Nigerian Agricultural Policy Research Journal (NAPReJ) Agricultural Policy Research Network (APRNet)
Vol. 10, Special Issue. Website:http:// www.aprnetworkng.org ©2022

ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

Estimation of Climate Change Influence on Poultry Production in Nigeria

Aroyehun, Adeyinka Richard and Onyenma, Grant Chukwuemeka
Department of Agricultural Economics, University of Port Harcourt, Choba, Nigeria.

Corresponding author's: richestaro2014@gmail.com +2347065528824

A R T I C L E I NFO

Keywords:

Adaptation;

Climate Change;

Poultry meat;

Poultry egg;

Productivity

ABSTRACT

Poultry farming is at risk of both direct and indirect impacts of climate change effect. Hence, this study examined the estimation of climate change influence on poultry production in Nigeria. It is apparent that climate change has become a global phenomenon. In Nigeria, the prospect is that climate change will have adverse impact, not only as a result of anticipated warming and erratic rainfall patterns, but due to vulnerability of poultry birds. Its effect on poultry production will be of great magnitude, affect the growth, adaptation and production of poultry egg and meat. This study estimates the trends of poultry meat and egg production in Nigeria from 2009 to 2020, using Ordinary Least Square model. The study estimates that the annual growth rate of poultry meat and egg, between 2009 and 2020 to be 3.12% and 3.93% respectively, Durbin-Watson estimates (1.5; 1.3) obtained for poultry meat and egg production respectively (signify that the test is inconclusive; however, absence of autocorrelation is an indication that the OLS coefficients or parameter estimates are statistically unbiased and gives credibility to the data) indicate the positive correlation and acceptability. Poultry meat (0.002) and egg (0.0008) were found to be statistically significant at 1% probability value. The result shows that precipitation was significant at 1% for poultry meat, while precipitation is significant at 5% for poultry egg production. CUSUM and CUSUMSQ test presents the suitability of OLS for the study. Also, the study extensively elaborates on the possible adaptation strategies to climate change as a means of curbing and sustaining poultry farming in Nigeria. Conclusively, policy implications necessary to counteract the adverse impacts of climate change in poultry farming that can foster sustained productivity increases were proffered. This includes, embarking on enlightenment campaigns on climate change adaptation strategies so as to facilitate the adoption of appropriate poultry management practices.

INTRODUCTION

Climatic change presents a major hazard to the sustainability of poultry farming practices globally. As a result, adaptation to, and mitigation of the harmful impacts of extreme climates has performed a vital role in coping with the climate change impacts on poultry farming (Sejian, Bhatta, Soren, Malik, Ravindra, Prasad & Lal, 2015). There is little doubt that climatic variation will have an effect on poultry productivity in several regions. Climatic change may possibly reveal itself as prompt changes in climatic condition in the short period (some years) or more sharp changes more than decades. In general, climatic change is connected and bonded with rising worldwide temperature. Several climate model predictions propose that by the year 2100, average global temperature might be 1.1–6.4^{o}C warmer than in 2010. The problem confronting poultry is weather condition extremes such as: severe heat waves, high humidity, high temperature, floods and droughts. Beside production deficiency and high cost of inputs, severe events also result in death of poultry birds (Gaughan & Cawsell-Smith, 2015), reduction in egg size, thin or poor egg shell formation, reduction in growth rate, low egg production, low feed intake, and poor meat production. Poultry birds can adapt to warm climatic conditions; nevertheless, the reaction techniques and mechanisms that are beneficial for survival and growth may be unfavorableas well as could disrupt production and reproduction ability of the birds (Sejian, Gaughan, Bhatta & Naqvi, 2016). Hence, this study stressed the effect of climate change and adaptive strategies in poultry farming in Nigeria. The remaining part of this paper is divided into literature, methodology, results and discussion, and conclusion and recommendation. The specific objectives of this study were:

i. to estimate the temperature and precipitation trends in Nigeria from 2009 to 2020; and
ii. to estimate the trends of poultry meat and egg production (in tons) in Nigeria from 2009 to 2020

Concept of Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) (as cited in Onyeneke & Madukwe, 2010) defines climate change as the variation in climatic conditions which is accredited directly or indirectly to human action that modifies the structure of the global, regional and/or local atmosphere in addition to inherent climatic alteration experienced over similar periods of time. Intergovernmental Panel on Climate Change IPCC (2007) defines climate change as the variation in the condition of the climate that can be described (for example by using statistical tools) by alteration in the mean and/or the inconsistency of its properties, and that continues for extensive period normally decades or more. Although the Planet's climatic conditions are continually changing and global climate variation happens naturally, the degree of future climatic change condition might be faster than at any experienced period in the last 10,000 years. Most of the world's scientists who study climate change conclude that this anticipated climate change would be different from prior climate change as a result of human activities (Koehler-Munro & Goddard, 2010).

