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Harnessing Aqua Crop ETo Calculator as New Normal to Generate Reference Evapotranspiration (ETo) for Crop Water Management in Epe, Western Nigeria

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Abstract: *Aqua crop ETo calculator was used to generate ETo from 1982 to 2018. Meteorological data were prepared into Aqua crop format in which Aqua crop ETo calculator uses the FAO Penman- Monteith equation. Data obtained from the archive of NASA power (radiation, maximum and minimum temperature, wind speed, and relative humidity) were saved in Micro soft Excel with csv or text file for compatibility in the directory of aqua crop. ETo data generated were processed into annual and seasons of January February March (JFM), April May June (AMJ), July August September (JAS) and October November December (OND). Data were analyzed using descriptive statistics. The results indicated that the annual mean, standard deviation, kurtosis and skewness are 3.53, 0.16, 2.22, and – 1.19 respectively. JFM and OND recorded the highest mean values signaling the peak and onset of the dry season while AMJ and JAS signaling the onset and peak of wet season. OND experiences extreme positive leptokurtic in trend showing that drought is probable and JFM and OND recorded positive regression ETo attributing to the high rate of crop water requirement occasioned by high evaporative demand of the atmosphere which means that more water is required during dry season by crops. Annual ETo is statistically significant because the P- value is less that 0.05 while JAS and OND are highly statistically significant because their P-values are less than 0.01. Aqua crop calculator proved to be reliable for determination of evapotranspiration especially in a new normal situation- an unfamiliar or atypical situation that suddenly becomes standard, usual orf expected due to unforeseen circumstances.*

Key Words: *Aqua Crop, ETo Calculator, Reference Evapotranspiration (ETo), Statistically significant, Trend Statistic and New Normal*

INTRODUCTION

Crop water management is based on two major processes which includes how water gets to the crop and how water escapes from the cropped field. In the process of unraveling these two processes, the study of evapotranspiration becomes necessary. Adeyemi (2005) reported that inflow and out flow are major components in the hydrologic equation in which precipitation is regarded as the inflow and the outflow consists of infiltration, surface runoff, interception, detention storage, depression storage, transpiration and evaporation. The combination of evaporation and transpiration processes is called evapotranspiration which is regarded as a big issue in crop water management. Transpiration entails escape of water from the soil surface through the stomata of leaves into the atmosphere while evaporation is the direct exit of water in vapor like from the water bodies, soil surface, streams and others into the atmosphere (Ghumman et al., 2020). NASA (2005) highlighted that in a farming season with respect to the size of the farm, irrigation water of about 400,000 gallons can be lost due to evapotranspiration into the atmosphere, and that account for why resources like logistics, energy and time factors are required in water supply. Over the years, determinations or measurements of evapotranspiration are basically based on direct and indirect measurements (Ilesanmi et al., 2012). Direct measurements involve use of lysimeter, energy balance and budget approach, soil water budget method, use of pan evaporimeter and the Eddy- covariance method while indirect approach is of model oriented which entails using meteorological data to estimate ETo and these models are of different categories viz; temperature based models such as the Thornthwaite, Blaney-Cridle, Blaney-Morin and McCloud models; the radiation based models.

There are numerous methods to estimate reference evapotranspiration (ETo), the use of Aqua crop ETo calculator is direct and easier (FAO, 2017). Determination of ETo, Aqua crop ETo calculator uses the FAO Penman-Monteith equation to process meteorological data such as radiation, maximum and minimum temperature, wind speed, and relative humidity into the reference evapotranspiration (ETo) which is regarded as a measure of evaporative demand of the atmosphere ((Allen et al., 1998; FAO, 2017).

