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RESEARCH ARTICLE

ASSESSMENT OF CROP YIELD AND RAINFALL SIMULATION IN NASARAWA TOWN NASARAWA STATE NIGERIA

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ABSTRACT

Recent technology use simulation to predict the amount and total crop production and yield in a particular piece of land. Crop yield is termed as the growth of crop per unit area. This study calculates the crop yield for 20 years and uses simulation to produce 18 years of crop yields at different locations in Nasarawa Local Government Area of Nasarawa State Nigeria. the study applies the use of time series analysis of both Linear, quadratic and growth curve models to ascertain the crop yield. The result indicates that there is a high amount of rainfall in the preceding year from 2020 -2038 with a rainfall trend of more than 2200mm-2300mm per annum. The crop yield simulation shows a higher growth curve with a bumper harvest in the next years to come.

KEYWORDS

Rainfall Trend, Simulation, Crop Yield, Growth Curve, Time Series.

1. INTRODUCTION

Crop yield is simply defined as the specific crop produced per unit area. Individual crops have growth rate value and level which a farmer count as its output (Fischer et al., 2014). A group researchers discussed the impact of temperature and annual crop yield (Wheeler et al., 2000). Sinclair observed the coefficient empirical context and evaporation of water (Sinclair, 1994). The relationship is simplified through assumptions about crop gas exchange. Fischer 2014 compared the crop yield on a global scale and crop production for food security. According to a study there is a need to increase crop yield for sustainable development to feed the world's growing population and society (Fischer et al., 2014). Some researchers suggested that there is an expectation for the occurrence of crop yields increase over the decade. Climate has a direct relationship with crop yield and crop production (Troy et al., 2015).

Other researcher uses a simple statistical approach of the Mann-Kendall test to analyse rainfall trend in Cuttack district Orissa (Mondal et al., 2012). Jain and Kumar reviewed the monsoon rain and its trend in India using a non-parametric estimator of the slope with the aid and assessment of the Mann-Kendall test. In other hand, researcher also observed the historical rainfall trend in Peninsular Malaysia, showing an increasing trend between1975-2010 (Syafrina et al., 2015). The result concluded that it is short temporal rainfall that causes flash floods during the monsoon season. Some researchers also argued that no trend was found in monthly rainfall except for November in the West Coast of Malaysia (Wong et al., 2009). The spatial change and rainfall extremity were observed by (Sa'adi et al., 2019) in Sarawak Malaysia. The same Mann- Kendall test was adopted to ascertain multiscale variability and trend in rainfall.

(Oguntunde et al., 2012) studied rainfall trend with its categories and classification in Nigeria between1901-2000. The rainfall pattern was classified into three; the Sahel, the Middle Belt and the Southern part of Nigeria. (Akinsanola & Ogunjobi, 2017) observed rainfall trend from 1971-2000. The result had shown that from 1991-1980 rainfall is on increase in almost all parts of Nigeria except Bida and Minna in Niger State with a decreasing trend in rainfall. According to (Fasina et al., 2008), crop yield depends on the quality of irrigation soil. The study carried in a farm-house in Ekiti State Nigeria shows that different crops require different soil types for their crop yield. The soil parameter was used to calculate the crop yields with the addition of water and fertilizer.

2. RAINFALL AND CROP ANALYSIS

(Jain et al., 2019) compared three crop sequences using wheat and sunflower in a Mediterranean climate of about 600 mm annual rainfall. As an example of an application to design an optimal cropping sequence, under such conditions, wheat does not use all the winter rainfall and there is substantial residual moisture in the subsoil at harvest. On the contrary, continuous sunflower cropping, a spring crop, can exhaust all available water well before harvest and even fails in the dry years. The current wheat-sunflower (W–S) rotation was compared in a simulation to continuous wheat (W), continuous sunflower (S), and a wheat-wheat-sunflower (W–W–S) rotation. The probability distributions for each case showed that the W–W–S sequence had higher average wheat yields than in the W–S rotation and also had higher sunflower yields in 9 of 10 years, thus it is more sustainable than the W–S sequence used in the area (Fereres et al., 1993).