Koehler-Munro and Goddard (2010) further stated that the atmosphere has an impact like a greenhouse on the planet earth atmosphere. The energy released by the sun reaching the planet earth is stabilized by the energy that the planet earth released back to the atmosphere. Greenhouse gases (GHGs) entrap some of the energy that the planet earth discharges to the atmosphere. These GHGs in the space act as a regulator regulating the planet earth's climate. Without this usual greenhouse influence, the mean temperature on the planet earth would be -18ºC instead of the present +15ºC. Therefore, life as we understand it would be unbearable. The main GHGs in our atmosphere are water vapour, carbon dioxide (CO_2), methane (CH_4), halocarbons — which are used as refrigerants, and nitrous oxide (N_2O). Since 1750, the atmospheric condition intensity of carbon dioxide, methane and nitrous oxide have increased by nearly 31%, 151%, and 17%, respectively.

Concept of Adaptation

Adaptation to climate change is an acclimatization made to human, environmental, physical, or socio-economic scheme, in reaction to perceived susceptibility or predicted and real climatic stimuli influence (Smit, Burton, Klein, & Wandel, 2000; IPCC, 2001;Adger, Agrawala, Mirza, Conde, O'Brien, Pulhin, *et al*, 2007). Nhemachena and Hassan (2007) elucidated adaptation to climate change as variations in agricultural operations and management procedures occur in reaction to variation in climatic conditions. Different forms of adaptation can be recognized, and they include: anticipatory and responsive adaptation; private and public adaptation; and independent and planned adaptation.

Adaptation is an essential constituent of climate change influence and susceptibility appraisal. Adaptation reaction or acknowledgement can be classified by the status of ownership of the adaptation rate or strategy. Individual or independent adaptations are measured to be those that take place in response to climatic stimuli (after appearance and expression of early impact), that is, as an issue devoid of supports from any public agency (Smit, Pilifosova, Burton, Challenger, Huq*et. al*, 2001).

Policy-driven or planned adaptation is frequently understood as being the response of a conscious and deliberate policy decisiveness on the part of a public organization, based on the knowledge and consciousness that situations are about to alter or have been altered, and that reaction is necessary to reduce losses and increase profit from opportunities (Pittock & Jones, 2000). Thus independent and policy-driven adaptation mainly tallies to private and public adaptation, respectively (Smit*et al.*, 2001). As implied, independent adaptation reactions will be assessed by the individual farmers in terms of availability of inputs and outputs. It is predictable that farmers will adapt effectively, and that markets only can strengthen effective adaptation in exchanged agricultural produce (Mendelson, 2000). Yet, in conditions where market deficiency occur, such as the lack of awareness and knowledge on climate change or poultry rearing system, climatic variation will further minimize the capability of individual farmers to handle risk efficiently. As a result, an accurate and suitable equilibrium between public agency efforts and inducement, such as competence structure, establishment of risk insurance and private venture, requires to be struck so that the misfortune and liability would be lifted from the poor producers (Rosegrant, Ewing, Yohe, Burton, Huq & Valmonte-Santos, 2008).

Direct impacts of climate change on poultry farming

The main substantial direct effect of climatic variation on poultry productivity occurs from the heat tension. Heat tension results in a vital financial problem to

ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

poultry farmers through reduction in meat production, soft egg shells, low egg production and bird health. Thus, a rise in atmosphere temperature, such as that forecasted by diverse climate change models, might directly have an effect on poultry bird performance (Sejian*et al*, 2016). Poultry birds opened to the elements of heat stress will reduce feed ingestion and increase water consumption, and there are variations in the endocrine level which in order to intensify the maintenance needs, result in low productivity (Gaughan & Cawsell-Smith, 2015). Ecological stressors lower body weight, mean daily attainment and body situation of birds. Adaptation to lengthened climatic changes may result in poultry production losses (Gaughan & Cawsell-Smith, 2015).

Indirect impacts of climate change on poultry farming

Majority of the poultry production losses are experienced through indirect impacts of climatic change mainly via declines or non-accessibility of feed and water resources. Climate variation has the capability to influence the quantity and availability of grains output, quality of grains, water require for growing grain crops. In the coming years, grain crops will keep on to be subdued to warmer temperatures, increased carbon dioxide, in addition to uncontrollably erratic water availability owing to changing in rainfall patterns. Climate change may negatively have an impact on production, variety composition and value, with potential effects not only on grain productivity but also on other environmental segments of grasslands (Giridhar & Samireddypalle, 2015). Due to the extensive instability in distribution of precipitation in planting season in some regions of the nations, the grain production will be significantly affected. With the possible emerging situations that are previously obvious impact of the climate change influence, the poultry farming systems are likely to confront more of harmful than the good impact. Also climate change affects the water requirement, accessibility and quality. Variations in temperature and weather conditions can influence the quality, volume and allocation of rainwater, snowmelt, river current and groundwater.

