INFLUENCE OF CLIMATE CHANGE ON FISH PRODUCTION IN NIGERIA: CO-INTEGRATION APPROACH (2000-2022)

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ABSTRACT
The study examined the Influence of Climate change on Fish Production in Nigeria. Secondary data were used and analyzed with both descriptive and inferential statistics. The result showed that climatic factors did not exhibit a stable trend during the period under review, but rather various patterns of instability in the trend were observed for all climatic factors considered for the study. Additionally, temperature, relative humidity, and CO_2 have statistically significant effects on fish production in Nigeria, whereas rainfall and sunshine do not. Furthermore, the study reports a growth rate of 4.38% for fish output. Therefore, it was recommended that the country should intensify efforts aimed at reducing the global temperature increase. Such policies as encouraging technologies that reduce temperature increase.

Keywords: Climate change, fish output, influence

INTRODUCTION
In Nigeria, the fisheries sector makes a significant contribution to the economy, providing employment opportunities for over 7 million people and accounting for 4.4% of the national GDP. Additionally, they ensure nutritional enhancement by supplying the nation with more than 85% of its total animal protein intake for the entire population (Oyebanji et al., 2021). The fish industry is involved in both small and large-scale fish farming (pisciculture) and the catching of fish (fisheries) for human consumption. However, as noted by Alo (2017), this vital industry has been severely impacted by the debilitating effects of climate change. Factors such as temperature variations, Changes in rainfall patterns, and a rise in sea levels have led to a perceptible decline in fish production in the Nigerian sector.

When there are variations in temperature, water temperature changes occur, which have a negative impact on fish abundance and diversity. Analyzing the influence of climate on temperature, it has been observed that rising temperatures can directly impact the biological processes of fish, including metabolism, growth, reproduction, and survival. Additionally, there is a reduction in the availability of oxygen in the water (hypoxia), which promotes the growth of harmful algal blooms, leading to fish diseases and a high mortality rate. Furthermore, a rise in sea temperatures leads to coral bleaching, which consequently escalates the fish mortality rate due to habitat loss (Béné *et al.,* 2016). According to Babawale (2020), there has been an average increase in temperature in Nigeria of 1.1°C since the 20th century, which has a direct impact on fish species acclimated to certain thermal conditions, leading to a decline in fish stocks.

Similarly, alteration in precipitation intensely affects fish production. Excessive rainfall can lead to hazardous flooding, while inadequate rainfall can result in droughts, both of which can trigger unfavorable outcomes for fisheries. Severe events, such as floods, can destroy fish habitats, thereby reducing the populations of these fish. Adeosun *et al.* (2020) noted that fish production in Nigeria has been in decline due to lower rainfall rates, resulting in severe water shortages that have demoralized local fisheries in the Benue and Niger River catchments. Furthermore, due to global warming, the occurrence of floods and droughts has been exacerbated with a significant increase. Overflooding can raze fish farms and lead to the migration or death of fish, while harsh drought conditions may result in a lack of essential water for aquaculture activities. Both scenarios perpetually lead to a decrease in fish production (Anyanwu *et al.,* 2019).

The rise in sea level is a comprehensive concern for Nigeria's coastal areas. Coastal erosion, saline water intrusion, and loss of crucial mangrove habitats are all consequences, have an adverse effect on fish species (Nwilo & Badejo, 2018). Recent studies have shown that sea levels in Nigeria have been rising at approximately 3.1 mm per year (Alo, 2018), precipitating severe consequences for the fisheries sector.

Furthermore, fish production is influenced by climate change through ocean acidification, a direct consequence of increased CO2 emissions. It subsequently affects shellfish's calcification processes due to raised levels of acidity, having a negative impact on their overall productivity (Fabry *et al.,* 2008). Ocean acidification can affect shell-forming species and disrupt the food chain, impacting fish survival and growth.

