Effect of Climate Change on Poultry Egg Production in Ogun State, Nigeria

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Abstract

Climate change is posing serious threat to poultry production and consequently affecting the profit of poultry farmers. This study examined the effect of climate change on poultry egg production in Ogun State, Nigeria. Secondary data on egg output in Ogun state from 1990 to 2019 was collected from National Bureau of Statistics (NBS) and time series data on amount of rainfall, temperature and relative humidity from 1990 to 2019 were also collected from Nigeria Meteorogical Agency, (NIMET). Trend analysis was carried out to examine the trend of climatic events over the years. Statistical result of climatic variables (rainfall, temperature and relative humidity) showed an increasing trend, although there is large variability (301.43 mm) in the amount of rainfall from year to year while temperature and relative humidity shows slim (2.118°C) and average (5.588%) variability respectively. The result of the linear regression shows that rainfall and relative humidity were positively related to egg output, however, rainfall was not significant. Temperature was negative and significant at 10 percent level. The study recommends that extension agents should be empowered with training on climate change adaptation strategies in order to build capacity of poultry farmers and introduce adaptation technologies that will ensure improvement in egg production.

Keywords: Climate change, climatic elements, egg output, poultry farmers, Ogun state.

Introduction

Poultry plays an important economic, nutritional and socio-cultural role in the livelihood of poor rural households in many developing countries, including Nigeria. Poultry birds that such as fowl, turkey, duck, goose, ostrich and guinea fowl. They render not only economic services but contribute significantly to human food as a primary sources of meat, egg, raw materials to industries (feathers, waste products), source of income and employment to people compared to other domestic animals (ASL, 2018). The poultry production contributes between 20% and 50% to total household livelihoods and income in Nigeria (FAOSTAT, 2018). This shows the important place of the poultry sub-sector in the livestock sector. Poultry production is an important practice in food production across the country which has economically empowered the poultry farmers. The importance of poultry to national economy cannot be over emphasized as it has become popular for the small-holder farmers that have contributed to the economy of the country (PAN, 2015).

Poultry are efficient converters of feed to egg and meat within a short period of time. In terms of nutritive value, poultry egg rank second to cow milk. Agriculturists and nutritionists have generally agreed that developing the poultry industry of Nigeria is the fastest means of bridging the protein deficiency gap presently prevailing in the country (Amos, 2006). It is obvious that extreme temperature has negative influence on poultry farming. This influence has amplified as there is a global climatic change across the globe (Demeke, 2004).

According to Ayoade (2004), climate is the mean state of the atmospheric condition of a location or an area over a defined period of 30 years. However, climate change represents a significant difference between two mean climatic states or climatic conditions with significant impact on the ecosystem (Agboola *et al.,* 2007). It refers to both natural and human-induced changes. The United Nations Framework Convention on Climate Change (UNFCCC) defined climate change as a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, which is in addition to natural climate variability observed over comparable time period (IPCC, 2007a). Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.

Egg production however has continued to record a steady rise because eggs are universally acceptable and are not discriminated unlike products of some livestocks that are religious or social taboos (Laseinde, 1994). Adepoju and Osunbor, (2018) reported that about 10 percent of Nigerians are engaged in poultry production, mostly on subsistence, and small or medium scale farms and they are the most threatened by climate change. Apart from the provision of direct employment and livelihoods to thousands of people, the poultry industry provides remarkably high quality nutritious foods especially animal protein in discrete convenient and hand packets known as eggs. Pisulewski (2005) also reported that consuming poultry and fish products has no risk of cancers. Furthermore, FAO (2003) reported that the by-products of poultry production are of value when managed and recycled properly.

Climate change alters global disease distribution, affects poultry feed intake, encourages outbreak of diseases which invariably affects poultry output (egg and meat) and also cost of production (Guis *et al.,* 2011). It also affects temperature, an important bio-climatic factor affecting the physiological function of layer chickens (McDowell, 1972), though the effect on egg production rate depends on the age of laying hens. The effect is more evident at old age when birds are exposed to a cold climate. When temperature falls below the thermo neutral zone of below 12.8°C (which is rarely experienced in the tropics) egg production drops (Oluyemi and Robert, 1979).

