfall variability mainly in terms of SST and land/sea thermal contrast. The work of Folland et al. (1991) over the same region confirms the results obtained in this study. These later authors explained rainfall variability over the Sahel in terms of SST and estimates of the difference between Southern and Northern Hemispheres SST anomalies (which is a form of thermal contrast). Infact, land surface temperature was incorporated into the construction of predictability models in this study purposely so as to be able to determine the land/ sea thermal contrast. So as observed by Adejuwon and Jeje (1976), Ojo (1977), Iloeje (1981), Hayward and Oguntoyinbo (1987), the factor appear not to constitute climatological problems in the tropics because it is naturally abundant throughout the whole year and so does not constitute a limiting factor for convention and precipitation. Also, as observed by Adefolalu (1981), ITD/ rainfall relationship can only be used to explain the mean- state conditions of rainfall, and that international variabilities seem to be poorly defined in terms of the mean ITD positions. Thus, as noted earlier in this paper while ITD appear to affect a major control of moisture supply over West Africa, rainfall distribution of the region appears to be principally governed by the SST factor of the tropical Atlantic Ocean (Adedokun 1978; Adejuwon et al. 1990; Folland et al. 1991).

It is important to note that the pattern of the relationship between the SST of the tropical Atlantic and rainy days frequency distribution in south-western Nigeria is such that different part of the ocean becomes significant to certain rainy day parameter of different locations at different time. Such that the predictor variables most often include SST of different or the same locations at different times for instances, SST location that is not significant in January may become significant in February. So also are the factors of land/sea thermal contrast, ITD and land surface temperature. The results obtained also showed that all the oceanic locations selected right from the Gulf of Guinea, through. St. Helena and Ascension Island, up to the Benguela current region of the

South Atlantic Ocean, have strong coherent relationship with rainy day frequency distribution in south-western Nigeria. This is not surprising because some authors have at one point in time or the other emphasized one or more of these locations. For instance while Adedokun (1978) emphasizes the Gulf of Guinea area, Folland et al. (1991), emphasized the Benguela current region of South Atlantic Ocean. Also, the Department of Meteorological Services, Federal Ministry of Aviation in Nigeria often include among other rainfall predictor variables, the St. Helena high pressure center values.

As noted earlier, this study further confirm that the direction of relationship between SST and some other related factors (i.e. land/sea thermal contrast) and rainy days frequency distribution is rather complex. As observed in the results obtained in this study, the direction of the relationship is sometimes direct and sometimes inverse. Such variations in the direction of the relationship in the literature SST and rainfall characteristics have been noted in Nigerian rainfall-SST relationships in the literature (Gbuyiro and Olaleye 1999). The pattern of complex relationships of SST with rainfall characteristics as observed in this study further corroborates the observation of Trenbeth (1993) and Kane (2000) on the SST characteristics. They noticed the changes in the location, extent, and time of year of year of SST anomalies, which results in differences in tropical rainfall. Despite these complex relationships, the composite of the factor provide statistically (and in reality) significant prediction models. It is the belief of this study that those SST that are inversely related with rainy day frequency distribution act to strengthen the southwesterlies and easterly shear, while those directly related act to enhance the moisture-holding capacity of the southwesterlies.

Also, the dual direction of relationship observed between ITD and land surface temperature and rainy days frequency distribution can easily be understood. The use of ITD in this study is not directly relative to the rainfall station. For instance, it is found to be positively related to Benin September rainy days during the month of March. What this simply means is that if the ITD has made significant movement as at March of a certain year, Benin rainfall station would experience more rainy days in such year. Conversely, when ITD is found to be inversely related to rainy days of a certain station at some earlier time, it simply means that the distance of the ITD from the coast should be relatively shorter as to enhance rainy days frequency of the station under consideration. Similarly, the land surface temperature of an earlier month that is inversely related to the rainy days frequency of some months later is just an indication that the earlier month is wet (thus low temperature) and that the later month would have more rainy days, in other words, both ITD and land surface temperature as used in this study, are not concurrent with the rainy days parameter under investigation and so may assume any direction of relationship.