Additionally, climate change aggravates the increase of harmful algal blooms, which produce toxins harmful to fish. An increased algal bloom results in a scarcity of dissolved oxygen in water bodies, which is a concern for fish survival and reflects a deeper, systemic ailment associated with climate change (Farmer *et al.,* 2020).

The most damning consequence of climate change is global warming, signaled by an increase in the Earth's average temperature due to the rise in greenhouse gases. A plethora of recent studies, including a UNDP report (2018), have highlighted its impending disaster, as it disrupts ecological balance and instigates drastic shifts in environmental weather patterns. These are some of the direct ways climate change impacts fish production.

The devastating consequences of climate change on agriculture and fishery production have propelled its relevance, which has gradually replaced the hitherto widespread negligence. The Nigeria scenario presents a quintessential case study. A country that is heavily reliant on the fisheries sector for livelihood, sustenance, and income provision and drawing upon numerous recent studies, it becomes clear that climate change has indeed fostered detrimental effects on both the quantity and quality of fish production.

The sector is crucial for global food security, accounting for approximately 20% of animal protein intake and serving around 3.3 billion people worldwide (FAO, 2020). In the face of climate change, fish production, particularly in developing tropical nations, is likely to become increasingly challenging due to shifts in species distribution, rising water temperatures, and ocean acidification.

Nigeria, the most populous nation in Africa, relies heavily on fish production as a primary source of animal protein for its growing population, job creation, and as a significant contributor to the national GDP. Nigeria's annual fish requirement stands at 3.6 million metric tonnes, but the actual yearly fish production, spanning across marine, brackish water and freshwater fisheries, is only about 1.1 million metric tonnes (FMARD, 2020). Nigeria's distinct marine and inland water ecosystems, which house an impressive array of fish species, are now threatened by changing climatic conditions. The Nigerian Institute for Oceanography and Marine Research (NIOMR, 2021) has recently noted that climate change-induced sea-level rise could have catastrophic effects on Nigeria's marine fish production.

Nigeria regularly experiences erratic rainfall patterns, causing significant fluctuations in river flow rates. This severely affects migratory fish species, which depend on stable rainy seasons for spawning and feeding. Furthermore, increased temperatures lead to heat stress in fish, which reduces growth rates and increases susceptibility to diseases (National Climate Assessment, 2016). The impacts also extend to aquaculture, or fish farming, which contributes approximately 48% of Nigeria's total fish production (FMARD, 2020). Reduced water availability due to changing rainfall patterns and increased evaporation rates could limit the potential for pond farming. Additionally, higher water temperatures can exacerbate challenges related to fish diseases and reproduction, resulting in lower yields.

These changes in climatic factors may lead to corresponding changes in fish production. Despite the existence of several previously conducted studies, such as Barange *et al.* (2018), which examined the impact of climate change on fisheries and aquaculture, Sahya et al. (2021) studied the Effects of Climate Change on aquaculture production, including sustainability implications, Mitigation, and adaptation. Similarly, Ipinjolu *et al.* (2014) determined the Potential Impact of Climate Change on Fisheries and Aquaculture in Nigeria, while Huang *et al.* (2021) reported the impacts of climate change on fish growth, summarizing the findings of conducted studies and current knowledge. There has been no known study that focused on examining the influence of climatic factors alone on fish production in Nigeria. This study, therefore, seeks to fill that gap by addressing the following research objectives. The primary objective of the study was to investigate the impact of climate change on fish production. However, the study sought to specifically address describe the trend of climatic factors, estimate the average fish output, and climatic parameters from 2000- 2022 and examine the influence of climate change on fish production in the study area from 2000-2022.