Climate change may lead to elevated intensity of rainfall that can result in greater height of excess and low groundwater boost. Excessive dry seasons may decrease groundwater boost, decrease River current and eventually distress water availability and drinking water supply for poultry birds. The deficiency of water has an effect on poultry bird physiological homeostasis resulting in loss of body weight, low egg production rates and reduced resistance to diseases (Naqvi, Kumar, Kalyan, & Sejian, 2015). Thompson, Berrang-Ford and Ford (2010) also noted that poultry farming is at risk of indirect climate change of feed materials availability, especially the commercial poultry farmers due to increase in temperatures, irregular rainfall patterns that affect abundant harvests required to stabilize feed prices particularly in arid and semi-arid regions. Climate change is envisaged to reduce crop production and increase market prices of crops in sub-Saharan Africa.

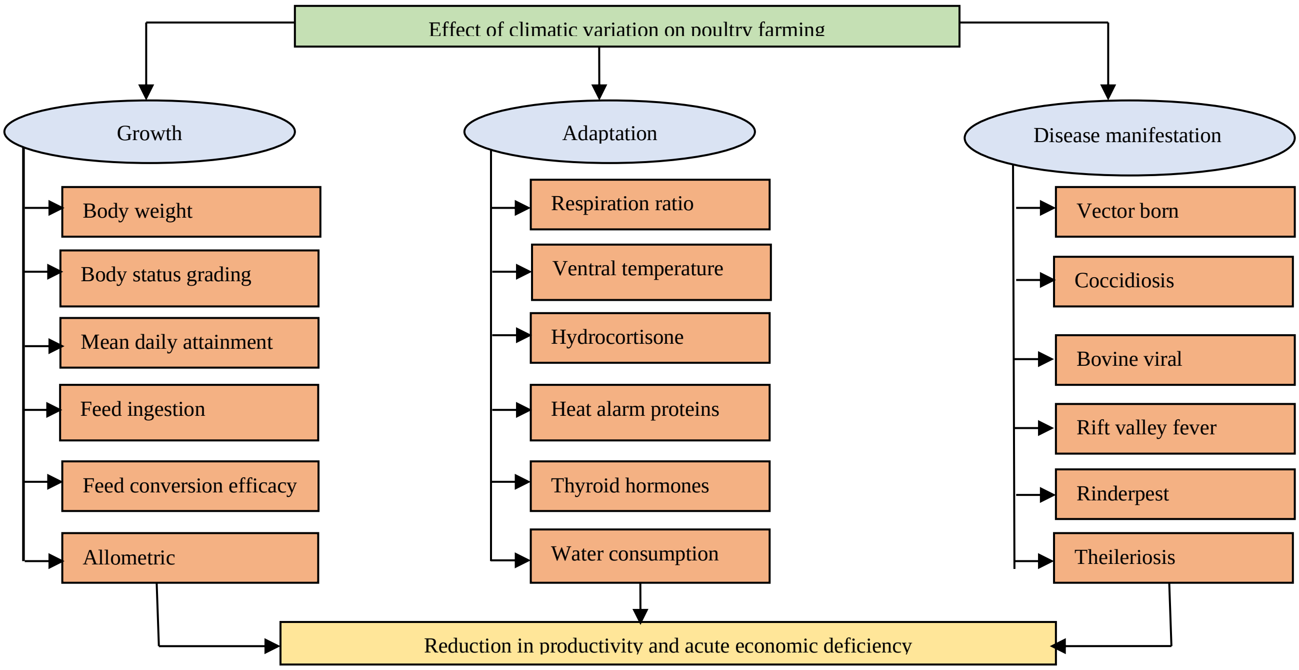


Figure 1: Effect of Climatic Variation on Poultry Productivity
Source: Gaughan & Cawsell-Smith, 2015

Impact of climate change on poultry birds' diseases

Alteration in usual temperature and rainfall are the major considerable climatic change influencing poultry disease epidemic. Heated and damped environment conditions (particularly during raining season) will encourage the threat and incidence of poultry diseases, because specific variety act as disease vectors, like flies, mice and ticks, are more prone to live throughout the year (Sejian *et al*, 2016). Increase in precipitation may trigger epidemic of diseases in poultry such as coccidiosis, typhoid, equine infectious anemia (EIA), diarrhea and Marek's disease (MD) among others. The Figure 1 above shows the effect of climatic variation on poultry productivity.

Adaptation Strategies Practiced by Poultry Farmers

Poultry farmers have traditionally adapted to several ecological and climatic condition variations by building on their wide-range information available to them in the environment in which they dwell. But the increasing human population, rural-urban migration, environmental deterioration and higher consumption of poultry products have rendered some of those coping techniques ineffective (Sidahmed, 2008). Furthermore, changes brought about by climatic alterations are prone to occur at such a pace that they will surpass the ability of unplanned adaptation of both human communities and livestock varieties including poultry birds (International Fund for Agricultural Development, 2010). Studies on climate change (Food and Agriculture Organization FAO, 2008; Thornton, Herrero, Freeman, Mwai, Rege, *et al*., 2008; Sidahmed, 2008) have identified the following as medium to enhance adaptation strategies in poultry farming sector. These adaptation strategies can be categorized broadly into:

1. Production adjustments: Changes in poultry operations could include the following: diversification, expansion and/or incorporation of small ruminant, poultry and crop farming; changing the rearing system from extensive and semi-intensive to intensive system; varying the timing of rearing for farmers that specialized in seasonal production; preservation of environment and ecosystems by reducing the GHGs; moderating the stock level with the space available; and establishing mixed poultry farming systems, such as rearing layers, broiler and cockerels among others together.

