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Effect of Climate Change on Fish Production in Nigeria

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ABSTRACT

Climate change is an important factor that affect both the production of crops and animals. This is so particularly in Africa and developing countries where agricultural production depends on the vagaries of nature. This study examined the effect of climate change on fish production in Nigeria (1960 – 2016). The specific objectives were to estimate the trend in fish production for the period and to examine the long run relationship between fish production and climatic, and other economic variables. Secondary data on climatic factors such as carbon dioxide, rainfall, relative humidity, and temperature were obtained from the Nigerian Meteorological Agency while data on fish output, price of fish, amount of loan obtained and inflation rate were sourced from publications of Food and Agriculture Organization Statistics (FAOSTAT), Central Bank of Nigeria, National Bureau of Statistics and Federal Department of Fisheries. The trend in fish production was estimated using trend analysis while the Autoregressive Distributed Lag (ARDL) model - Bounds testing methodology was used to examine the long run relationship between fish production and climatic variables. The result of trend analysis showed that the coefficient of fish production has a positive coefficient of 15373.07 implying an increasing trend. The result of the ARDL model revealed that carbon dioxide, temperature and price with coefficients of 0.467, 3.328 and 1.271 respectively had a positive and significant long run effects on the quantity of fish produced while rainfall and inflation rate with coefficients of 0.836 and 8.658 respectively showed a negative and significant long run effect on the fish output for period under study. Findings from the study clearly indicated that an increase in some climatic factors directly influence the output of fish in the country. We recommend that fish production in controlled environment and price stability would boost fish output.

Key Words: Climate Change, Fish Production, ARDL Model, Long-run, Short-run

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) defined climate change as statistically significant variations in climate that persist for an extended period, typically decades or longer. It is widely accepted as that unavoidable consequence of 200 years of greenhouse gas emissions from fossil fuel, transport, industry, deforestation and intensive agriculture (IPCC, 2007). According to Eboh (2009) climate change will result in changes in the frequency and intensity of drought, flooding, water shortages, worsening of droughts, worsening soil conditions, desertification, disease and pest outbreaks on crops and livestock.

The relationship between climate change and fish production are interwoven. The influence of climatic variables on fish production could be either positive or negative on natural resources depending on the extremity of the shift in the climate elements. The frequency and intensity of extreme climate events will adversely affect fish production either inland or marine system (Brander 2008). These effects occur both directly, due to inherent sensitivities of marine organisms to changing environmental conditions, and/or indirectly through the influence of climate change on the habitats that support fish or the pathogens that can control their abundance (FAO, 2012; Brander, 2010). Climate change may lead to extinction and loss of biodiversity. Changes in temperature affect reproductive success, recruitment processes, survival and growth of target species and/or their prey. With increased global temperature, the spatial distribution of fish stocks might change due to the migration of fishes from one region to another in search of suitable conditions (Mohanty *et al.*, 2010). The economic consequences of climate change on fisheries might manifest themselves through changes in the price and value of catches, fishing costs, fishers' incomes, earnings to fishing companies, discount rates and economic rent (that is, the surplus after all costs, including 'normal' profits, have been covered), as well as throughout the global economy (Sumaila *et al.*, 2011).

The Third assessment report of IPCC (2001) stated that the poorest countries are more vulnerable to the risk of climate change. Available evidence show that climate change will be global, likewise its impacts, but the biting effects will be felt more by the developing countries, especially those in Africa, due to their low level of coping capabilities (Nwafor, 2007; Jagtap, 2007). Watson (1997) stated that African countries are particularly vulnerable to climate change because of their dependency on rain-fed agriculture, high levels of poverty, low level of human and physical capital, inequitable land distribution and poor infrastructure. Nigeria is one of such developing countries. Researchers have shown that Nigeria is already being plagued with diverse ecological problems, which have been directly linked to the on-going climate change (Odjugo and Ikhuoria, 2003; NEST, 2003; Mshelia, 2005; Ayuba *et al*., 2007).

The importance of fishery subsector to the world and the Nigerian economy cannot be overemphasized. The global fisheries sector supports the livelihood of between 660 - 820 million people directly or indirectly approximately 10 - 12% of the world population (FAO, 2014). Fish is very important in the diet of many Nigerians, high in nutritional value with complete array of amino acid, vitamins and minerals (Akinrotimi *et al.,* 2007).