REVIEW OF RELATED LITERATURE

Average Fish Production in Nigeria

The estimated annual average per capita fish consumption for Nigeria is 13 kg, although Osei et al. (2023) reported a lower estimate of 8.33 kg. Odioko and Becer (2022) report on the Nigerian fishery sector, showing that between 2015 and 2020, 6,861,700 metric tonnes of fish were produced (Figure 1). In the same report, the fishery sector tends to have done better in 2017, with the highest tonne of fish produced of about 1,212,480 tonne, which comprised 17.67% of the total tonne of fish produced within the years in consideration; the second-highest tonne of fish produced was recorded in 2020, while the least was recorded in 2015 (Odioko and Becer, 2022).

Fisheries involve all the activities involved in producing fish and other aquatic resources for the basic purpose of providing human food, although other aims are possible (such as sport or recreational fishing) or obtaining ornamental fish or fish products such as fish oil. Over 10% of the world's population is economically dependent on fisheries as a source of employment, with the majority being women (Odioko and Becer, 2022). The world population is currently over 7.8 billion, with a projected increase of about 25% over the next 30 years, reaching 9.9 billion by 2050 (Population Reference Bureau, 2021).

While the global population is projected to increase by 25% by 2050, Nigeria's population is projected to be 401.3 million (a 99.82% increase) by 2050 (Population Reference Bureau, 2021). This rapid increase in Nigeria and the world population in general has led to high competition for natural resources, especially food resources. To achieve global food security, the fisheries and aquaculture sector has been identified as a crucial sector (Action, 2020). Fishery production is significant to the Nigerian economy, given its importance in providing a cheap source of food and nutrition security, generating income, creating employment opportunities, and serving as a source of foreign exchange, particularly among riverine communities (Odioko and Becer, 2022).

The fisheries sector contributed 1.09% of the country's total GDP in 2020 and 0.9% in the third quarter of 2021 (Odioko and Becer, 2022). In 2020, the county spent over $876,081,485.00 on the importation of frozen fish (excluding fish fillets and other fish meat) and generated only $106,964.00 in exports (TrendEconomy, 2021). It is not a hidden fact that fish is a major source of animal protein in the diet of most Nigerians, especially those living in rural areas. According to the Nigerian Minister of Agriculture and Rural Development, Nigeria's total fish production is estimated at 1.123 million metric tonnes, with marine catches accounting for 36 percent, inland water catches for 33 percent, and aquaculture catches for 31 percent (Odioko and Becer, 2022). In 2021, the Nigerian Ministry of Agriculture and Rural Development estimated the country's fish demand at 3.6 million metric tonnes, of which it only meets approximately 31.19%, relying on importation to bridge the significant gap of about 68.80% (Odioko and Becer, 2022).

Fish Demand and Supply

According to Odioko and Becer (2022), Nigeria produces approximately 600,000 metric tonnes of fish annually from aquaculture and capture fisheries; however, the country's fish supply shortfall is around 900,000 metric tonnes. Akinsorotan *et al.* (2019) reported a shortfall of approximately 1.3 million metric tonnes in Nigeria's fish supply. Although WorldFish (2018) put the domestic production of fish in Nigeria at 1 million metric tonnes, there is a shortfall of about 800,000 metric tonnes. Nigeria's top supplier of fish and fish products in Africa in 2020 was Mauritania, with a supply worth $53.3 million tonnes (Odioko and Becer, 2022).

From 2006 (2,660,000 metric tonnes) until 2014 (3.420,000 metric tonnes), the demand for fish grew consistently by 3 percent (Busari and Ayanboye, 2022). However, in 2015, the demand fell to about 140,000 metric tonnes. The projected demand for fish was expected to continue growing from 3,280,000 metric tons (mt) in 2016 to 4,515,000 mt in 2025, an increase of almost 38%. The average anticipated demand for fish is 3,488,050. Starting in 2006, the average annual growth rate of the anticipated fish production was 3.19 percent (Busari and Ayanboye, 2022). There were 1,954,116 mt in total supplies on average. According to Oparinde (2019), the demand-supply gap is expected to be 1,533,934 MT yearly between 2006 and 2025.