2. Breeding strategies: A lot of local species are already coped to severe living situations. However, developing nations are generally described by inadequate of technology in poultry breeding and agricultural agenda that may facilitate the rapid adaptation. Adaptation strategies refer not to only the acclimatization of poultry bird to heat, humidity and wind speed but also their capability to stay alive, grow and produce in a situations of deficient nutrition, parasites and diseases (Hoffmann, 2008). Such actions could include: recognizing and improving local species that have adapted to native climatic trauma and feed resources; strengthening local heredities via cross-breeding with heat resistance, humidity tolerance and disease free breeds. when climate variation is quicker than natural choice, the possibility of the hybrid to live and adapt will be higher.

3. Market reactions: The agriculture market may possibly be strengthened by, for instance, the encouragement of interregional business and credit systems. Prices indicate the fundamental powers of supply and demand and influence national and international market of agricultural produce. Increase in the prices of agricultural products and price flows, were the cause of structural variations in international agricultural markets (FAO, 2018).

4. Institutional and policy changes: Eliminating or initiating subsidies, insurance schemes, revenue diversification procedures and establishing poultry early cautionary schemes and other predicting and crisis-awareness approaches that could help adaptation strategy influences.

5. Science and technology improvement: Operating with regard towards to develop understanding of the effects of climatic change on poultry, rising new varieties and genetically modified breeds, developing poultry bird vigor and improving water and soil management conditions could strengthen adaptation procedures in the long period.

6. Capacity building for poultry keepers: There is a desire to develop and strengthen the capacity of poultry product producers and workers to comprehend and treat the climate change by improving their knowledge of global climatic changes. Furthermore, training in agricultural ecological technologies and operations for the productivity and maintenance of grains enhances the supply of poultry feed and minimizes malnutrition, disease infestation and mortality in poultry.

7. Poultry rearing management systems: Effective and expansive adaptation strategies must be make available for the rural poor dwellers that are not capable to afford costly adaptation equipment and/or technologies. These could include: provision of shield or covering and water to minimize heat trauma from higher temperature. Knowing recent excessive energy costs, supplying natural (little cost) shield or covering

Nigerian Agricultural Policy Research Journal (NAPReJ) Agricultural Policy Research Network (APRNet)
Vol. 10, Special Issue. Website:http:// www.aprnetworkng.org ©2022
ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

in-place of expensive cost air conditioning system is more appropriate for rural poor poultry farmers; reducing the stock level of poultry birds numbers – a smaller number of better valuable poultry birds will results in high efficiency and reduced GHG emissions from poultry production operation (Batima, 2007); changes in poultry birds selection (selection of large breeds of birds instead of small); better management of water means via the establishment of simple methods for rural poor poultry farmers – for example construction of tanks to garner rainwater from the roofs and store it for farm uses (IFAD, 2009).

METHODOLOGY

The focus of this study is on the two major climatic factors which are: temperature and precipitation (rainfall). The data for this study were from the records of the monthly, quarterly and yearly official record of Food and Agriculture Organization Statistical Database, Nigeria Meteorological Data Website, Knoema Database, information on value of poultry meat and egg (in tonnes), temperature (in ^{o}C) and precipitation (in mm) from 2009 to 2020. Ordinary Least Square (OLS) was used to estimate the trends of poultry meat and egg production (in tons) in Nigeria from 2009 to 2020 is expressed thus:

$$P_m = \beta_0 + \beta_1 T + \beta_2 P \quad (1)$$

Where;

P_m = poultry meat production
β_0 = Constant
β_1- β_2 = Coefficient of the parameters
T = Temperature
P = Precipitation

$$P_e = \alpha_0 + \alpha_1 T + \alpha_2 P \quad (2)$$

Where;

P_e = poultry egg production
α_0 = Constant
α_1- α_2 = Coefficient of the parameters
T = Temperature
P = Precipitation

Data was analysed and graphs plotted using Excel Spreadsheet and GRETL Software.