CONCLUSION

Models that can predict rainy days in south-western Nigeria have been generated, using the rainfall-engendering factors of sea surface temperature of the tropical Atlantic Ocean, land/sea thermal contrast between south-western Nigeria and the tropical Atlantic ocean, the surface location of the Inter-tropical Discontinuity across southwestern Nigerian and land surface temperature in south-western Nigeria include, Ikeja, Benin City, Ibadan and Ilorin. The method of analysis employed in the construction of the models is stepwise multiple regression analysis.

Results from the study revealed that, the hypothesized rainfall- engendering factor proved adequate in predicting rainy days in the sub-region. At 95% confidence level, the R^2 of most models are more than0.70 (with many of them approaching 0.90). The overall contribution of the various predictor variables to the dependent variable is highly at variant. Since sea surface temperature and land/ sea thermal contrast, overwhelmingly explained (87%) the overall variations observed in the various rainy day parameters. The results also showed that all the areas of the tropical Atlantic Ocean, right from the Gulf of Guinea, through the St. Helena and Ascension Island, up to the Benguela current region, significantly account for the variation in rainy days characteristics in southwestern Nigeria.

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APPENDIX I

Ikeja April rainy days= 40.71-1.58T_2M_1……………….(1)

"=0.05
R=0.43
R^2=0.19

Where T_2M_1 is January SST of location 22.5^{0}S; 2.5^{0}E.

Benin April rainy days=74.18-3.20 T_1, M_2 –2. 19 T_9 M_3……..(2)

"=0.05
R=0.77
R^2=0.59.

Where: $T_{11}M_2$ is February SST of location 2.5^{0}N; 2.5^{0}E and T_9M_3 is February SST of location 2.5$_0$S; 2.5^{0}W

Ibadan April rainy days= 24.72+3.60 T9M2-2.45T_6M_2………………………………………………….(3)

"=0.05
R=0.73
R^2=0.54

Where: T9 M2 is February SST of location 2.5^{0}S; 2.5^{0}W and T_6 M_2 is February SST of location 7.5^{0}S. 2.5^{0}E.

Ikeja May rainy days=42.59-2.04T_4M_1+2.02T_8M_1-1.01XM_3+1.72T_6M_2- 2.74$T_1$0M_2………………………..(4)

"=0.05
R=0.89
R^2=0.79

Where: T_4M_1 is January SST of location 17.5^{0}S; 2.5^{0}W, T8 M1 is January SST of location 2.5^{0}S; 2.5^{0}E, XM3 is March surface location of ITD, T_6M_2 is February SST of location 7.5^{0}S, 2.5^{0}E and $T_{10}M_2$ is February SST of location, 12.5^{0}S; 7.5^{0}W.

Benin May rainy days= -698+0.91Yt_8M_2 -5.92$T_{10}M_3$+4 .06$T_1$2M_3+1.65T_7M_2-1.06Yt_8M_1+0.85T_6M_3…………. (5)

"=0.05
R=0.93
R^2=0.87

Where: YT_8M_2 is February land/sea thermal contrast between Benin and location 2.5^{0}S; 2.5^{0}E, $T_{10}M_3$ is March SST of location 2.5^{0}S; 7.5^{0}W, $T_{12}M_3$ is March SST of location 2.5^{0}N; 2.5^{0}W, T_7M_2 is February SST of location 7.5^{0}S; 12.5^{0}W, Yt_8M_1 is January land/sea thermal contrast between Benin and location 2.5^{0}S; 2.5^{0}E and T6M3 is March SST of location 7.5^{0}E.

Ibadan May rainy days= 59.93+4.87T_3M_1-1.94T_7M_4 –2.79T_2M_1-1.80T_7M_2………………………………………(6)

"=0.05
R=0.84
R^2=0.71

Where: T3M1 is January SST of location 22.5^{0}S; 2.5^{0}W, T_2M_1 is January SST of location 22.5^{0}S; 2.5^{0}E and T_7M_2 is February SST of location 7.5^{0}S; 12.5^{0}W.

Ilorin May rainy days= 127.50-209T_7M_3-1.69LtM_4+3.65T_2M_2-2.74T_1M_2-1.44T_5M_1…………………………………………………(7)

"=0.05
R=0.92
R^2=0.85

Where: T_7M_3 is March SSST of location 7.5^{0}S; 12.5^{0}W, LtM4 is April land surface temperature of Ilorin, T_2M_2 is February SST of location 22.5^{0}S; 2.5^{0}E, T_1M_2 is February SST of location 22.5^{0}S; 7.50E and T5M1 is January SST of location 17.5^{0}S; 7.5^{0}W.