According to Indian Council for Agricultural Research (ICAR) (2010), ambient temperatures significantly influence the survivability and performance of the poultry production. High temperature, especially when coupled with high humidity, imposes severe stress on birds and leads to reduced performance. The environmental conditions affecting the performance, health and productivity of a layer include temperature, relative humidity, light and sunshine at a given time. High temperature and humidity have some negative effects on poultry body temperature. High temperature also results in reduction in poultry live weight, high mortality, decrease on productivity and low quality of the eggs (Obayelu and Adedapo, 2006).

Poultry keeping is well practiced in Nigeria because it represents an entry point into business with a small start-up capital required. As a result, the industry is dominated by small-scale poultry producers. This implies that if poultry production is improved, it will create an avenue for development of poor segments of the society (Permin *et al.* 2000; Gueye, 1998; Todd, 1998; Quisumbling *et al.,* 1995). Although, studies on climate change and poultry farming have been carried out in the study area such as small scale poultry farmers choice of adaptation strategies to climate change (Adepoju *et al.,* 2018) but no study have been done to examine the effect of climatic elements on poultry egg production in the study area. Meanwhile, this study will provide up-to-date information on the effect of climate change on egg output. The research efforts on effects of climate change on poultry egg production will contribute positively to knowledge of the problem climate change poses to poultry sector that bears the contribution to the economy of the developing countries in the supply of protein to a large number of populations and also the source of livelihood for the rural populace. For poultry enterprise to thrive and maintain its balance in this era of climate change, this research focused on the following objectives: examine the trend of climatic elements over the years and determine the climatic factors affecting poultry egg production.

Materials and Method

Study Area

The study was carried out in Ogun State. This area was considered most appropriate because of heavy concentration of the poultry production, particularly layers production (Yussuf and Malomo 2007; PAN 2015). Before now, Ogun State had good climatic elements for poultry production, given its moderate temperature range, but due to the recent change in climate, most poultry farms are somewhat at risk. The state is made up of 20 Local Government Areas spread across the four main agricultural zones of the state Egba, Ijebu, Remo, and Yewa/Awori. Ogun state shares an international boundary with the Republic of Benin to the West and Oyo State to the North, Lagos State to the South, and Ondo State to the East. The population of the state stands at 3.75 million (NPC, 2006). The state lies within latitude 6.20N and 7.80N and longitude 30E and 5ºE. There are two distinct seasons in the State, the rainy season and the dry season. The concentration of livestock production, poultry egg production in particular in these areas is traceable to the perceived favourable characteristics of the vegetation in the area. The vegetation in the area is predominantly Rainforest and Derived Savannah.

Source of data collection

This study employed secondary data in form of time series data on egg output from 1990 - 2019 collected from the Nigeria Bureau of Statistics, NBS while time series data on climatic variables such as annual temperature, annual rainfall and annual relative humidity from 1990 - 2019 were collected from the Nigeria Meteorological Agency (NIMET).

Analytical techniques

The data obtained from this study were analyzed trend analysis and linear regression.

Trend analysis

The term trend analysis refers to the concept of collecting information and attempting to spot a pattern or trend in the information. Although trend analysis is often used to predict future events, it could be used to estimate uncertain events in the past. In statistics, trend analysis often refers to techniques for extracting an underlying pattern of behaviour in a time series which would otherwise be partly or nearly completely hidden by noise. A simple description of these techniques is trend estimation, which can be undertaken within a formal regression analysis. (Trend Analysis Definition, 2005).

The model for the trend analysis is in the linear form, semi log form, exponential form and Cobb Douglas form. The best fit was chosen based on the value of the coefficient of determination, R^2.

Linear Form: $C_i = b_0 + b_1T$

Semi log: $C_i = b_0 + b_1 \ln T$

Exponential: $\ln C_i = b_0 + b_1T$

C_i = climate variables (Temperature, Rainfall and Relative Humidity)

T = time

b_0 and b_1 = parameters to be estimated

In this study, trend analysis will be used to examine and establish the pattern for climate variables (Precipitation, Temperature and Relative Humidity).

Multiple regression Analysis

Regression analysis was used to determine the effect of climate elements on egg production in the study area.

