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Trend Significance Levels of Rain Onset and Cessation and Lengths of the Wet and Dry Seasons in Epe, Lagos State, Nigeria

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Abstract

This study aims to reduce crop failure resulting from a dry spell, which is the first occurrence of unsustainable rainfall that deceives farmers into planting. Thus, trends need to be tested using hypothesis, kurtosis, and other statistics to analyze the risks associated with unstable planting calendars and their possible mitigation strategies. The daily rainfall data from 1982 to 2018 were obtained from the archive of NASA/POWER SRB/FLASH, and the research location is Epe, Lagos State, Nigeria, which lies at latitude 6.585° N and longitude 3.962° E. Microsoft Excel was used to perform the tests. Results show that the null hypothesis of no trend in the distribution was rejected on the basis of the fact that the probability value ($p = 0.00$) is less than the significance level ($\alpha = 0.05$). The mean onset and cessation dates are March 27 and October 18, with skewness values of −0.63 and 11.02, respectively. Rain onset and cessation that occur from February 12 to April 27 and from September 28 to November 28, respectively, are safe with low risks of dry spell. Moreover, drought and dry spell were most probable in years that experienced a shorter length of wet season than dry season.

Abstrak

Level-Level Signifikansi Kecenderungan dari Awal dan Akhir Musim Hujan serta Lamanya Musim Basah dan Kering di Epe, Lagos State, Nigeria. Kajian ini bertujuan untuk mengurangi kegagalan panen yang disebabkan oleh suatu periode cuaca kering berkepanjangan, yang merupakan kejadian pertama turunnya hujan yang tidak berkesinambungan yang mengecoh para petani dalam menanam. Dengan demikian, kecenderungan perlu diuji dengan menggunakan hipotesis, kurtosis, dan statistik lainnya untuk menganalisis risiko-risiko yang berkaitan dengan kalender penanaman yang tidak stabil dan strategi mitigasinya yang mungkin. Data turunnya hujan harian dari tahun 1982 sampai tahun 2018 diperoleh dari arsip NASA/POWER SRB/FLASH, dan lokasi riset adalah Epe, Lagos State, Nigeria, yang terletak pada garis lintang 6,585° Utara dan garis bujur 3,962° Timur. Microsoft Excel digunakan untuk melaksanakan pengujian. Hasil-hasilnya menunjukkan bahwa hipotesis nol dari tidak adanya kecenderungan distribusi ditolak berdasarkan pada fakta bahwa nilai probabilitas (p = 0,00) lebih kecil dari level signifikansi (α = 0,05). Tanggal-tanggal awal dan akhir nilai tengah (mean) adalah 27 Maret dan 18 Oktober, dengan masing-masing nilai ketidak-simetrian (skewness) sebesar −0,63 dan 11,02. Awal dan akhir musin hujan yang terjadi masing-masing dari 12 Februari sampai 27 April dan dari 28 September sampai 28 November, merupakan waktu yang aman dengan risiko periode cuaca kering yang rendah. Lebih jauh lagi, kekeringan dan periode cuaca kering yang panjang paling mungkin terjadi pada tahun-tahun yang mengalami lama musim basah yang lebih pendek dibandingkan dengan musin kering.

Keywords: dry spell, kurtosis, rain cessation, rain onset, significance level

1. Introduction

Given the trend of climate change, whereby global temperature has been increasing in the past decades [1], [2], and the significant changes in rainfall [3], the actual planting dates have posed a serious challenge to our farmers in the sense that rain onset date has become uncertain over the years. The implication of uncertainty in the actual rain onset date is the issue of a dry spell that is capable of causing colossal waste of resources and crop failures [4]. The dry spell is the first occurrence of unsustainable rainfall that deceives farmers into planting [5]. Several authors have defined rain onset, but the most prominent among the definitions is that rain onset is the amount of rain that is sufficient to ensure the establishment of crops and their emergence and growth [6]-[8].

Among the authors who investigated rain onset, Oguntunde *et al*. [9] and Oloruntade *et al*. [10] stated that between 6% and 7% of the annual rainfall led to rain onset, whereas 90% of the annual rainfall led to rain cessation. Moreover, Oguntunde *et al*. [9] stated that the difference between rain onset and cessation is equal to the length of the growing season, which is referred to as the length of the wet season. Meanwhile, the length of the dry season is the difference between the length of the wet season and the annual rainfall. Among different results obtained by previous authors, Fajemidagba [17] conducted a similar study in Ijebu-Ode (which is less than 10 km from Epe), and the results obtained are within the same month bracket and trend pattern for the mean rain onset date, mean rain cessation date, and mean length of the rainy season. Meanwhile, Obarein and Amanambu [18] analyzed the variation, characteristics, coherence, and interrelationships that exist among the rain attributes and reported that rain onset has a larger spatial coherence than rain cessation but rain cessation has more divergent characteristics than rain onset. With all of these results obtained by authors across the globe, no one considered the direction of the trend significance levels of rain onset and cessation and lengths of the wet and dry seasons.