Several researches such as Oguntunde (1998), and Stricevic et al. (2018) highlighted that among methods for determination ETo include step by step calculation of the Penman-Monteith evapotranspieration; evaluating the methods of estimating evapotranspiration potentials in humid and sub humid stations in Nigeria; A parametric model for potential evapotranspiration estimation based on a simplified formulation of the Penman-Monteith equation. Review of previous works on the determination of evapotranspiration shows that no work has ever been done on the use of aqua crop embedded ETo calculator to generate evapotranspiration in Nigeria tropical region. The objectives of this paper are to generate reference evapotranspiration using aqua crop ETo calculator as an alternative and also to produce trend statistics from the data generated.

MATERIALS AND METHODS

Location

The research location is at Epe in Lagos state, Nigeria which lies on the latitude and longitude of 6.58 N and 3.96 E with elevation of 3.98 meters above the sea level. Epe is located at the bank of the North side of Lekki Lagoon.

Data Sourcing and Processing

Data sourcing

Data needed include radiation (MJ/M^2), maximum and minimum temperature (^{o}C), wind speed (m/Sec), and mean relative humidity (%) which ranges from 1982 to 2018 on daily basis 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 X 0.5 Degree.

Data processing

Data processing was of two stages. Data were first processed into Aqua crop format. Data from the archive of NASA power were saved in Micro soft Excel with csv or text file for compatibility in the directory of aqua crop. Evapotranspiration data with the aid of ETo calculator were generated from the aqua crop data, and processed into annual and seasonal. The seasons are JFM, AMJ, JAS and OND which means January February March (JFM), April May June (AMJ), July August September (JAS) and October November December (OND).

(a) Description of Aqua Crop ETo Calculator and Applications of Statistical Functions Used

The ETo calculator used is of version 3.2, FAO Land and water digital Media series No. 36 september 2012 (FAO, 2012), with the main function of calculating reference evapotranspiration (ETo) according to FAO standards.Aqua crop used for this paper is version 6.1, FAO Land and water division, Rome, Italy, Nr. 02052018. It is of crop water productivity model (Hsiao et al., 2009).

Data Analysis

T- statistic

The t- statistic is the ratio of the departure of the estimated value of a parameter from its hypothesized value to its standard error which can be expressed below;

$$t\beta i = \frac{\beta i - \beta o}{S.e\ (\beta i)}$$

Where,βi is an estimator;βo is a non random and S.e is the standard error.

The T- statistic is used in a t- test to determine if you should support or reject the no hypothesis, and it is similar to Z- test. The t-test is used to also test the significance of corresponding regressors (Kothari et al., 2004).

Probability-value or P-value

P-Value is the probability of obtaining test results at least as extreme as the results observed during the tests, assuming that the null hypothesis is correct. The larger the absolute value of the t- value, the smaller the P – value and the greater the evidence against the null hypothesis. If P- value is less than the significance level, it shows that null hypothesis is rejected. Most authors refer the values $P < 0.05$ and $P < 0.01$ as statistically significant and highly statistically significant respectively which means a decision is less than 5 % and 1 % chances of being wrong.

Skewness and Kurtosis

Alli and Omofunmi (2020) **re**ported that in a descriptive statistic, skewness and kurtosis are two important functions for analysis. Skewness, as the standardized fourth moment about the mean, can be mathematically represented as thus:

$$a_3 = \sum \frac{(X_i - \bar{\mu})^3}{n\,\sigma^3} \qquad 2$$

Where, n = the sample size; X_i = the ith X value; μ = the mean; σ = sample standard deviation and $\sum$ = summation

RESULTS AND DISCUSSIONS

Table 1 shows the descriptive statistic of the annual and seasonal evapotranspiration such that the mean values of seasonal ETo are varied based on the wet and dry seasons. JFM and OND recorded the highest mean values signaling the peak and onset of the dry season. The mean value of AMJ is higher than that of JAS meaning the onset and peak of wet season. The annual, JFM and AMJ are still under kurtosis of a normal distribution while JAS is platykurtic i.e it shows a negative excess kurtosis and OND shows a positive excess kurtosis which is called leptokurtic. The implication of OND leptokurtic status is that ETo may be prone to extremes positive trend which may likely lead to drought or other negative events. The degree of symmetry of ETo data shows that annual, JFM, AMJ and OND are negatively screwed while JAS is positively screwed.