Ikeja September rainy days= 248.16+7.65$T_{10}M_8$+4.49XM_5+1.48Kt_6M_1+2.16Kt_5M_3-2.84Kt_4M_2+1.66T_8M_1-1.00JtM_5………………………………………………..(8)

"=0.05
R=0.94
R^2=0.89

Where: T10 M8 is August SST of location 2.5^{0}S; 7.5^{0}W, XM_5 is May surface location of ITD, Kt_6M_1 is January land/sea thermal contrast between Ikeja and location 7.5^{0}S; 2.5^{0}E, Kt_5M_3 is March land/sea thermal contrast Ikeja and location 17.5^{0}S; 7.5^{0}W, Kt_4M_2 is February land/sea thermal contrast between Ikeja and location 17.5^{0}S; 2.5^{0}W, T_8M_1 is January SST of location 2.5^{0}S; 2.5^{0}E and KtM_5 is land surface temperature of Ikeja.

Benin September rainy days= 625.12+4.55Yt_1M_8-0.28year-3.08T_1M_7-3.34 $T_{12}M_1$+ 2.61T_1M_4+1.60T_8M_1+0.72XM3-1.94T_8M_2-0.57$Yt_{10}M_1$+0.35Yt_9M_6…………………………………………………………….(9)

"=0.05
R=0.99
R^2=0.98

Where: Yt1M8 is August land/sea thermal contrast between Benin and location 22.5^{0}S; 7.5^{0}E, T_1M_7 is July SST of location 22.5^{0}S; 7.5^{0}E, T8M1 is January SST of location 2.5^{0}E, XM_3 is March surface location of ITD, T_8M_2 is February SST of location 2.5^{0}S; 2.5^{0}E, $Yt_{10}M_1$ is January land/sea thermal contrast between Benin and location 2.5^{0}S; 7.5^{0}W and Yt_9M_6 is land/sea thermal contrast between Benin and location 2.5^{0}S; 2.5^{0}W.

Ibandan September rainy days= 116.16+4.30T_5M_7+2.76Bt_7M_2-3.18XM_6-0.59XM_4-3.42T_7M_5-2.28T_2M_7…………………………………………………(10)

"=0.05
R=0.93

R^2=0.86

Where: T_5M_7 is July SST of location 17.5^{0}S; 7.5^{0}W, Bt_7M_2 is land/sea thermal contrast between Ibadan and location 7.5^{0}S; 12.5^{0}W, XM_6 is June surface of ITD, XM_4 is April surface location ITD, T_7M_5 is May SST OF location 7.5^{0}S; 12.5^{0}W and T_2M_7 is July SST of location 22.5^{0}S; 2.5^{0}E.

Ilorin September rainy days= 192.28+6.32LtM_5+5.05T_1M_4-1.62T_6M_6+3.41T_7M_7-2.24LtM_6-2.11T_3M_3……………………………………………………….(11)

"=0.05
R=0.97
R^2=0.92

Where: LtM_5 is May land surface temperature in Ilorin, T_1M_4 is April SST of location 22.5^{0}S; 7.5^{0}E T_6M_6 is June SST of location 7.5^{0}S;12.5^{0}W, LtM_6 is June land surface temperature in Ilorin and T3M3 is March SST of location 22.5^{0}SL2.5^{0}W.

Ikeja October rainy days= 35.17-1.88T_2M_1+4.77T_1M_3-1.81T_6M_4+2.39$Kt_{11}M_9$-1.57Kt_9M_g-

$1.25T_9M_7$……………………………………………….(12)

"=0.05
R=0.91
R^2=0.82

Where: T_2M_1 is January SST of location 22.5^{0}S; 2.5^{0}E, T_1M_3 is March SST of location 22.5^{0}S; 7.5^{0}E T_6M_4 is April SST of location 7.5^{0}S; $Kt_{11}M_9$ is September land/sea thermal contrast between Ikeja and location 2.5^{0}N; 2.5^{0}E, Kt_9M_9 is September land/sea thermal contrast between Ikeja and location 2.5^{0}S; 2.5^{0}W and T_9M_7 is July SST of location 2.5^{0}S; 2.5^{0}W.

