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Impact of Climate Change on Poultry Production in Nigeria: A Co-integration Analysis Approach (1971-2012)

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Abstract

The level of performance of poultry production does not depend on its genetic make up only but also to a large extent on environmental conditions. Therefore, this study was carried out to examine the impact of rainfall and temperature on chicken and chicken egg production in Nigeria from 1971-2012. Time series data were used. Data on chicken production, egg production, temperature, and rainfall were obtained from various sources such as Nigeria Metrological Agency (NiMET), Food and Agricultural Organization (FAOSTAT), and National Bureau of Statistics (NBS) in Nigeria. Analytical tools employed in the study include unit root, Granger causality tests, and co-integration. The Granger causality tests showed that there is a linear causation from rainfall to egg production output while no directional causation was observed from rainfall to chicken production output in the period studied. The study revealed that a rise in maximum temperature negatively affects egg production while a lower minimum temperature has positive impact on production. A better understanding of climate impacts on poultry output is needed for the purpose of averting its effects on the total poultry production.

Keywords: chicken, egg, environmental, rainfall, temperature

Introduction

Poultry production is a source of livelihood for most rural communities because it provides ready cash for emergency needs (Atteh, 2004), supplies the fast-growing human population with high quality protein, contributes significantly to food security, and promotes poverty alleviation and ecological management of natural resources (Guẽye, 2002). Since there is a continuing rise in the production cost of cattle, sheep, and goat meat (Onuekwusi, 2001), consumer preferences have shifted now for poultry meat (white meat) given the ecological, economic, social, and health advantages it has over other types of meat (red meat) (Guèye, 2002; Atteh, 2004). The poultry is the most commercialized of all the Nigerian livestock agricultural production. The types of poultry that are commonly reared in Nigeria are chickens, ducks, guinea fowls, turkeys, pigeons, and more recently ostriches. Those that are of commercial or economic importance are chicken, guinea fowls, and turkeys, among which the chickens predominate (Ugwu, 2009). Poultry production in the past was not counted as an important occupation. In some communities, fowl is used in the past as a means of knowing the time of the day. Nowadays, poultry production has developed and occupies a place of pride among the livestock enterprise due to its rapid monetary turnover (Laseinde, 1994; Atteh, 2004). Poultry production has long been recognized as one of the quickest ways for a rapid increase in protein supply, of recent there has been a recorded improvement in poultry production sub-sector in Nigeria with its share of the Gross Domestic Product (GDP) increasing in absolute terms. Poultry eggs and meat contribution of the Livestock share of the GDP increased from 26% in 1995 to 27% in 1999 (Central Bank of Nigeria [CBN], 1999). This significant improvement in poultry production has been sustained by availability and use of improved vaccines which curtailed mortality rates in birds, reduction in the tariffs on imported day-old chicks and parent stock (CBN, 1999) and the relative ease of compounding efficient food using easily available local feedstuffs (Ojo & Afolabi, 2000).

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Poultry production systems are, however, influenced by climate variables. Climate change has impact on agricultural production since climate variables are important factors of production, providing required inputs for plant and animal production. Variability of climate is likely to have effects on poultry production because study has shown that poultry performance does not only depend on genetic makeup but also on the environmental factors.

Climate change is defined as the change in the normal atmospheric conditions which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to the natural variability observed over comparable time (Adejuwon, 2004). Further, climate change is a change in the statistical distribution of weather over a period of time that ranges from decades to millions of years (Issa et al., 2011). It refers to persistent changes in the mean of climate parameters such as temperature, rainfall, relative humidity, and soil moisture (Alade & Ademola, 2013). It is a change in the average weather condition that a given area experienced over a long period of time (Issa et al., 2011; Uzokwe & Bakare, 2013).

Climate is an important factor in agricultural productivity. The threat of climate change to agriculture does not apply to crop husbandry alone but also to livestock production and the general agricultural sectors (Ayinde et al., 2010, 2011, 2013). For instance, Elijah and Adedapo (2006) reported that climate parameters like temperature, rainfall, wind-speed and relative humidity in Ilorin, the state capital of Kwara in Nigeria, contributes up to about 81%, 96%, and 43% to the variance in poultry egg production, feed intake and outbreak of disease of poultry production, respectively.