According to Chan *et al.* (2019), analysis of the global aquaculture demand-supply gap, the trend growth in freshwater and diadromous finfish farming would result in 13.8 million metric tonnes of supply growth, which accounts for 87 percent of the 15.8 million metric tonnes of demand growth driven by the level of income and population growth. This would leave a 2 million tonne demand-supply gap.

The supply of freshwater and diadromous fish is expected to occur in 34 countries worldwide, as the trend increase in these industries in 150 nations would not be sufficient to meet the growing demand. Countries with relatively large freshwater and diadromous fish demand-supply gaps (greater than 100,000 metric tonnes) include the following, in ascending order: Uganda in Africa, the United States of America in the Americas, Thailand, the Philippines, Bangladesh, Myanmar, India, and China in Asia (Action, 2020).

METHODOLOGY

The study area is Nigeria, located in the West African region, bounded by Niger and Chad to the North, Cameroon to the east, and the Benin Republic to the south-western region of the country. Nigeria is famously the most populous nation in Africa, with an estimated population of approximately 229,152,217 as of 2024 (NPC, 2024) and is renowned for its rich and diverse cultural heritage. It is considered a great nation blessed with abundant natural and human resources.

Nigeria spans an area of approximately 923,768 square kilometers, with a coastline of about 853 kilometers bathed by the Atlantic Ocean. This naturally occurring resource bestows the country with an opportunity to harness the potential of both freshwater and saltwater fishing, contributing significantly to national fish production. Some Nigerian states located along the coastline are Akwa Ibom, Bayelsa, Cross River, Delta, Ogun, Ondo, Lagos, and Rivers States.

The geographical positioning of Nigeria is indeed a strategic one. Bordering the Gulf of Guinea, the country encompasses a portion of the rich fishing grounds of the Atlantic Ocean. Nigeria's coastline is also surrounded by a lush region endowed with mangrove swamps, lagoons, and estuaries, which provide optimal conditions for marine fish cultivation. Further inland, Nigeria boasts of a diverse topographical construction extending from mangrove forests and swamps in the south to the Sahel savannah in the far north. This variance is marked by fertile plains, forested hills, and a series of rivers, including the Niger and Benue, the country's longest rivers, and their multiple tributaries.

The study utilized secondary data on climatic parameters, including temperature, rainfall, sunshine, relative humidity, CO_2 emissions, and average fish output, spanning a total period of twenty-two years (2000-2022).

Time series data on the trends of various climatic parameters and fish production, measured in their respective standard units, were sourced from secondary sources. Data for the study were sourced from the Food and Agriculture Organization statistics (FAOSTAT), the Central Bank of Nigeria, the National Bureau of Statistics, and the Federal Department of Fisheries.

The study utilized both descriptive and inferential statistics to achieve its objectives. Objective (i) was achieved through trend analysis, utilizing mean, frequency, percentages, and graphical presentations of the trends of various variables during the review period. Objective (ii) was achieved using the quadratic growth rate model.

Model Specification

Trend Growth Model

The Trend equation, as stated by Robert and Trevor (1956), specified time as the explanatory variable and is stated as:

$$Y_t = \alpha + \beta_{t+e}$$

Where Y = dependent variable (fish production in metric tonnes)

t = period (Time)

α =intercept

β = slope/coefficient

e = error term

The exponential trend equation is given as:

$$Y_i = exp\ (\beta_0 + \beta_1 + e_i)$$

Where Yi = fish production output; t = time trend (years); β0 and β1 are parameters to be estimated.

The linearized form of equation (2) is;

$$Log\ Y_i = \beta_0 + \beta_1 t_1 + e_i$$

Where log Yi is the natural log of the real fish production, and other variables are as previously defined.