The implicit form of the regression model is given as;

$Y=f(X_1, X_2, X_3, X_4, e)$

Where:-

Y = egg output (No of Crates)

X_1 = Total annual rainfall/precipitation (mm)

X_2 = Mean annual temperature (°C)

X_3 = Mean annual relative humidity (%)

X_4 = Time period

e = error term

Various functional forms of the model were estimated in order to choose the lead equation.

Linear function: $Y=b_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4$

Semi-log function: $Y=\log b_0+b_1\log X_1+b_2\log X_2+b_3\log X_3+b_4\log X_4$

Exponential function:

$\log Y=b_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4$

The *a priori* expectations of the regression model are;

X_2, Temperature above or below this range

(11°C - 26°C) is hypothesized to affect the rate of egg droppings. This is according to Kekeocha (1985).

X_3, Relative humidity level above or below 75% is hypothesized to cause a reduction in egg laying. (Obayelu and Adedapo, 2006).

Unit root and co-integration tests

The co-integration analysis involve unit roots test performed on both level and first difference to determine whether the individual input series are stationary and exhibit similar statistical properties. It must be noted that regressing a non-stationary time series data over another non-stationary time series data gives a spurious or nonsense regression (Ayinde *et al.,* 2011). To correct for this, a unit root test is performed.

A time series data is stationary if the joint distribution of any set of *n* observations $X(t_1)$, $X(t_2)$, …X(tn) is the same as joint distribution of any set of $X(t_1+_k)$, $X(t_2+_k)$, …$X(t_n+_k)$ for all *n* and *k.*

$$Y_t = pY_{t-1} + U_t, 1 \leq \text{p}$$

p ≤ 1 where U is the white noise error.

If Yt is regressed on its lagged value of Y_{t-1} and the estimated p is statistically equal to 1 then Yt is non-stationary that is, it exhibit unit root [I(1)]. On the other hand, if the estimated value of p is not statistically equal to 1, the Yt is stationary that is, it has no Unit root [I(0)]. The Augmented Dickey Fuller (ADF) Test was used to test for the stationarity of the data. The test consists of the following regression:

$$\Delta Y_t = \beta_1 + \beta_{2t} + \Delta Y_{t-1}\alpha\Delta Y_t + \varepsilon_t$$

where

$$\varepsilon_t = \Delta Y_{t-1} = (Y_{t-1} - Y_{t-2}), \Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$$

The Augmented Dickey Fuller (ADF) Test was used to test for the number of co-integration vectors in the model. The Johansen technique was suggested by Maddala (2001) not only because it is vector auto-regressive based but because it performs better in multivariate model. If two time series variables, pt and qt, are both non-stationary in levels but stationary in first-differences, i.e., both are *I(1)*, then there could be a linear combination of *pt* and *qt*, which is stationary, i.e., the linear combination of the two variables is *I(0)*. The two time series variables that satisfy this requirement are deemed to be co-integrated. The existence of co-integration implies that the two co-integrated time series variables must be drifting together at roughly the same rate (i.e., they are linked in a common long-run equilibrium). A necessary condition for co-integration is that they are integrated of the same order. To check whether or not two or more variables are co-integrated, it is necessary to first verify the order of integration of each variable by performing unit root tests (Granger 1986).

The co-integration model is given as:

$$Y_\tau = \beta_0 + \beta_1 X_{1\tau} + \beta_2 X_{2\tau} + \beta_3 X_{3\tau} + \beta_4 X_{4\tau} + Y_\tau$$

Where

Y = egg output (No of crates)

X_1 = Total annual rainfall/precipitation (mm)

X_2 = Mean annual temperature (°C)

X_3 = Mean annual relative humidity (%)

X_4 = Time Period

Unit root and co-integration tests

The result of the Augmented Dickey Fuller (ADF) unit root tests for the climate variables and egg output is summarized in Table 1. These results implied that egg output, temperature and relative humidity were not significant in level and first difference at 1%, 5% and 10% significance levels but rejected at the 1%, 5% and 10% significance level for all of the time series in second difference. These results implied that each series is non stationary in level and first difference but stationary in the second difference. Accordingly, it can be concluded that egg output, rainfall, relative humidity and temperature are *I(2) series.* For the tests, a constant term and time trend were included. Results of the unit root tests with both constant term and time trend variable included are reported in Table 1.