Benin October rainy days=115.11-5.47T_5M_2+2.63T_4M_3-4.20$Yt_{12}M_1$+0.93Yt_8M_1-2.10T_4M_7-2.22T_7M_8+2.20T_7M_4……………………………………..(13)

"=0.05
R=0.96
R^2=0.92

Where: T_5M_2 is February SST of location 17.5^{0}S; 7.5^{0}W, T_4M_3 is March SST of location 17.5^{0}S; 2.5^{0}W, $Yt_{12}M_1$ is January land/sea thermal contrast between Benin and location 2.5^{0}W, YtgM location 17.5^{0}S; 2.5^{0}W, T_7M_8 is August SST of location 7.5^{0}S; 12.50W, and T7M4 is April SST location 7.5^{0}S; 12.5^{0}W.

Ibadan October rainy days= -88.55-5.8$Bt_{10}M_1$+6.53T_2M_7+1.63XM_7+2.34$Bt_6M_2$2.52Bt_4M_2+2.11Bt_5M_1-1.52BtM_7………………………………………………..(14)

"=0.05
R=0.95
R2=0.90

Where: $Bt_{10}M_1$ is January land/sea thermal contrast between Ibadan and location 2.5^{0}S; 7.5^{0}W, T_2M is July SST of location 22.5^{0}S; 2.5^{0}E, XM_7 is July surface location of ITD, Bt_6M_2 is February land/sea thermal contrast between Ibadan and location 17.5^{0}S; 2.5^{0}W, Bt_5M_1 is January land/sea thermal contrast between Ibadan and location 17.5^{0}S; 7.5^{0}W BtM_7 is July land surface temperature in Ibadan.

Ilorin October rainy days= 152.97-5.13T9M_4+12.15Lt_5M_7-10.45Lt_3M_7-2.28T_8M_6+5.18$T_{10}M_5$-2.72T_8M_5…………………………………(15)

"=0.05
R=0.95
R^2=0.91

Where: T9M4 is April SST of location 2.5^{0}S; 2.5^{0}W, Lt_5M_7 is July land/sea thermal contrast between Ilorin and location 22.5^{0}S;2.5^{0}W, T_8M_6 is June SST of location 2.5^{0}S; 2.5^{0}E, $T1_0M_5$ is May SST of location 2.5^{0}S; 7.5^{0}W and T8M5 is May SST of location 2.5^{0}S; 2.5^{0}E.

Ikeja total annual rainy days= 53.57+ 20.30Kt_1M_1-13.39Kt_8M_1-13.97Kt_1M_2+8.15$Kt\,M_2$…………………………………………………………(16)

"=0.05
R=0.86
R^2=0.73

Where: Kt1M1 is January land/sea thermal contrast between Ikeja and location 22.5^{0}S; 7.5^{0}E, Kt8M1 is January land/sea thermal contrast between Ikeja and location 2.5^{0}S; 2.5^{0}E, Kt_1M_2 is February land/sea thermal contrast between Ikeja and location 22.5^{0}S; 7.5^{0}E and Kt_9M_2 is February land/sea thermal contrast between Ikeja and location 2.5^{0}S; 2.5^{0}W.

Benin total annual rainy days= 456.27-13.76T_5M_1 – 7.36$Yt_{11}M_2$……………………………………………………(17)

"=0.05
R=0.73
R^2=0.53

Where: T5M1 is January SST of location 17.5^{0}S; 7.5^{0}W and $Yt_{11}M_2$ is February land/sea thermal contrast between Benin and location 2.5^{0}N;2.5^{0}E.

Ibadan total annual rainy days= -60.78+10.55Bt_6M_2-+63T_8M_1…………………………………………………..(18)

"=0.05
R=0.78
R^2=0.60

Where: Bt6M2 is February land/sea thermal contrast between Ibadan and location 7.50S; 2.50E, Bt1M2 is February land/sea thermal contrast between Ibadan and location 22.5^{0}S; 7.5^{0}E and T_8M_1 is January SST of location 2.5^{0}S; 2.5^{0}E.