Thus, we need to test the hypothesis of the presence of trends in rain onset and cessation and lengths of the wet and dry seasons to eliminate losses associated with dry spells and crop failures [4],[11],[12]. The significance level (α) is used to determine if the null or alternative hypothesis will be rejected or approved on the basis of the strength of the available evidence contained in the samples and conform to the conclusion that the effect is statistically significant.

2. Data and Methods

Research location. The research location is Epe, Lagos State, Nigeria, which lies at latitude 6.585° N and longitude 3.962° E and is 3.98 m above sea level. Epe is located at the bank on the north side of Lekki Lagoon in Lagos State. The main occupations of the people are fishing, farming, logging, and other forestry activities.

Data sourcing and processing. The daily rainfall data from 1982 to 2018 were obtained from http://power/arc.nasa.gov/data-access-viewer (NASA/POWER SRB/FLASH flux/MERRA 2/GEOS 5.12.4(FT-IT) 0.5° × 0.5° at latitude 5.5845° N, longitude 3.9755° E and elevation of 55.68 m representing Epe). Microsoft Excel was used to process and calculate the rain onset and cessation and lengths of the wet and dry seasons.

3. Description of the Statistical Tests Used

Microsoft excel. Microsoft Excel was used to obtain the descriptive statistics and perform hypothesis testing and one-tailed and two-tailed tests.

Hypothesis testing. The probability of rejecting the null hypothesis when it is true is the significance level [14]. The lower the significance level is, the stronger the evidence to reject the null hypothesis. In hypothesis testing, the significance level is used to determine which hypothesis the data support when comparing the *p*-value with the significance level. If the significance level is greater than the p-value, then the null hypothesis is rejected. If the p-value is statistically significant, then the null hypothesis is supported [13],[15].

Null and alternative hypotheses. In the context of statistical analysis, we often talk about the null and alternative hypotheses. If we are to compare Method A with Method B in terms of superiority and if we proceed with the assumption that both methods are equally good, then this assumption is considered the null hypothesis. By contrast, if we think that Method A is superior or Method B is inferior, then we are stating an alternative hypothesis.

The null hypothesis is generally denoted by H_0, and the alternative hypothesis is denoted by H_1. If we want to test the hypothesis that the population mean μ is equal to the hypothesized mean (μ_0) = 100, then we would say that the null hypothesis is that the population mean is equal to the hypothesized mean 100, which can be expressed as H_0: $\mu = \mu_0 = 100$. If our sample results do not support this null hypothesis, then we should conclude that something else is true.

Type 1 and type 11 errors in hypothesis testing. Hypothesis testing involves two types of errors, i.e., we may reject H_0 when H_0 is true and we may accept H_0 when H_0 is not true. The hypothesis that is rejected when H_0 is true is considered a Type 1 error, and the hypothesis that is accepted when H_0 is not true is considered a Type 11 error (Table 1). In other words, Type 1 error means rejecting the hypothesis that should have been accepted, and Type 11 errors mean accepting the hypothesis that should have been rejected.

Procedures in generating the tables. Tables 2, 4, and 5 were generated using the Mann–Kendall nonparametric test (MAKESENS 1.0) to analyze the data on rain onset and cessation and lengths of the wet and dry seasons.

Table 1. Possible Hypothesis Testing Outcomes

Possible Hypothesis Testing Outcomes		
	Actual Situation	
Decision	H_0 True	H_0 False
Accept H_0	No Error Probability = $1-\alpha$	Type 11 Error Probability = β
Reject H_0	Type 1 Error Probability = α	No Error Probability = $1-\beta$

Source: Kothari *et al*. [13]

MAKESENS 1.0 was developed using the Microsoft Excel template to detect and estimate trends in the time series [16]. The Mann–Kendall nonparametric test has been used by several authors to analyze trends and predict dry spells [19]. Tables 3 and 6 show the descriptive statistics and results of hypothesis testing obtained using Microsoft Excel. However, the raw data used to generate the aforementioned tables were excluded because of the large volume.