The annual fish demand in Nigeria is estimated at about 3.32 million metric tons but domestic production is only about 1.12 million metric tons leaving a deficit of 2.2 million metric tons, which is largely supplied through fish importation (NFSR, 2016). This means there is demand-supply gap of fish in Nigeria. This situation has left the general populace in sub-optimal protein consumption. Empirical studies on climate change in Nigeria focused primarily on the effect of climate change on agricultural productivity in general (see Ayinde *et al*., 2011; Aondoakaa, 2012; Ajayi and Pritee, 2013; Akintola, *et al*., 2015; among others) and in cases crop production in particular (see Adejuwon, 2004; Sowunmi and Akintola, 2010; Nwalieji and Uzuegbunam, 2012; Akinbile, 2015, among others). Quantitative empirical studies that focuses on the effect of climate change and fish production in Nigeria are scanty. Most of the studies on climate change and agricultural production used the ordinary least squares (OLS) regression analysis and Johannsen co-integration. This study used the ARDL approach which does not require that the variables must be integrated of the same order. In other words, the ARDL model incorporates variables that are integrated at order zero [I (0)] and order one [I (1)] to estimate the long-run relationship between the variables. It is against this backdrop that this study is carried out to examine the influence of climatic and other economic variables on fish production and to determine the short run and long-run effect of climatic factors on fish production in Nigeria from 1970- 2016.

2. MATERIALS AND METHODS

This study was conducted in Nigeria. The country is located between latitude 07^o to 14^oN and longitude 03^o and 15^oE with a land area of about 923,768 km^2 and a population of about 200 million. The country is blessed with many water bodies notably rivers Niger and Benue.

This study used secondary data collected over a period of 57 seven years (1960 – 2016) based on data availability as at the time of study. Data on climatic factors such as carbon dioxide, rainfall, relative humidity, and temperature were obtained from the Nigerian Meteorological Agency while data on fish output, price of fish, amount of loan obtained and inflation rate were sourced from publications of Food and Agriculture Organization Statistics (FAOSTAT), Central Bank of Nigeria (CBN), National Bureau of Statistics (NBS) and Federal Department of Fisheries.

The trend in fish production was analyzed by using trend growth model formulated by Robert and Trevor (1956). The Trend equation was estimated with time as the explanatory variable specified as follows:

$$Y_i = \beta_0 + \beta_1 T_i + \varepsilon_i \quad \ldots\ldots 1$$

Where: $Y_i =$ Fish output; T_i = Time (year); $\beta_0 =$ Intercept; $\beta_1 =$ coefficient; $\varepsilon_i =$ Error term.

The Autoregressive Distributed Lag (ARDL) model - Bounds testing methodology was used to estimate short and long-run effect of climatic and some economic factors on fish production. An autoregressive distributed lag (ARDL) model is an ordinary least square (OLS) based model which is applicable to times series data with mixed order of integration (Pesaran and Shin, 1999). In addition, the short run and long effects can be estimated simultaneously from a data. The ARDL Model produces consistent coefficients despite the possible presence of endogeneity because it includes lags of Dependents and independent variables.

The Augmented Dickey-Fuller (ADF) test was used to test for stationarity of each of the variables. A variable Y, is said to be integrated of order d, [I (d)] if it attained stationarity after differencing d times (Engle and Granger, 1987). In ADF the null hypothesis H_0: P_1 = 0 (p1 ~ I(1)) is tested against the alternate H_a : P_1 < 0 (p1~ I(0)). An ADF value with less than its critical value shows that the underlying series is non-stationary. Contrarily, an ADF value that is greater than its critical value shows that the underlying series is stationary.

In specifying an ARDL model, one must determine the maximum number of lags for each variable included in the model. The usual procedure for doing this is by using Akaike, Schwarz and Hannan-Quinn information criteria. The automatic lag selection option in E-views 9 was used to select the optimal lag in this study. The ARDL model is expressed as follows:

$$\Delta lnQ = Q_0 + \sum_0^p Q_1 \Delta lnQ_{t-i} + \sum_0^p Q_2 \Delta lnLN_{t-i} + \sum_0^p Q_3 \Delta lnPR_{t-i} + \sum_0^p Q_4 \Delta lnCO2_{t-1} + \sum_0^p Q_5 \Delta lnRF_{t-i} + \sum_0^p Q_6 \Delta lnRH_{t-i} + \sum_0^p Q_7 \Delta lnT_{t-i} + \sum_0^p Q_8 \Delta lnINF_{t-i} + \beta_1 lnQ_{t-1} + \beta_2 lnLN_{t-1} + \beta_3 lnPR_{t-1} + \beta_4 lnCO2_{t-1} + \beta_5 lnRF_{t-1} + \beta_6 lnRH_{t-1} + \beta_7 lnT_{t-1} + \beta_8 lnINF_{t-1} + u_t \quad \ldots\ldots 2$$