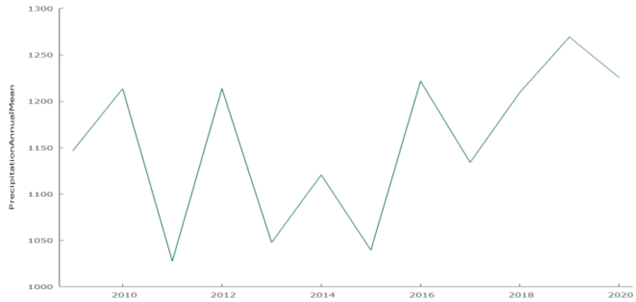
RESULTS AND DISCUSSION

The temperature and precipitation trends in Nigeria from 2009 to are presented in figure 2 and 3 below:

Figure 2: Temperature trends in Nigeria from 2009 to 2020

Source: Authors estimates, 2022

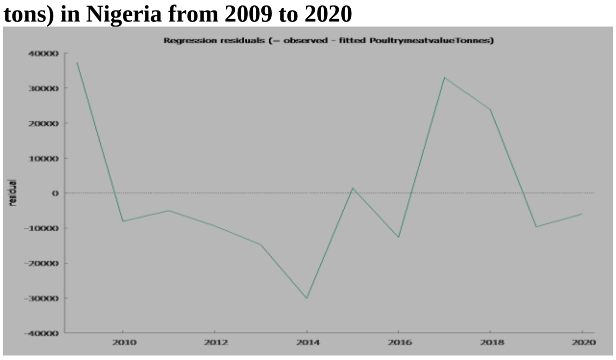
Figure 3: Precipitation trends in Nigeria from 2009 to 2020



Source: Authors estimates, 2022

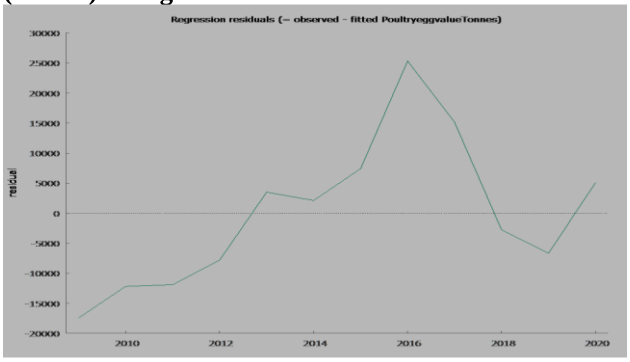
Figure 2 and 3 above was the annual graphs plotted for the the relationship between the temperature, precipitation and the years. It was observed that the temperature was at the lowest in 2012 and 2019. While the lowest precipitation (rainfall) are 2011, 2013 and 2015 respectively as shows on the graph. This finding agrees with World Bank Group (2021) report of annual mean temperature and rainfall of 27.2^{o}C and 1,162.8 mm respectively. Both temperature and precipitation witnessed the highest increase in 2015 to 2016 and reduced collectively from 2016 to 2017, which shows the evidence of change in climatic factors.

Figure 4: Estimated trend of poultry meat production (in tons) in Nigeria from 2009 to 2020



Source: Authors estimates, 2022

Figure 5: Estimated trend of poultry egg production (in tons) in Nigeria from 2009 to 2020



Source: Authors estimates, 2022

Figure 4 and 5 above shows the trend of poultry meat and egg production (in tonnes) in Nigeria from 2009 to 2020. Between 2016 and 2018 both poultry meat and egg production shows increase in production; this could be as a result of equal increase in temperature and precipitation as seen in figure 2 and 3 which implies that there was equilibrium in both temperature and precipitation. This finding is consistent with Capital Partners and Advisory Limited (2015) in their assessment of the growth of the poultry farming sector in Nigeria. Also, it is in consonance with Akande (2016) that reported that temperature between 26-29^{o}C is the best condition at which poultry birds produce meat and egg at maximum proportion, with accompanying normal mortality rate. Temperature above 29^{o}C could reduce the productivity and increase mortality and feed intake. Poultry meat production in Nigeria increased in 2009 from about 273,000 tons to about 238,250 tons in 2020, thus growing at an average annual rate of 3.12%. While poultry egg production in Nigeria increased in 2009 from about 612,600 tons to about 646,667 tons in 2020 with annual growth rate estimated to be 3.93%.

Table 1: Ordinary Least Square (OLS) of the trend of poultry meat production (in tons) in Nigeria from 2009 to 2020

Variables	Coefficient	Std. Error	t-ratio	p-value
Constant	−176283	4.21176e+06	−0.04186	0.9676
Temperature	23582.1	22530.4	1.047	0.3258
Precipitation	218.936	47.4305	4.616	0.0017***

Log-likelihood = −135.6622; R^2 = 0.450051; Adjusted R^2 = 0.243820; Durbin-Watson = 1.472215; F(3, 8) = 12.93631; P-value(F) = 0.001951***;*** is significant level at 1%; Observations 2009-2020 (T = 12)

Source: Authors estimates, 2022

Table 1 shows the log-likelihood function of -135.6622, suggesting that the model is well fitted. Thus indicating the goodness of fit of the model. The coefficient of multiple regression (R^2) shows that the set of variables have an importance of 0.45 while Adjusted R^2 (0.24) obtained shows the reliability of the variables included in the model. The Durbin-Watson statistic will always have a value ranging between 0 and 4. A value of 2.0 indicates there is no autocorrelation detected in the sample. Values from 0 to less than 2 point to positive autocorrelation and values from 2 to 4 mean negative autocorrelation; acceptable range is from 1.5 to 2.5. Hence, the estimated Durbin-Watson coefficient (1.5) indicates the positive correlation and acceptable. The estimate from F-statistic (P-value — 0.002 < 0.01) is significant at 1%. The result from the factors influencing poultry meat output indicates that precipitation is significant at 1%. This implies that 1% increase in precipitation during high temperature will result in about 218.58 tons increase in poultry meat production. High temperature reduces the appetite of poultry birds to feed as they tend to resort to more water intake to cushion their internal temperature. As a result, the birds may loss some body weight thereby lowering the growth rate of the poultry birds. This finding agrees with Akande (2016) who discovered that high precipitation will result in high relative humidity which in consequence lead to the proliferation of disease-causing organisms to poultry birds, loss of body weight, low quality and quantity of poultry meat, death and eventually, economic losses.