Critical values of ADF t-statistic

1% level of significance = -3.96, 5% level of significance = -3.41, 10% level of significance = -3.13 Critical values of ADF t-statistic for constant with no trend

Table 1: Results of stationary test from Augmented Dickey-Fuller Test

Variables	Level	1st difference	2nd difference	Order
Egg output	-1.5391	-2.7100	-4.0539***	*I(2)*
Rainfall amount	0.06485	-2.0694	-3.9450**	*I(2)*
Average Humidity	-0.60104	-1.6787	-3.3133*	*I(2)*
Temperature	-1.9414	-2.3411	-5.9674***	*I(2)*

***** Significant at 1%, **Significant at 5%, *Significant at 10% level of significance**

Table 2: Results of the co-integration tests

Regressand	Condition	ADF test	R^2	Durbin Watson
Egg output	Constant, no trend	-1.1359(0)	0.3389	0.4406
	Constant, trend	-2.189(0)	0.9117	1.338

Source: Computer printout of SHAZAM result

1% level of significance = -4.96, 5% level of significance = -4.42, 10% level of significance = -4.13.
Critical values of ADF t-statistic for constant with trend
1% level of significance = -5.25, 5% level of significance = -4.72, 10% level of significance = -4.43.

The numbers in parentheses for the ADF test are the optimal lag lengths, which are determined using Akaike Information Criterion (AIC). Since there is long term relationship between the variables, we can conclude that the series are co-integrated.

Trend of egg output data

Statistical result of egg output in Ogun State of Nigeria between 1990 and 2019 shows an increasing trend with the highest in 2018 and lowest in 1990. The value of the highest crates of egg which was recorded in 2018 was 273,038 crates while the lowest was recorded in 1990 with value of 7,000 crates. The mean and standard deviation of the egg output data in the state from 1990-2019 are 97,735 crates and 76,585.2 crates respectively. Correlation test revealed that there was positive significant relationship (p<0.01) between egg output and time (r=0.961).

Table 3: Descriptive analysis of data on egg output from 1990-2019

Mean	97735
Minimum	7000
Maximum	273038
Standard Deviation	76585.2
Trend coefficient	8364.03***
Correlation	0.961***

significant at 1% ***Source: NBS and Computer printout of SPSS result

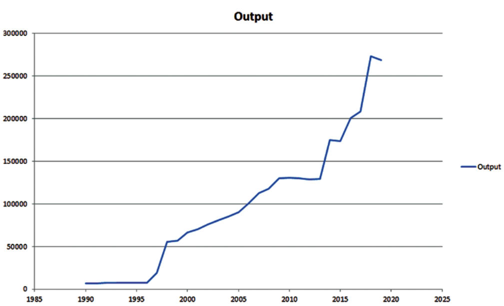

Figure 1: Pattern of egg output data from 1990-2019 in Ogun State

Table 4: Descriptive and trend analysis of data on climate from 1990 - 2019

	Rainfall (mm)	Temperature (°C)	Relative Humidity (%)
Mean	1392.3	30.11	67.07
Standard deviation	301.43	2.118	5.588
Maximum value	1912.80	33.00	74.33
Minimum value	947.50	25.90	50.75
Trend coefficient	173.029	1.784xxx	4.111***
Correlation coefficient	0.488	0.716xxx	0.626***

*** significant at 1% ***Source:*** NIMET, Oshodi and Computer printout of SPSS result.

Trend of climatic elements

Trend of rainfall

Statistical record of rainfall in Ogun state of Nigeria between 1990 and 2019 shows an increasing trend with the highest in 2018 and lowest in 2001. The value of the highest volume of rainfall which was recorded in 2018 was 1912.8 mm while the lowest was recorded in 2001 with value of 947.5 mm and the mean and standard deviation of the rainfall data in the zone from 1990-2019 are 1392.3 mm and 301.43 mm respectively. The standard deviation shows that there is a large variability in the amount of rainfall from year to year. The coefficient of correlation between rainfall and time has a value of 0.488. The trend model is lnR = 961.685 + 173.029 lnT and is not significant at 10% level of probability. (R stands for rainfall and T stands for time i.e. year).