Agricultural sector is climate-dependent that poses serious burden on the society in the process of providing the teeming Nigeria population with food and fibers, source of income, and generate employment opportunity. Effects of climate variation are physical, economic, social and cultural, endangering environmentally-based livelihoods of the Nigeria population. Climate variability has direct impacts that cause vulnerability to the natural and social systems

through changes in average temperatures, temperature extremes, and extreme weather events like flooding and droughts. Adger et al. (2007) reported that poor infrastructure, economic poverty, drought, excess rainfall, poor livestock health, reduced crop yields, low productivity, and a range of other problems associated with climate variability will constitute important challenges for Africa Countries in particular. Africa's population in which Nigeria is a key player in terms of population size and market for agricultural produce domestically is very vulnerable to climatic and non-climatic changes, due to high level of poverty, conflicts, and prevalence of diseases (Oluwasusi & Tijani, 2013). Increased temperatures and accompanying decrease in water availability reduce the length of growing seasons and yield potential and hence the areas suitable for agriculture, further adversely affecting food security over the continent (Thornton et al., 2006) Nevertheless, the impact of climate change could also have positive effects on agricultural production in some regions. For instance, growing seasons might become longer where the climate is cold, that is, in the high latitude and in high land areas. Increased Carbon (IV) Oxide (CO_2) content in the atmosphere could also have a positive influence on plant growth, even though in practice the beneficial effect of this factor is expected to be rather low because of other limitations on plant growth (Giger, 2010).

Despite the increasing number of poultry farmers in the nation, meeting the protein requirements has always been a challenging feat as there has just been marginal improvement in terms of contribution of the poultry subsector to the nation's GDP. Studies have shown that extreme temperature and relative humidity affect poultry production in certain ways including decrease in feed consumption and feed efficiency, reduction in poultry growth and live weight, high mortality and morbidity rate, decrease in quality and quantity of egg production, and increase in poultry body temperature (Atteh, 2004; Elijah & Adedapo, 2006; Uzokwe & Bakare, 2013) all of which have financial implications if poultry farmers are to successfully mitigate such attendant risks.

Research has shown that poultry keeping helps in poverty alleviation, meeting up the protein requirement and requiring simple management practices with low cost of production, high profitability and

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quick turnover compared to other livestock production. There is therefore the need for sufficient information on such things as climate variables and how they affect poultry productivity since a better understanding of climate impacts on poultry output is needed for the purpose of averting its effects on the total poultry production (Roudier et al., 2011).

Materials and Methods

The study was carried out in Nigeria which comprises 36 states and the FCT. Nigeria is one of the sub-Saharan African nations in the western part of Africa, its main longitudes and latitudes are 10^0N and 8^0E, respectively (Maps of the World, 2009). Nigeria is bordered in the West, North, East, and South by the Republic of Benin, Niger, Chad and Cameroon, and Atlantic Ocean, respectively. The country covers a land area of 923,768 square kilometers. The vegetation ranges from the mangrove and thick forests in the South where annual rainfall is 60 to 80 inches per year, followed by Savannah and the Sahel in the middle belt and the North, respectively. The far north is defined by its almost desert-like climate where rainfall is less than 20 inches per year. The rest of the country that is everything in between the far north and the far south is savannah and rainfall is between 20-60 inches per year (Nation Master, 2009). The 2006 Population and Housing Census put the population of Nigeria at 140,431,790 consisting of 71,345,488 males and 69,086,302 females. The estimated average growth rate of the population is put at 2.8%, implying an estimated population for Nigeria of 168 million in 2010. This results to an estimated male population of 85, 351, 344 and a female population of 82,648,656. Agriculture is the mainstay of the Nigerian economy being characterized by majority of the farmers being small-scale holders. The study employed the use of secondary data which were sourced from the National Bureau of Statistics (NBS) summary and annual abstract of statistics, Nigeria metrological agency (NIMeT), Federal livestock department, and an online database maintained by Food and Agricultural Organization (FAOSTAT).