Table 2: Ordinary Least Square (OLS) of the trend of poultry egg production (in tons) in Nigeria from 2009 to 2020

Variables	Coefficient	Std. Error	t-ratio	p-value
Constant	−6.03600e+06	2.95164e+06	−2.045	0.0751*
Temperature	−11439.6	22556.4	−0.5072	0.6257
Precipitation	−112.151	35.0899	−3.196	0.0127**

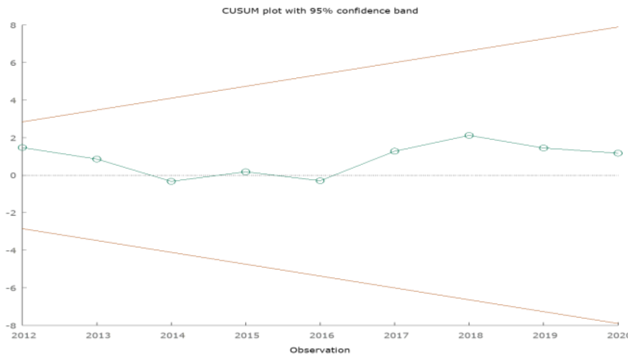
Log-likelihood = −124.3966; R^2 = 0.743665; Adjusted R^2 = 0.647539; Durbin-Watson = 1.331624; F(3, 8) = 16.75530; P-value(F) = 0.000825***;***, **, and *are significant at 1%, 5% and 10% respectively; Observations 2009-2020 (T = 12)

Source: Authors estimates, 2022

Table 2 shows the log-likelihood function of -124.3966, this indicating the goodness of fit of the model. The coefficient of multiple determination (R^2) shows that 74% variation in poultry egg output were explained by the independent variables included in the model, while the Adjusted R^2 estimated to be 0.64, shows the correct specification of the model. The estimated Durbin-Watson coefficient (1.3) indicates the positive correlation and falls within the inconclusive regions, since it value is below 1.5. However, absence of autocorrelation is an indication that the OLS coefficients or parameter estimates are statistically unbiased and gives credibility to the data. The F-ratio estimated [P-value(F) — 0.0008 < 0.01] is significant at 1%. Precipitation (−112.151) is the parameter estimates that significantly influenced the output of poultry egg at 5% level of significance. This implies that increase in precipitation could lead to reduction in poultry egg production; because poultry birds would not be able to drink optimally during high rainfall which could affect their laying capacity. This also indicates that the years are favourable years for the birds to produce eggs. In addition, these are the years with a stable and measured increase in precipitation, with a corresponding moderate temperature. This finding agrees with Akande (2016) who reported that 46.6% of poultry egg production was at 28°C with low mortality, while 44.9% of poultry egg was produced at 29°C with relatively lesser mortality.