Two-tailed and one-tailed tests. The three types of hypotheses are expressed as follows:

$$Ho\colon \mu = \mu o \; against \; Hi : \mu \neq \mu o \qquad (1)$$

$$Ho\colon \mu = \mu\, o \; against \; Ha\colon \mu > \mu\, o \; or \; Ho\colon \mu \leq \mu\, o \; against \; H1 : \mu > \mu\, o \qquad (2)$$

$$H\, o\colon \mu = \mu o \; against \; Ha\colon \mu < \mu o \; or \; Ho\colon \mu \geq \mu\, o \; against \; H\, 1 : \mu < \mu o \qquad (3)$$

The signs in the alternative hypothesis (i.e., ≠, >, or <) denote three different tests. The sign "≠" in the alternative hypothesis denotes the two-tailed test, the sign ">" denotes the right-tailed test, and the sign "<" denotes the left-tailed test.

4. Results and Discussions

As shown in Table 2, the significance level of 0.001 means that there is a 0.1% probability of making a mistake when rejecting H_0 of no trend in the distribution. Thus, the significance level of 0.001 means that the existence of a monotonic trend is probable. The significance level of 0.1 means that there is a 10% probability of making a mistake when rejecting H_0. However, the essence of the significance levels and % probability is to make a far-reaching decision.

Table 3 shows that the mean rain onset date was March 27, with maximum and minimum dates of April 27 and February 12, respectively, and the mean rain cessation date was October 18, with maximum and minimum dates of November 28 and September 28, respectively. The mean values for the lengths of the wet and dry seasons are 204 and 161 days, respectively. The standard deviation values for rain onset, rain cessation, and lengths of the wet and dry seasons are 19.79, 11.86, 22.49, and 22.56, respectively. Kurtosis of rain onset, rain cessation, and lengths of the wet and dry seasons are −0.44, 2.68, −0.94, and −0.95, respectively, which shows that kurtosis of the dataset has lighter tails than that of a normal distribution (i.e., 3). The skewness values for rain onset, rain cessation, and lengths of the wet and dry seasons are −0.63, 11.02, 0.14, and −0.14, respectively.

The practical implication of the results shown in Table 3 is to generate a safe window for planting.

Table 2. Interpretation of the Significance Levels

Significance Levels α	% Probability
+0.1	10%
*0.05	5%
**0.01	1%
***0.001	0.1%

Table 3. Descriptive Statistics of Rain Attributes

Parameters	Rain Onset	Rain Cessation	Length of the Wet Season	Length of the Dry Season
Mean	March 27	October 18	204 days	161 days
Maximum	April 27	November 28	248 days	204 days
Minimum	February 12	September 28	161 days	117 days
Standard Error	3.25	1.95	3.70	3.71
Standard Deviation	19.79	11.86	22.49	22.56
Kurtosis	−0.44	2.68	−0.94	−0.95
Skewness	−0.63	11.02	0.14	−0.14
Count	37	37	37	37

Table 4. Test Z and Slope Magnitude

Parameters	Rain Onset	Rain Cessation	Length of the Wet Season	Length of the Dry Season
Test Z	0.69	2.49	0.46	−0.46
Significance	*	*	Nil	Nil
Slope Q	0.212	0.375	0.199	−0.185
Trends	Positive	Positive	Positive	Negative

Table 4 shows that the rain onset, rain cessation, and length of the wet season experienced an upward trend with slope magnitudes of 21.2%, 37.5%, and 19.9%, respectively, whereas the length of the dry season experienced a downward trend with a slope magnitude of 18.5%. Meanwhile, rain onset and cessation show significance levels of 5% probability of an upward trend. The results show that more days in the year are becoming available for planting and nurturing crops, which is a good omen for agriculture in the study area. However, the period regarded as a safe window in Table 3 must be considered to avoid off-season planting.

Table 5 shows that the 99% maximum confidence levels for rain onset, rain cessation, and lengths of the wet and dry seasons are 89, 291, 205, and 163 days, respectively, and the 99% minimum confidence levels for rain onset, rain cessation, and lengths of the wet and dry seasons are 88, 291, 202, and 160 days, respectively. Meanwhile, the 95% maximum confidence levels for rain onset, rain cessation, and lengths of the wet and dry seasons are 90, 290, 203, and 163 days, respectively, and the 95% minimum confidence levels for rain onset, rain cessation, and lengths of the wet and dry seasons are 91, 290, 203, and 163 days, respectively. The confidence interval will assist farmers in knowing the limits of their expertise in managing risks and ensuring a safe window for crop production.