Crop yields in the DASs are not always constrained by water deficits. Other

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limiting factors, such as nutrition, weed competition, etc., often reduce yields below the potential for the amount of water available. The crop improvement varies with soil fertility, water sufficiency, and pest control. For example, in the last 25 years, there is an increase world-wide of crop yields such as the wheat 55%, 70% Maize, 18% Barley and 55% for rice production (Jain et al., 2019). The FAO suggested that for the next 50 years there is a need to double or triple crop production (Jain et al., 2019)

3. Material and Methods

For this study, the data was collected in the field Air Force Meteorological unit in Markudi, Benue State Nigeria and appropriate statistical techniques such as time series analysis and modeling has been applied to develop the rainfall simulation model. The short-term estimates are available just before or around harvest time. Long-term predictions are required in predicting drought for next year so that long-term planning for tackling drought impacts can be initiated in time. Regression techniques need to use weather data during a growing season for short-term estimates (Ray et al., 2015); (Yun et al., 2009).

3.1 Study Area

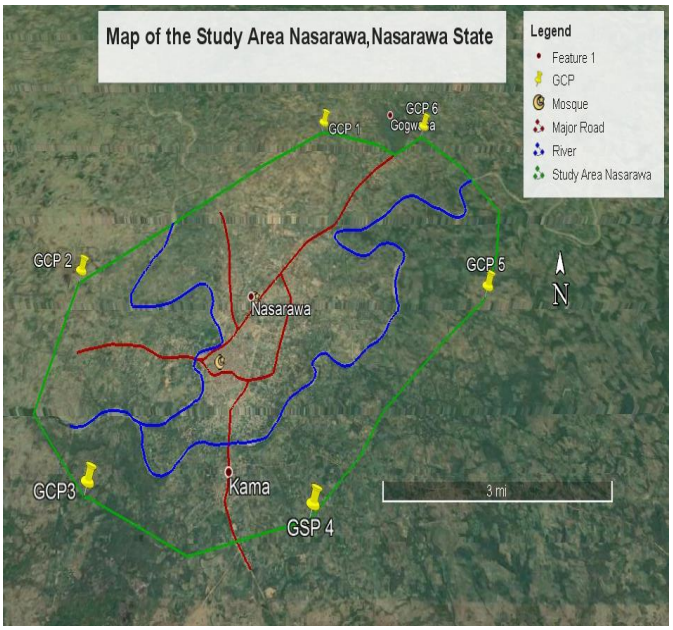

Figure 1: The Coordinates of the Study Area Nasarawa, Nasarawa State Nigeria

3.2 Locations

The demarcation was done in the field and transfers to Google Earth Pro for the extraction of the coordinates in the study area:

GCP 1=Lat 8°35'43.91"N, Long 7°43'48.98"E

GCP 1=Lat 8°33'7.88"N, Long 7°40'16.22"E

GCP 3=Lat 8°30'35.68"N, Long 7°40'51.82"E

GCP 4=Lat 8°30'23.10"N, Long 7°43'25.77"E

GCP 5= Lat 8°32'54.39"N, Long 7°45'56.78"E

GCP 6= Lat 8°35'39.94"N, Long 7°45'28.91"E

4. Result and Discussion

Nasarawa was endowed with tropical rainfall characterized by seasonality (wet and dry periods). Different varieties of crops are being cultivated with a large amount of crop yield due to the excess rainfall from May to September every year. Most of the grains and tuber crops such as sorghum, maize, groundnuts, peanut, Yam, Cassava and even paddy rice (Fadama cultivation in the Hausa Language were encouraged by the Federal Government of Nigeria (Sam, 2014). This was done especially through the enhancement of small, medium and large scale agricultural incentives for production and enterprises. For example, the introduction of Fadama III Projects by the Nigerian government (Umar & Tyem, 1995).

4.1 Rainfall Trend in Nasarawa

Table 1: Rainfall Trend from 2000 to 2019 in Nasarawa

S/no	Year	Amount of Rainfall (mm)
1	2000	2000
2	2001	2200
3	2002	1900
4	2003	2300
5	2004	2150
6	2005	2000
7	2006	2300
8	2007	2100
9	2008	2179
10	2009	1985
11	2010	1800
12	2011	2000
13	2012	1900
14	2013	2200
15	2014	2100
16	2015	2000
17	2016	2150
18	2017	2300
19	2018	2250
20	2019	2100

Source: Air Force Meteorological unit in Markudi, Benue state 2019

The data presented show the rainfall trend of 20 years in Nasarawa Local Government Area of Nasarawa State, Nigeria. There is the variability of the amount of rainfall and the years presented as in Table 1.