Quadratic Growth Model

The influence of climate change on fish production was calculated by the equation below

$$Q = \alpha + \beta x^1 + \beta x^2$$

The annual exponential or compound growth rate (g) in fish production is given as:

$$G = (e^{\beta 1} - 1) \times 100\%$$

Where e represents Euler's exponential constant = 2.71828

The existence of acceleration, stagnation, or deceleration in the climatic trend variables affecting fish production will be determined by fitting the data for the periods into quadratic equations in the time trend variables. The quadratic equation is as follows:

$$Log\ Y_i = \beta_0 + \beta_1 t_1 + \beta_2 t_2 + e_i$$

Where log Yi is the natural log of the real fish production, t is the time of trend, and β0, β1, and β2 are parameters to be estimated.

Unit Root Test

The unit root test was carried out using the Augmented Dickey-Fuller (ADF) test for unit roots. In an ADF Test, the null hypothesis states that the variable has a unit root; we reject the null hypothesis if the ADF Statistic is greater than the critical values and conclude that the variable is stationary. If the ADF Test statistic is less than the critical values. We reject the null hypothesis and conclude that variables have no unit root, therefore its stationary

$$Y_t = D_t + Z_t + \epsilon_t$$

The model can be specified as: Dt = Deterministic Component; Zt = Stochastic Component; Ɛt = Stationary Error Process.

The task of the test is to determine whether the stochastic component contains a unit root or is stationary (Bhargava, 1986).

Autoregressive Distributed lag (ARDL) Bound Testing

Autoregressive distributed lag (ARDL) bound testing procedure to examine the co-integration (long-run) relationship between fish production and its determinants. The ARDL can be used with variables of different orders of integration, regardless of whether they are I (0) or I (1). Additionally, the short-run and long-run effects can be estimated simultaneously using the data. The ARDL Model produces consistent coefficients despite the possible presence of endogeneity because it includes lags of the Dependents and independent variables

Pearsan et al (2001), the ARDL Model is expressed as an unrestricted error correction model specified as follows:

$$\boldsymbol{Q = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + e}$$

Once co-integration is established, the long-run relationship is estimated using the conditional ARDL Model specified as

lnQt= Q0+B1lnQt-1+B2lnrlt-1+B3lnTt-1+B4lncot-1+B5lnlot-1+B6lner+Ut.

The short-run effect of climatic factors on fish production from 1960-2015 was analyzed using the error correction model specified as

$$\Delta \boldsymbol{l}\text{n}\boldsymbol{Q} = \boldsymbol{Q_0} + \sum_{=1} \boldsymbol{Q_1}\Delta\boldsymbol{l}\text{nQ}_{t-i} + \sum_{=0} \boldsymbol{Q_2}\Delta\boldsymbol{l}\text{nrf}_{t-i} + \sum_{=0} \boldsymbol{Q_3}\Delta\boldsymbol{l}\text{nT}_{t-i} + \sum_{=0} \boldsymbol{Q_4}\Delta\boldsymbol{l}\text{nCO}_{t-i} + \sum_{=0} \boldsymbol{Q_5}\Delta\text{Su}_{t-i} + \sum_{=0} \boldsymbol{Q_6}\Delta\boldsymbol{l}\text{nPr}_{t-i}\delta\text{ecm}_{t-i} + \text{U}_t$$

Where Q =Fish output(kg)

Rf=rainfall

T=Temperature

Co =CO2

Pr = Precipitation

Su = Sunshine

Qo =Constant term

Ut = White Noise

Q1-Q5 = Short-run elasticicities

B1-B5 = Long-run Elasticities

Ecmt-1 = error correction form

δ = Speed of adjustment

Δ = First difference operator

ln = Natural logarithm

P = lag length.

Hypothesis Testing

The null hypothesis: There is no short-run and long-run effect of climatic factors on fish production from 2000-2022, the hypothesis was tested by means of difference (F-test)

Decision

If the F-test exceeds upper critical value, it means there is long-run and short-run relationship

RESULTS AND DISCUSSION

The trend of climatic factors and fish production in the study area from 2000-2022.

The Result of the Augmented Dickey Fuller Test is presented in Table 1.