Table 6 shows that the sample variance for rain onset, rain cessation, and lengths of the wet and dry seasons are 391.65, 140.58, 505.91, and 509.08, respectively. The F-value for rain onset, rain cessation, and lengths of the wet and dry seasons are 2.79, 140.58, 0.99, and 0.99 with p-values of 0.00, 0.00, 0.49, and 0.49, respectively. The F-critical region for rain onset was 1.74. The significance level of 0.05 is greater than the p-value, which shows that the null hypothesis of no trend in the distribution is rejected and the alternative hypothesis is accepted. The null hypothesis was that there is no trend in the rain onset, rain cessation, and lengths of the wet and dry seasons, whereas the alternative hypothesis established the presence of trends in the rain onset, rain cessation, and lengths of the wet and dry seasons. The kurtosis value showed that the level of risk involved in the trends is low [15], which indicates that low or high kurtosis is associated with risks in financial management.

Figure 1 shows that the years 1983, 1992, 1998, 2007, 2008, and 2010 experienced a shorter length of wet season than dry season, which denote late rain onset and early rain cessation in those years and the possibility of recurrence or return every 10 years. In the concerned years, drought and dry spell were most probable.

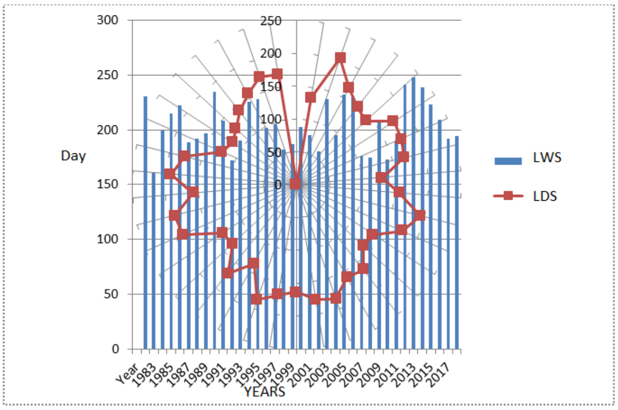

Figure 1. Relationship between Lengths of the Wet and Dry Seasons

Table 5. Confidence Intervals

Parameters	Rain Onset (Days)	Rain Cessation (Days)	Length of the Wet Season (Days)	Length of the Dry Season (Days)
99% Maximum Confidence Level	89	291	205	163
99% Minimum Confidence Level	88	291	202	160
95% Maximum Confidence Level	90	290	203	163
95% Minimum Confidence Level	91	290	203	163

Table 6. One-Tailed Test

Parameters	Rain Onset	Rain Cessation	Length of the Wet Season	Length of the Dry Season
Sample variance	391.65	140.58	505.91	509.08
F-value	2.79	2.79	0.99	
p (F < f) one tailed	0.00	0.00	0.49	
F-critical one tailed	1.74		0.57	

5. Conclusions

The null hypothesis of no trend in the distribution was rejected on the basis of the fact that the probability value (p = 0.00) is less than the significance level (α = 0.05) for rain onset. Moreover, the kurtosis value of the distribution that is less than the kurtosis value of the normal distribution (i.e., 3) indicated that the level of risk involved in the trends is low. A kurtosis value that is higher than the value of the normal distribution means a higher risk [15]. The mean rain onset date is March 27 with maximum and minimum dates of April 27 and February 12, respectively, whereas the mean rain cessation date is October 18 with maximum and minimum dates of November 28 and September 28, respectively. This finding indicates that rain onset that occurs from February 12 to March 27 and rain cessation that occurs from November 28 to September 28 are still safe with low risks of dry spell. The rain onset, rain cessation, and length of the wet season experienced an upward trend with slope magnitudes of 21.2%, 37.5%, and 19.9%, respectively, whereas the length of the dry season experienced a downward trend with a slope magnitude of 18.5%. Meanwhile, rain onset and cessation show significance levels of 5% probability of an upward trend.

Summary of the Implications and Significance of the Statistical Results. The implications and significance of the results for local farmers are summarized as follows:

- The results obtained so far will enhance the ability of local farmers to identify a safe window for planting, which will invariably reduce the incidence of dry spells.
- The kurtosis of the dataset will help identify the degree of damage a dry spell can cause if it occurs.
- The essence of trend analysis is to predict future occurrences and plan possible mitigation strategies.
- Climate-smart agriculture will be enhanced.

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