Time series data on temperature, rainfall, chicken, and chicken egg production in Nigeria for the period 1971- 2012 were used in this study. The methods of data analysis involve an initial unit root and co-integration tests which are preliminary tests carried out on the time series data to ensure that data were suitable for Granger causality test, and the analysis proceeded to employ the Granger causality test. Granger Causality test (Granger, 1969) was used to examine the relationship between chicken & chicken egg production and climatic variables with their direction of causation. The Granger causality analysis used in the study involves the estimation of the following pairs:

For chicken production output

$$Y_1 = Y_{t-1} + X_{1-1} + X_{2-1} + X_{3-1} + U_t \quad \ldots\ldots\ldots\ldots\ldots (1)$$
$$Y_1 = X_{t-1} + X_{2-1} + X_{3-1} + U_t$$
$$Y = Y_t - Y_{t-1}$$

For egg production output

$$Y_2 = Y_{t-1} + X_{1-1} + X_{2-1} + X_{3-1} + U_t \quad \ldots\ldots\ldots\ldots\ldots (2)$$
$$Y_2 = X_{t-1} + X_{2-1} + X_{3-1} + U_t$$
$$Y = Y_t - Y_{t-1}$$

Where it is assumed that the disturbance terms U_t is uncorrelated and Y_t and X_t are time series. Y_1 = chicken production at time t, Y_2 = egg production at time t, X_1 = maximum temperature at time t, X_2 = minimum temperature at time t, X_3 = annual rainfall at time t, U_t = error, $_{t-1}$ = lag variables.

By this model, variable that causes the other is identified. This leads to a bivariate regression model with lag variables:

$$Y = \beta_0 + \beta_1 + \beta_2 + \beta_3 + U_t \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where Y_t = dependent variable identified by the causality model (Wt or Z_t); Y_{t-1} , X_{t-1} = lagged dependent and independent variable; and U_t = disequilibrium term

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Results and Discussion

Table 1 shows the result of the unit root test for stationarity in all variables using the Augmented Dickey Fuller (ADF) test. All the variables are stationary at different lag lengths either at 1% or 5% level of significance. The result of stationary test showed that temperature and rainfall were stationary at level while chicken and egg production output exhibited unit root at level but became stationary after the first differencing.

Table 1. Result of stationary test.

Variables	Statistics	P-value	Implication	Lag Length	Order of integration
Y_1	-4.8124	0.002	Stationary	9	Stationary at first difference
Y_2	-6.6199	0.000	Stationary	9	Stationary at first difference
Mean temperature	-5.2426	0.0006	Stationary	9	Stationary at level
Annual rainfall	-5.6156	0.0002	Stationary	9	Stationary at level

The result of the granger causality test shown in Table 2 reveals that there is linear causation from rainfall to egg production output changes in Nigeria. The finding implies that there is a relationship between the changes in the egg production output and rainfall which may be due to the fact that when rainfall changes, it has effect on temperature which has an effect on the laying ability of birds. This finding is in tandem with the findings of Ozcelik and Ozbey (2004) that high temperature results to a decrease in production and quality of eggs. The result also gives credence to the finding of India Council of Agricultural Research (2010) in which it was noted that egg and meat

production patterns are affected by climate change because periods of high temperature and sunshine intensity caused the birds to drink more water and reduce feed intake which many at times result to high mortality of the chickens, low egg production, and low feed conversion ability of the birds to meat, hence, low meat production.

The result also showed that there is no directional causation from rainfall to chicken production output in the period under study. Rainfall changes do not occur suddenly, as a result, rainfall may not significantly affect chicken production unless the changes have been accumulated over a long period of time. This result does not quite agree with the findings of Elijah and Adedapo (2006) who observed that high rainfall and relative humidity provide a conducive environment for breeding of parasites that cause outbreak of diseases which invariably reduced egg and meat production.

Table 2. Granger causality Wald tests result between poultry production and rainfall.

Equation	Excluded	F- statistics	Optimum lag	Probability	Decision
X_2	Y_2	3.81592	2	0.0317	Accept
Y_2	X_2	0.34545	2	0.7103	Reject
X_2	Y_1	0.31824	2	0.7295	Reject
Y_1	X_2	1.26521	2	0.2948	Reject

Source: Data analysis 2015
Decision made at 5%

Table 3 shows that there is linear causation from temperature to egg and chicken production output in Nigeria. The result implies that there is a relationship between the changes in the egg and chicken production output and temperature. This finding agrees with the study of Barua and Howlider (1990) showing that high temperature, and humidity have some negative effects such as an increase in poultry body temperature, a decrease on feed consumption, and feed efficiency. High temperature also results to a reduction in poultry live weight

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(Elijah & Adedapo, 2006), growth rate, and high mortality (Arjona et al., 1988).