If one co-integrating vector (that is the underlying equation is identified, the ARDL model is re-parameterized into error correction model (ECM). The re-parameterized result gives short-run dynamics (i.e. .traditional ARDL) and long-run relationship of the variables of a single model. The re-parameterization is possible because the ARDL is a dynamic single model equation and of the same form with the ECM. Distributed lag Model simply means the inclusion of unrestricted lag of the regressors in a regression function. The model is specified as follows:

$$\Delta lnQ = Q_0 + \sum_0^p Q_1 \Delta lnQ_{t-i} + \sum_0^p Q_2 \Delta lnLN_{t-i} + \sum_0^p Q_3 \Delta lnPR_{t-i} + \sum_0^p Q_4 \Delta lnCO2_{t-1} + \sum_0^p Q_5 \Delta lnRF_{t-i} + \sum_0^p Q_6 \Delta lnRH_{t-i} + \sum_0^p Q_7 \Delta lnT_{t-i} + \sum_0^p Q_8 \Delta lnINF_{t-i} + \delta ecm_{t-1} + u_t \quad \ldots\ldots 3$$

Where: Q = Fish output; *LN* = loan*;* Pr = price of fish*;* $C0_2$ = carbon dioxide*; RF* = rainfall; *RH* = relative humidity; *T* = temperature INF = inflation rate; Q_0 = constant; u_t = error term; $Q_1 - Q_8$ = short-run elasticities; ecm_{t-1} = error correction form; δ = Speed of adjustment; Δ = First difference operator; *ln* = Natural logarithm; P = lag length.

The Bounds test is used to test for the existence of long-run relationship between the dependent and the explanatory variables. The Bounds test is based on F-test carried out on the joint null hypothesis that the coefficients of the lagged variables are zero (H_0: $\delta 1 = \delta 2 = \delta 3 \ldots \delta k = 0$) against the alternative hypothesis (H_1: $\delta 1 \neq \delta 2 \neq \delta 3 \ldots \delta k \neq 0$).

The distribution of F-test is non-standard and involves asymptotic critical value bounds, depending whether the variables are I (0) or I (1) or a mixture of both. Consequently, two sets of critical values are produced. One set is related to the I(1) series which is called upper bound critical values and the other refers to the I (0) series that is called lower bound critical values. If the F- test statistic exceed supper critical values, it means that there is long-run relationship between the variables regardless of the order of integration of the variables. If the test statistic is less than the upper critical value, the null hypothesis of no co-integration cannot be rejected and if it lies between the bounds, a decision cannot be made without knowing the order of integration of the underlying regressors.

RESULT AND DISCUSSION

The descriptive statistics of the variables used in the study are presented in Table 1.

Table 1: Descriptive statistics of the variables (1960 -2016)

Variable	**Obs.**	**Mean**	**Std. Dev.**	**CV**	**Minimum**	**Maximum**
Fish output(MT)	57	392243.9	282772.2	0.72091	55010	1171644
Loan	57	4542019	16621811	3.65956	227.5	93332484
Price/kg of fish	57	177.875	248.1698	1.39519	0.693793	737.5301

Carbon dioxide	57	52636.08	28421.14	0.53996	3406.6	104696.5
Rainfall	57	103.121	19.92388	0.19321	19.92388	150.1
Relative Humidity	57	33.35307	10.24323	0.30712	19.20000	51.80000
Temperature	57	25.6702	3.316241	0.12919	14.7	34.4
Inflation rate	57	16.74842	16.31477	0.97411	0.880000	72.81000

Source: Author's computation, 2019

Note: CV = Coefficient of Variation, Std. Dev. = Standard Deviation and Obs. = Observation

3.1 Trend in Fish Production

The trend equation for fish production is given as: $Output = -53305.45 + 15373.07\,t$ while the graph is presented in Figure 1. The positive coefficient shows an increasing trend line in fish output over the years. This result is in consonance with Oyibo *et. al.*, (2013) who reported that there has been an increase in fish production over the years with fluctuations but demand – supply gap (fish deficit) rising much faster than the growth in fish production.