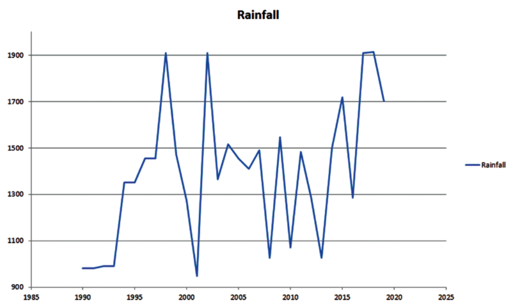

Figure 2: Pattern of rainfall data from 1990-2019 in Ogun State

Trend of temperature

Data on temperature from 1990-2019 shows an increasing trend with the minimum temperature (25.9°C) recorded in 2003 and maximum temperature (32°C) recorded in 2019. The mean value of temperature and its standard deviation over the period were 30.11°C and 2.118°C implying that there is a slim variability in temperature values from year to year. The trend coefficient is 1.784 and is statistically significant at 1%. The coefficient of correlation of temperature and time is 0.716 and is statistically significant at 1%. The model for the trend is Ln C=25.675+1.784 LnT and is significant at 1% (C stands for temperature and T stands for time i.e. year).

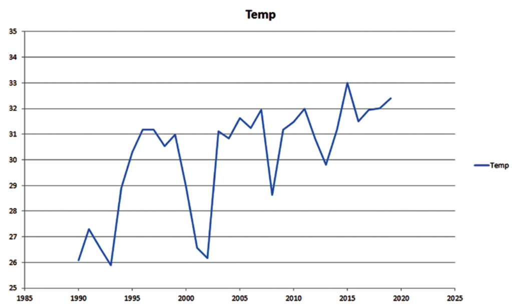

Figure 3: Pattern of temperature data from 1990-2019 in Ogun State

Trend of relative humidity

The relative humidity record from on Ogun state of Nigeria from 1990-2019 shows an increasing trend with its highest value for the period (74.33%) recorded in 2017 and the lowest value (50.75%) recorded in 1993. The mean and standard deviation values of the relative humidity over the period were 67.07% and 5.588% implying that relative humidity has a considerable variability from year to year. The trend coefficient was 4.11 and it is an increasing trend. It is, however, also statistically significant. The coefficient of correlation had a value of 0.626. The equation for the trend is LnH= 56.841 + 4.111LnT. (H stands for Relative humidity and T stands for time i.e. year).

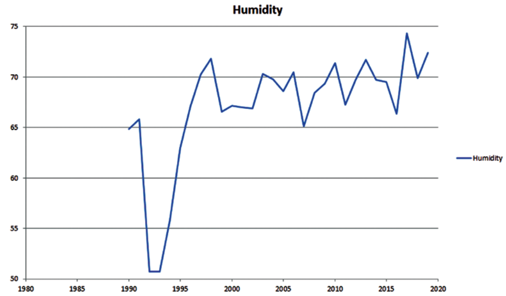

Figure 4: Pattern of Relative Humidity Data from 1990-2019 in Ogun State

Effect of climate change on egg output

The results of the regression analysis on egg output against climate variables are presented in Table 5. In order to determine the effect of climate change on egg output, a model was subjected to regression analysis in three functional forms (linear, semi-log and exponential functional form). The linear function, stated below was chosen as the lead equation ($Y=2.784+0.045X_1-3.387X_2+3.987X_3+1.765X_4$). It was chosen because it had the highest adjusted R^2 (0.893) value, and highest F - ratio value (59.473). The results of the effect of climate change on egg output shows that R^2 which is the multiple coefficient of determination for the collective effect of all the independent variables (rainfall, temperature, relative humidity and year) was 0.893. This implies that about 89.3% of the variance of Egg output is explained by rainfall, temperature, relative humidity and year. From the above equation, it can be deduced that rainfall (X_1) is positively related to egg output even though it was not statistically significant. A degree rise in Temperature (X_2) would lead to a decrease in egg output by 3.387. This shows that temperature had an inverse relationship with egg output. Also, relative Humidity (X_3) was positively related to egg output. It is significant at 1% level of significance. Year (X_4) i.e. time has a positive relationship with egg output.