The result of the co-integration in Table 4 shows that the lagged values of output positively affected the current output. The result implies that the output of the last previous year affects the production of the current year output that leads to a rise or fall in output. Also, the lagged values of minimum and maximum temperature have a negative impact on output. This means that increase or decrease in temperature causes a decrease or increase in the output, respectively. This is in line with the findings of Ande and Wilson (1981) who observed that at higher temperature broilers grow more slowly than at lower temperature which shows that at a given age the total meat production (kg/bird) is reduced.

Table 3. Granger causality Wald tests result between poultry production and temperature.

Equation	Excluded	F- statistics	Optimum lag	Probability	Decision
X_1	Y_2	4.37826	1	0.0431	Accept
Y_2	X_1	0.01118	1	0.9163	Reject
X_1	Y_1	5.45982	1	0.0248	Accept
Y_1	X_1	2.32785	1	0.1354	Reject

Source: Data analysis 2015; Decision made at 5%.
Granger Causality Test on Poultry Production and Climate Variables
SAMPLE 1971 – 2012 Where; Y_2 = Egg output, Y_1= Chicken output, X_2= Rainfall pattern, X_1 = Temperature

Table 4. Co-integration analysis result of chicken output and temperature. Dependent variable: Y_1.

Variable	Coefficient	Std. Error	T. statistics	Probability
ΔY_1	0.100298	0.127364	0.787495	0.4366
X_1	5774.829	1771.584	3.259699	0.0026
ΔX_1	-1589.030	1645.067	-0.965937	0.3411
X_2	29415.97	3618.030	8.130381	0.0000
ΔX_2	-1891.602	1902.785	-0.994123	0.3274
K	-616725.7	92763.56	-6.648362	0.0000

R-squared	0.993756	Mean dependent var	115570.9
Adjusted R-squared	0.992621	S.D. dependent var	37159.89
S.E. of regression	3192.073	Sum squared resid	3.36E+08
Durbin-Watson stat	2.352535	Long-run variance	2738995

The estimation indicated in Table 5 reveals that the explanatory variables jointly account for approximately 96% changes in egg production. The Durbin-Watson statistics of 2.63 implies absence of auto-correlation. Coincidentally, the goodness of fit for the regression remained low after adjusting for degree of freedom as indicated by the adjusted R^2 (R^2 =94%). The result also shows that lag value of maximum and minimum temperature and lag value of rainfall are statistically significant in explaining changes in egg production as a result of climate change. This result therefore implies that a 1% increase in maximum temperature and rainfall will cause 4.2% and 5.2% reduction in egg production in Nigeria, which showed a negative impact. Minimum temperature has a positive effect in that for every 1% increase in minimum temperature, there is an increase of 9.1% in egg production.

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Table 5. Co-integration result of egg production output, temperature and rainfall. Dependent variable: Y_2.

Variable	Coefficient	Standard Error	T- statistics	Probability
ΔY_2	3.56E-11	1.07E-12	33.13105	0.0000
X_1	18391.93	8.38E-08	2.20E+11	0.0000
ΔX_1	-4.19E-07	5.39E-08	-7.773941	0.0000
X_2	100893.2	1.11E-07	9.05E+11	0.0000
ΔX_2	9.07E-07	9.45E-08	9.594621	0.0000
X_3	268.7622	3.58E-09	7.50E+10	0.0000
ΔX_3	-5.16E-08	3.82E-09	-13.49708	0.0000
K	-2430472.	2.78E-06	-8.73E+11	0.0000

R-squared	0.960000	Mean dependent var	340215.0
Adjusted R-squared	0.940000	S.D. dependent var	150847.4
S.E. of regression	1.86E-06	Sum squared resid	1.07E-10
Durbin-Watson stat	2.625237	Long-run variance	3.61E-15

Based on the findings of this study, climate change has a negative impact on poultry production in Nigeria. The Poultry Industry of the country will experience more serious adverse effects from climate change in the coming years if the situation is not mitigated.

Conclusion and Recommendations

The impact of climate change on poultry production in Nigeria is negative on egg production with increasing temperature. Since climate change is inevitable, strategies towards mitigating the effects should be focused on programs and policies targeted at increasing poultry production. Animal scientists should work on improving the breeds of poultry to enable them to adapt well to warmer climates. The private

sector likewise should develop affordable and custom-built technologies that are suitable for poultry rearing in warmer countries so as to empower poultry farmers and boost production level.

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