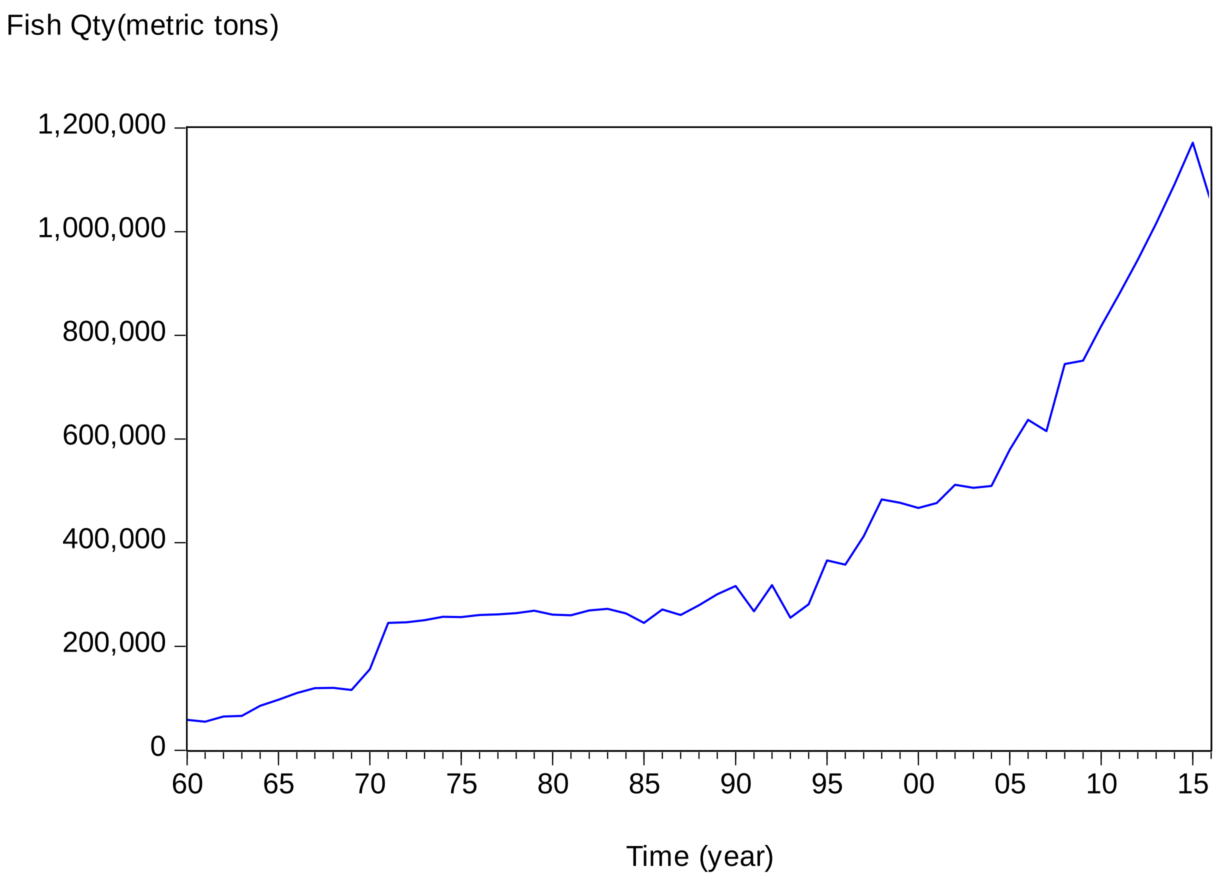

Figure 1: Trend Graph of Fish Output Over Time in Nigeria

3.3 Short and Long-run effect of Climate change on Fish Production

The short and long –run effect of climate change on fish production in Nigeria for the period (1960 – 2016) was estimated using the ARDL - Bounds testing methodology. The results of the Augmented Dickey – Fuller unit root test is presented in Table 2.