Discussion

According to the trend of egg output data from 1990-2019, There is positive relationship between egg output and time which probably may be attributed to better management practices, increased number of producers and bigger flock sizes of farmers from year to year, farmers are bound to expand their flock sizes and scale of egg production. Statistical records of rainfall amount in Ogun State of Nigeria between 1990 and 2019 shows an increasing trend and also there is large variability in the amount of rainfall from year to year. The coefficient of correlation between rainfall and time implies that there is a weak positive relationship between rainfall and time. This correlation is however not statistically significant. The coefficient of correlation of temperature and time implies that temperature has significant positive relationship with time. Therefore, temperature changes with time significantly. The warming is real and significant. The coefficient of correlation between relative humidity and time shows a positive relationship and was also statistically significant.

The result of the effect of climate change

Table 5: Regression estimates of climatic variables and egg output

Variables	Linear Form		Semi-log Form		Exponential Form	
	Coefficient	T ratio	Coefficient	T ratio	Coefficient	T ratio
Constant	2.784	0.756	-375557.031	-0.594	7.659	4.531
Rainfall (X_1)	0.045	0.072	21953.061	0.446	0.000	0.747
Temperature (X_2)	-3.387*	-1.865	-31815.088	-0.168	-0.085	-1.391
Humidity (X_3)	3.987***	2.956	-59358.955	0.475	0.054***	2.622
Year (X_4)	1.765***	7.365	-69803.4***	4.627	0.123***	8.872
R^2	0.852		0.693		0.893	
Adjusted R^2	0.893		0.644		0.875	
F ratio	59.473		14.137		51.915	

****Significant at 1% level,* ***Significant at 5% level,* **Significant at 10% level* on egg output with respect to rainfall variable was not significant which may be as a result that farmers have made appreciable efforts to militate against the adverse effect of rainfall through heating of poultry houses during the rainy season. This is probably because of the general belief that egg production drops during the rainy season. Furthermore, temperature had an inverse relationship with egg output. This is consistent with the findings of Elijah and Adedapo (2006) who opined that at high temperature, the feed intake of poultry birds reduces because more energy is required to conserve the heat caused by high temperature. Hence, a decrease in rate of feed intake which invariably reduces egg production. With respect to the positive relationship of relative humidity and egg output in the regression result, this is consistent with the findings of Azzam *et al.* (2011) who stated that the addition of L-threonine at 0.3% into the feed composition of laying hens in sub-tropical climates may have a positive effect on the humoral immune response of laying birds during high humidity.

Conclusion and Recommendations

Statistical records of rainfall, average temperature and relative humidity in Ogun State of Nigeria between 1990 and 2019 shows an increasing trend. Average temperature has a significant positive relationship with time which may confirm that climate change is real and significant. The pattern of egg output decreased in 2019 as revealed by the trend analysis on egg output which may have been due to unfavourable climatic variations and other socioeconomic factors.

Rainfall and humidity are positively related to egg output but rainfall was not significant. Temperature was significant and had an inverse relationship with egg output. Therefore, Climate change significantly affects egg output. The study highlights some pertinent climatic factors that affect poultry egg production and performance in the study area. These climatic factors were mainly rainfall, temperature, and relative humidity. The increasing pattern of rainfall may expose the farmers to flood attacks and increasing temperature pattern will aggravate global warming in if unchecked.

Researchers should direct effort towards research in this area of study as climate change and variability is a continuous natural phenomenon. As climate change has significant effects on poultry egg production, there is need to empower extension agents on climate change adaptation methods in order to build the capacity of poultry farmers and introduce adaptation technologies that will ensure improvement in egg production thereby increasing output.

Acknowledgement

The authors appreciate the effort of Late Mr. Oluwadamilola Omidiji who worked tirelessly in collecting some of the secondary data used for this study. He died on the 3rd October, 2019 after been a victim of a fire explosion in Lagos State, Nigeria. I pray his gentle soul will continue to rest in perfect peace.

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