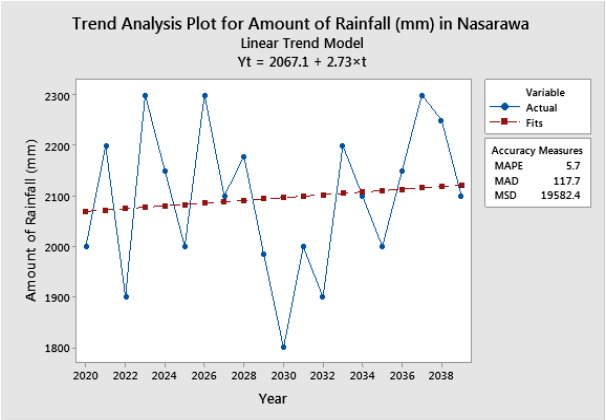

Figure 2: Rainfall Trend in Nasarawa, Nasarawa State

The rainfall trend model shows the result through the mutual relationship between the rainfall and the duration of the rain. The linear model simulates and predicated 2038 exactly 18 years of rainfall variability. The model fit cut across the median indication higher rainfall up more the 2000mm per annum as shown in figure 2.

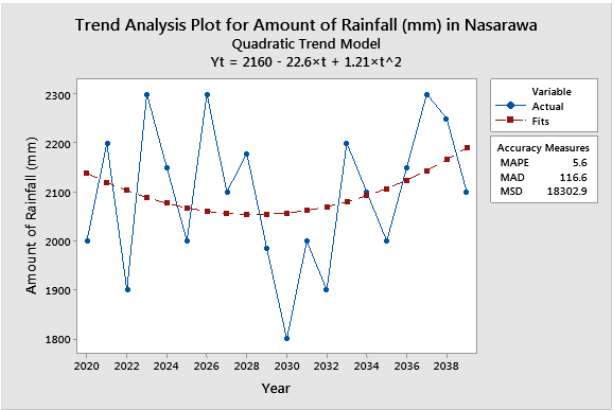

Figure 3: Has verified and validated the Regression analysis through the quadratic trend model.

The rainfall trend figure 3 is showing the growth curvature with a significant fit between the years of rainfall and its amount. The highest being 2023, 2027 and 2037.

4.2 Effects of Rainfall on crop yield

Aside from the agricultural production, that overseer the all crop yields, there exists the livestock rearing and fish farming which was affected by climate change. Rainfall is one single parameter of climate associated with others such as temperature, humidity, pressure and wind (I Sufiyan & Zakariya, 2018). Long term rainy season signifies bumper harvest with high crop yields in the tropical environment, short term rainfall indicates lower crop yields this is effective in the Sahelian region (Ibrahim Sufiyan et al., 2020).