Table 2: Result of Augmented Dickey-Fuller (Unit root) test

Variable	T-statistic	Critical value	Level of Significance	Order of integration
lnFish	-7.4205	-3.5550	1%	I(1)
lnLN	-4.0413	-3.5713	1%	I(0)
lnPR	-4.3549	-3.5550	1%	I(1)
$lnCO_2$	-3.0583	-2.9145	5%	I(0)
lnRF	-2.7357	-2.5986	10%	I(0)
lnRH	-8.2027	-3.5575	1%	I(1)
lnT	-3.8584	-3.5550	1%	I(0)
lnINF	-3.8042	-3.5527	1%	I(0)

Source: E-Views 9

Results in Table 2 revealed that $lnCO_2$, lnLN, lnRF, lnT and lnINF were stationary at level and therefore integrated at I(0) while lnFish , lnPR and lnRH became stationary after their first difference and are therefore integrated at I(1). This means that the variables are a mixture of I (0) and I (1). .

Table 3: ARDL Bounds Test for Co-integration

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	1.92	2.89
5%	2.17	3.21
2.5%	2.43	3.51
1%	2.73	3.9
F-statistic	4.983	

The results of Bounds test for co-integration as presented in Table 3 revealed that the F-Statistic (4.983) is greater than the upper bound value (3.9) at 1% significance level. So, we reject the null hypothesis and accept the alternative hypothesis that the coefficients are statistically different from zero, that is, there the four variables have long run association. So we proceeded to examine the long run relationship between the variables. The automatic option was used to select a lag length of 1 for the dependent variable (lnFish) and 2 for lnPR and lnRF respectively while a lag length of 4 was selected for lnLN, lnCO2 and lnRH. Finally, a lag length of 3 was selected for lnT and lnINF respectively.

The ARDL co-integrating equation is presented below while the long-run coefficients is presented in Table 5.

$$cointeg = LNFISH - (-0.0800 * LNLOAN + 1.2710 * LNPRICE + 0.4673 * LNCO_2 - 0.8358 * LNRAINFALL + 0.8904 * LNRH + 3.3279 * LNTEMP - 8.6576 * LNINF + 27.5032$$

Table 4: Estimated long-run coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNLOAN	-0.08	0.11948	-0.6697	0.51
LNPRICE	1.27103	0.63134	2.01322	0.0565
LNCO2	0.46729	0.20767	2.25013	0.0348
LNRAINFALL	-0.8358	0.40393	-2.069	0.0505
LNRH	0.89036	0.52702	1.68945	0.1053
LNTEMP	3.32793	1.74593	1.90611	0.0698
LNINF	-8.6576	3.68544	-2.3491	0.0282
C	27.5032	7.48277	3.67554	0.0013
R^2 = 0.771264	Adj. R^2 =0.459	F-stat.= 2.47	Prob. (F-stat) = 0.0156	DW= 2.18

Source: Eviews 9

From Table 4, ecm (-1) is the speed of adjustment towards long-run equilibrium and it is negative and significant. This means that the system is getting adjusted towards long-run equilibrium at the speed of 44.79 percent.

The long-run coefficients as presented in Table 5 revealed that price, CO_2, relative humidity, temperature had a positive long run effect on the output of fish within the period under review while loan, rainfall and inflation showed a negative long run effect on fish output. The variables (price, Co_2, rainfall, temperature, inflation) significantly influence fish output for the period under review.

4. SUMMARY AND CONCLUSION

This study utilized secondary data on climatic and economic factors from 1960 – 2016 to estimate the trend in fish production and the long-run effect of climatic and economic factors on fish production in Nigeria. The results of trend analysis revealed that the coefficient of fish production (15373.07) has a positive coefficient indicating an increasing trend in fish production. The result of the ARDL model revealed that carbon dioxide, temperature and price with coefficients of 0.467, 3.328 and 1.271 respectively had a positive and significant long run effects on the quantity of fish produced while rainfall and inflation rate with coefficients of 0.836 and 8.658 respectively showed a negative and significant long run effect on the fish output for period under study. Relative humidity showed a positive but insignificant positive long-run effect on fish output in Nigeria. The coefficient of amount of loan obtained showed a negative and statistically insignificant relationship with fish output. Findings from the study clearly indicated that climatic factors have a mixed effect on the output of fish in the Nigeria. We recommend production of fish in confined environments where the effect of climate change can be controlled.

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