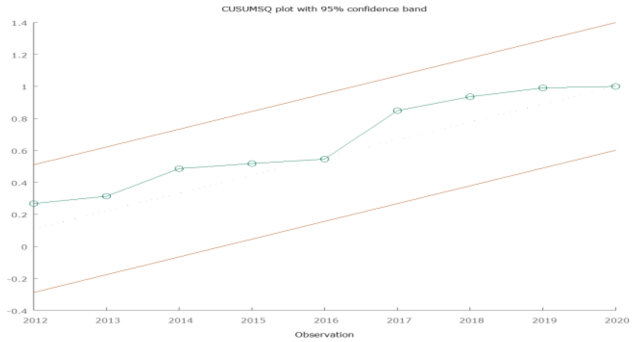
Diagnostic Test

Figure 6: CUSUM Test of poultry meat production



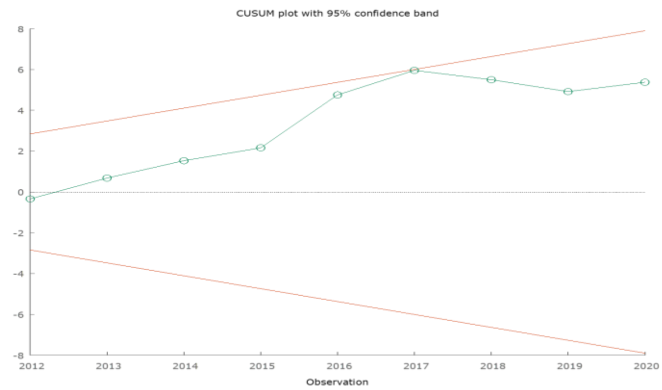
Source: Authors estimates, 2022

Figure 7: CUSUMSQ Test of poultry meat production



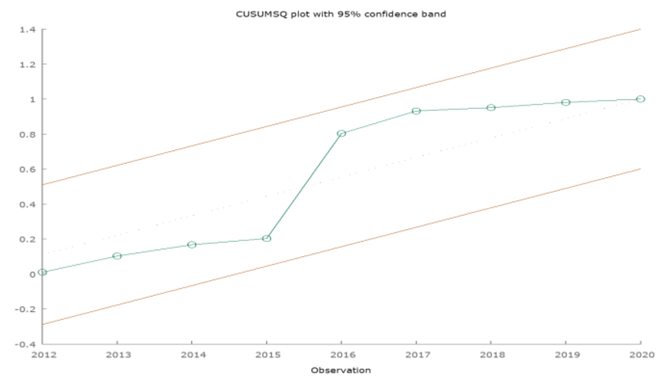
Source: Authors estimates, 2022

Figure 8: CUSUM Test of poultry egg production



Source: Authors estimates, 2022

Figure 9: CUSUMSQ Test of poultry egg production



Source: Authors estimates, 2022

For the robustness test of the OLS model, the cumulative sum control chart (CUSUM) and cumulative sum control chart of the square (CUSUMSQ) testing methods were used in this study. CUSUM and CUSUMSQ test are used to test for the stability of the parameter. The test results are presented in Figure 6 and 7, as well as 8 and 9 for poultry meat and egg production respectively. As it can be seen the broken line that formed the data collected shaped by the CUSUM and CUSUMSQ does not formed or extended outside the boundary under the 5% significance level. Hence, it can be concluded that the OLS model employed in the study is suitable.

CONCLUSION AND RECOMMENDATION

The effect of climate change on poultry farming in Nigeria, as noticed and observed is a very essential part of poultry farming that should be taught to the poultry farmers. The effects of climate change on poultry farming affect the growth, adaptation, egg and meat production and optimal productivity in general due to variations in rainfall, temperature and sunshine intensity. High sunshine intensity makes the poultry birds to drink more water and reduces their feed consumption which subsequently, results in low feed conversion rate, increases mortality and significantly impact on the egg and meat production. CUSUM and CUSUMSQ test present suitability and stability of OLS parameter model used for this study.

The study therefore recommended that:

i. Awareness campaign to minimize the effects of climate change and adaptation strategies on poultry farming should be intensified.
ii. Extension agents and other agencies should intensify educating poultry farmers on productive adaptation strategies for optimum production.
iii. Poultry farmers should adopt and follow some set of adaptation strategies to climate change, such as use of livestock insurance, revenue diversification, improve air and water ventilation, and incorporation of small ruminants to poultry farming.
iv. Poultry farmers should rear poultry birds that are adapted to their environment and adopt effective management systems.

REFERENCES

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien,K., Pulhin, J., *et al*. (2007). Assessment of adaptation practices, options, constraints and capacity. Climate change: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the IPCC.In Parry, M.L., Canziaw, O.F., Palutikof, J.P., Vander Linden, J.P., Hanson, C.E. (Eds.), 717- 743. Cambridge UK: Cambridge University Press

Akande, S.O. (2016). Temperature and relative humidity effects on egg production in Nigeria. DOI:10.13140/RG.2.2.26834.91841

Batima, P. (2007). Climate change vulnerability and adaptation in the livestock sector of Mongolia. Assessments of impacts and adaptations to climate change. International START Secretariat, Washington DC, US

Food and Agriculture Organization of the United Nations FAO. (2008). Expert meeting on climate-related trans-boundary pests and diseases including relevant aquatic species: Options for decision makers.FAO Headquarters, Rome, Italy. Retrieved from http://www.fao.org/fileadmin/user_upload/foodclimate/presentations/diseases/OptionsEM3.pdf

Food and Agriculture Organization of the United Nations FAO. (2018). The state of agricultural commodity markets: Agricultural trade, climate change and food security. Rome, Italy. Retrieved from http://www.fao.org/3/I9542EN/i9542en.pdf

Gaughan, J. B., & Cawsell-Smith, A. J. (2015). Impact of climate change on livestock production and reproduction. In climate change impact on livestock: Adaptation and mitigation.Sejian, V., Gaughan, J., Baumgard, L., & Prasad, C.S (Eds.), 51-60. New Delhi, India, Springer-VerlagGMbH

Giridhar, K, & Samireddypalle, A. (2015). Impact of climate change on forage availability for livestock. In climate change impact on livestock: Adaptation and mitigation.Sejian, V., Gaughan, J., Baumgard, L., & Prasad, C. S. (Eds.), 97-112. New Delhi, India, Springer-VerlagGMbH

Hoffmann, I. (2008). Livestock genetic diversity and climate change adaptation. Livestock and

ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

global change conference proceeding. Tunisia

Intergovernmental Panel on Climate Change [IPCC]. (2001). Glossary of terms used in the IPCC third assessment report. Retrieved from www.ipcc.ch/glossary/index.htm

Intergovernmental Panel on Climate Change [IPCC].(2007). Contribution of working group II to the fourth assessment report of IPCC- summary for policymakers. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/wg2-spm.pdf

International Fund for Agricultural Development [IFAD]. (2010). Livestock and climate change Rome, Italy. Retrieved from https://fcrn.org.uk/sites/default/files/IFAD_LivestockPaper.pdf

International Fund for Agricultural Development IFAD. (2009). Comprehensive report on IFAD's response to climate change through support to adaptation and related actions. Rome, Italy

Koehler-Munro, R.B. & Goddard, T. (2010). Climate change and agriculture, agriculture and rural development. Government of Alberta. Retrieved from http://www.agric.gov.ab.ca/&department/deptdocs.nsf//all/cl9706

Mendelson, R, (2000). Measuring the effect of climate change on developing country agriculture. In two essays on climate change and agriculture: A developing country perspective. FAO economic and social development paper 145.Retrieved from http://www.fao.org/3/x8044e/x8044e00.htm

Naqvi, S. M. K., Kumar, D., Kalyan, D., & Sejian, V. (2015). Climate change and water availability for livestock: Impact on both quality and quantity. In climate change impact on livestock: Adaptation and mitigation. Sejian, V., Gaughan, J., Baumgard, L., & Prasad, C. S. (Eds.), 81-96, New Delhi, Springer-VerlagGMbH

Nhemachena, C. & Hassan, R. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa. (IFPRI Discussion Paper No. 00714). Washington DC, USA: International Food Policy Research Institute (IFPRI), Environmental and Production Technology Division

Onyeneke, R.U., & Madukwe, D.K. (2010). Adaptation measures by crop farmers in the southeast rainforest zone of Nigeria to climate change. *Science World Journal*, *5*(1), 32-34. Retrieved from http://www.scienceworldjournal.org

Pittock, B. & Jones, R.N. (2000). Adaptation to what and why? Climate impacts group CSIRO atmospheric research, Australia. *Environmental Monitoring and Assessment*, *61*(1), 9-35. doi.org/10.1023/A:1006393415542

Rosegrant, M.W. Ewing, M, Yohe, G. Burton, I., Huq, S. & Valmonte-Santos, R. (2008).Climate change and agriculture: Threats and opportunities. Deutsche Gesellschaft fur TechnischeZusammenarbeit (GTZ). Climate protection programme for developing countries. Federal Ministry for Economic Cooperation and Development, Germany

Sahel Capital Partners & Advisory Limited. (2015). An assessment of the Nigerian poultry sector, 15. Nigeria, Lagos. Retrieved from http://sahelcp.com/wp-content/uploads/2016/12/Sahel-Newsletter-Volume-11.pdf

Sejian, V., Bhatta, R., Soren, N. M., Malik, P. K., Ravindra, J. P., Prasad C. S., & Lal, R. (2015). Introduction to concepts of climate change impact on livestock and its adaptation and mitigation. In climate change impact on livestock: Adaptation and mitigation. Sejian, V., Gaughan, J., Baumgard, L., & Prasad, C. S. (Eds.), 1-26, New Delhi, India, Springer-VerlagGMbH

Sejian, V., Bhatta, R., Soren, N. M., Malik, P. K., Ravindra, J. P., Prasad C. S., & Lal, R. (2015). Introduction to concepts of climate change impact on livestock and its adaptation and mitigation. In climate change impact on livestock: Adaptation and mitigation. Sejian, V., Gaughan, J., Baumgard, L., & Prasad, C. S. (Eds.), 1-26, New Delhi, India, Springer-VerlagGMbH

ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

Sejian, V., Gaughan, J. B., Bhatta, R., & Naqvi, S. M. K. (2016).Impact of climate change on livestock productivity.1-4, New Delhi, India, Springer-VerlagGMbH

Sejian, V., Gaughan, J. B., Bhatta, R., & Naqvi, S. M. K. (2016).Impact of climate change on livestock productivity.1-4, New Delhi, India, Springer-VerlagGMbH

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R.J.T. & Yohe, G. (2001). Adaptation to climate change in the context of sustainable development and equity. In McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J.,& White, K.S. (Eds.),climate change 2001: Impacts, adaptation, and vulnerability – The contribution of working group II to the third scientific assessment of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Thompson, H. E., Berrang-Ford, L. & Ford, J.D. (2010). Climate change and food security in sub-Saharan Africa: A systematic literature review. *Sustainability, 2*(8), 2719-2733. Retrieved from: https://doi.org/10.3390/su2082719

Thornton P., Herrero, M., Freeman, A., Mwai, O., Rege, E., Jones, P., & McDermott, J. (2008).Vulnerability, climate change and livestock – Research opportunities and challenges for poverty alleviation. ILRI, Kenya

World Bank Group. (2021). Climate risk profile: Nigeria. Retrieved from: www.worldbank.org