Table 1. Descriptive Statistics of evapotranspiration of the study area

Statistics	Annual	JFM	AMJ	JAS	OND
Mean	3.53	4.02	3.45	3.03	3.57
Standard Error	0.03	0.04	0.04	0.02	0.03
Standard Deviation	0.16	0.27	0.22	0.15	0.15
Sample Variance	0.02	0.07	0.05	0.02	0.02
Range	0.80	1.30	1.10	0.60	0.90
Median	3.60	4.10	3.50	3.00	3.60
Minimum	3.00	3.20	2.80	2.80	2.90
Maximum	3.80	4.50	3.90	3.40	3.80
Kurtosis	2.22	1.37	1.45	-0.22	9.65
Skewness	-1.19	-1.11	-0.51	0.36	-2.35

Table 2 shows the linear regression and R^2 values for annual and seasonal ETo. The annual, AMJ and JAS recorded negative regression while JFM and OND seasons recorded positive regression. The positive regression of JFM and OND ETo is attributed to the high rate of crop water requirement as a result of high evaporative demand of the atmosphere. Hence more water is required during dry season by crops.

Table 2. Linear Regression and R Square

Time series	Linear Regression	R Square
Annual	$Y = -0.004\,x + 3.62$	0.11
JFM	$Y = 0.008\,x + 4.18$	0.12
AMJ	$Y = -0.004\,x + 3.53$	0.45
JAS	$Y = -0.002\,x + 3.08$	0.04
OND	$Y = 0.00\,x + 3.57$	0.00

Table 3 shows the trend statistics of ETo for annual, JFM, AMJ, JAS and OND. The JFM experienced the strongest trend among other being the peak of dry season. Meanwhile, the ETo trend rate of annual, AMJ. JAS and OND are negligible. The essence of the significance value is to accept or reject null hypothesis of trend. The significance values of annual, JFM, AMJ, JAS and OND confirmed that hypothesis of no trend was rejected and the alternative hypothesis of the presence of trends was established in such a manner that for every 100 chances of making the decision, only 0- 5 % chances of being wrong as applicable.

Table 3. Trends Statistics

Time Series	Annual	JFM	AMJ	JAS	OND
Test Z	-2.83	-2.39	-2.66	-1.03	-0.88
Significance	0.01	0.05	0.01	Nil	Nil
Sens' slope estimate	-0.006	-0.010	-0.008	0.00	0.00
Constant B	3.64	4.23	3.59	3.00	3.60

CONCLUSION

Reference evapotranspiration (ETo) in the study area were determined using aqua crop calculator. Aqua crop ETo calculator presents a direct and easy way of generating evapotranspiration. Findings indicated that:

- The evapotranspiration data generated are subjected to trend analysis which shows that both annual and seasonal ETo experienced down ward trend in the study area.
- The significance values of annual, JFM, AMJ, JAS and OND seasonal ETo signified the presence of trend i.e the alternative hypothesis by rejecting the null hypothesis of no trend.
- The trend status of ETo also suggested that other required data used to generate ETo such as precipitation, mean relative humidity, wind speed, minimum and maximum temperature and radiation or sunshine have inherent likely trend status.
- The kurtosis of annual, JFM and AMJ are of a normal distribution while JAS is platykurtic i.e it shows a negative excess kurtosis and OND shows a positive excess kurtosis which is called leptokurtic.
- The implication of OND leptokurtic status is that ETo may be prone to extremes positive trend which may likely lead to drought or other negative events.
- The degree of symmetry of ETo data shows that annual, JFM, AMJ and OND are negatively screwed while JAS is positively screwed.
- Aqua crop calculator proved to be reliable for determination of evapotranspiration.

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