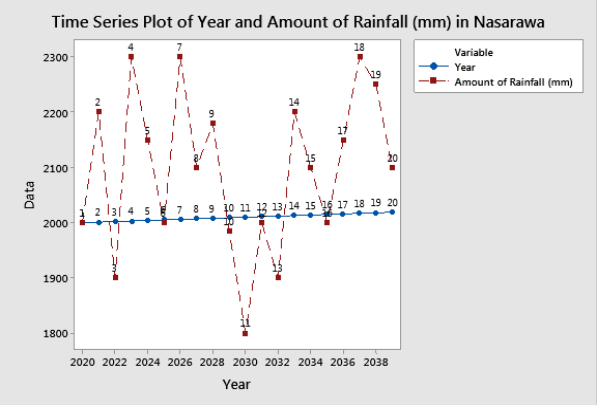

Figure 4: Time Series Analysis showing rainfall amount and years

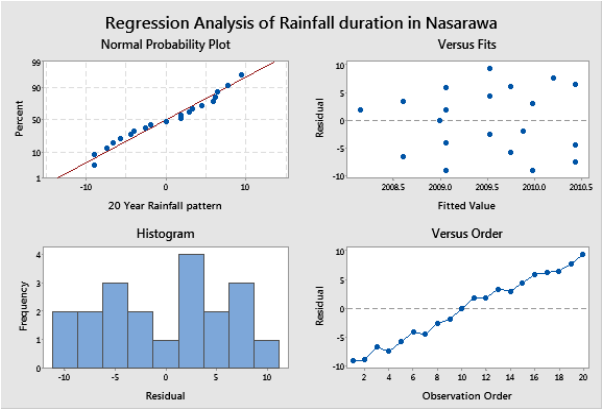

Figure 5: Combined analysis of showing regression analysis and model fits

The 20 years rainfall trend model has significantly clustered together. This implies that there is a mutual relationship between the rainfall amount and the year of the rainfall in Nasarawa.

Table 2: Effect of Rainfall and the Crop Yields

S/no	Year of Harvest	Rainfall Variability (mm)	Crop Yield per 10 Hectare (kg)
1	2000	2000	1200
2	2001	2200	1500
3	2002	1900	2000
4	2003	2300	2500
5	2004	2150	3000
6	2005	2000	3500
7	2006	2300	3700
8	2007	2100	4000
9	2008	2179	4500
10	2009	1985	5000
11	2010	1800	2200
12	2011	2000	2100
13	2012	1900	2000
14	2013	2200	1890
15	2014	2100	2250
16	2015	2000	2150
17	2016	2150	2450
18	2017	2300	2550
19	2018	2250	2350
20	2019	2100	2250

Table 2 presents the data on the rainfall variability and the effects of crop yields. The 2008 and 2009 have recorded the highest crop yields in the station.

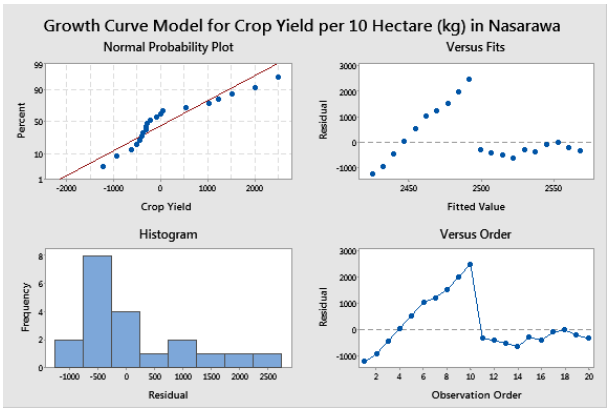

Figure 6: The growth curve Model of Crop yield in Nasarawa

The model in figure 6 displays the result showing the high correlation using regression analysis. The equation in figure 6 indicates positive the relationship between the rainfall and the crop yields. The rainfall is 93% significant in the production and increment of crop yields.

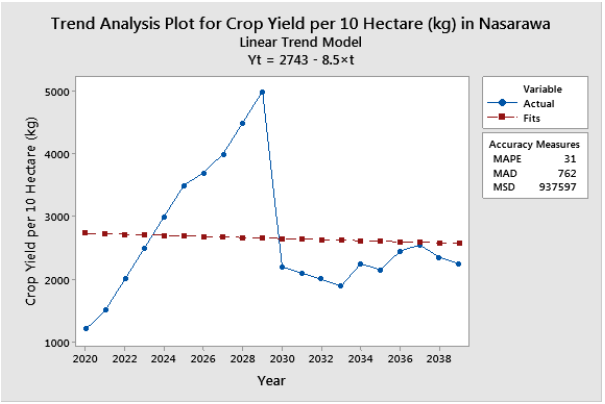

Figure 7: Rainfall variability and the root crop yields in Nasarawa

The crop yield is one of the significant expectations of the farmer and the nation at large. The prices of food items will be lowered due to high supply. It is expected through the simulations that by the year 2029 figure 7; there will be very high crop yields in the study area by Allah's Grace.

5. Conclusion

Rainfall plays a significant role in the agricultural sector for increasing crop yields. The more the crop yields the more the food security in every nation. There are positive relationships in the simulated crop yield and the extent of the period assumed. All the cultivable crops are having a different duration of harvest but when compared to the period of growth curve might seem to the same outcome of having high crop yield.

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