Table 1: Result of Augmented Dickey Fuller Test

Variable	T-Statistic	Critical value	Significance level	Level/order
LFish	-7.420490	-3.555023	1% level	1(1)
LnCo2	-3.265252	-3.020686	5% level	1(0)
LnT	-3.579880	-3.029970	5% level	1(0)
LnRH	-4.205586	-3.959148	1% level	1(1)
LnSu	-3.385001	-3.020686	5% level	1(0)
LnRf	-9.436964	-3.831511	1% level	1(1)

Source: Author's computations, 2024, using E-views software 9.5

The results contained in Table 1 above show the ADF test results for the levels as well as the first differences of the variables. The results reveal that Fish output, CO2, temperature, relative humidity, sunshine, and rainfall are stationary. However, the variables exhibited stationarity at different levels. It further reveals that CO2, temperature, and sunshine remained stationary at a certain level, while fish output, relative humidity, and rainfall initially stabilized at the first difference.

Since the dependent and independent variables were stationary at different levels. Hence, the test for the existence of a long-run relationship (Co-integration) among the variables. The Autoregressive Distributed Lag (ARDL) model was used to examine the long-run relationship between the variables. Consequently, the ARDL co-integration was preferred for use.

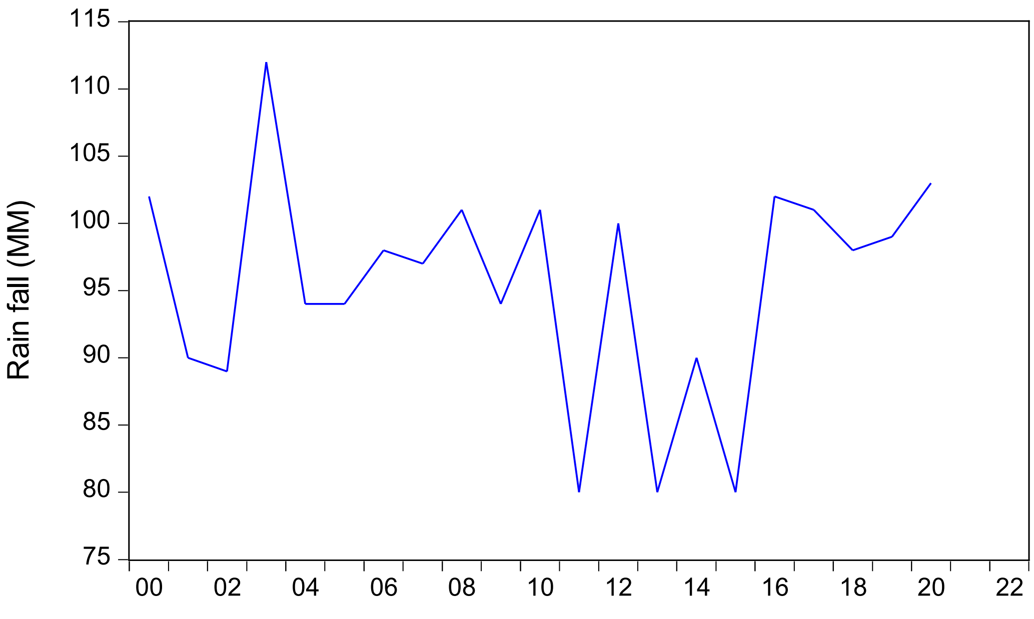

Figure 1: Trend of Rainfall

The trend equation is given as: Rainfall = 4.63 - 0.004t. The trend line has a negative coefficient, indicating that the rainfall distribution or volume in the country has been decreasing over time. The graph of mean annual rainfall shows an unstable general trend in the pattern of rainfall distribution under the study years. The highest precipitation level was recorded in 2003, while the lowest levels were in 2011, 2013, and 2015. This recent change may be linked to climate change, a global phenomenon. From 2016, there was a sharp increase in rainfall. According to Oluwasegun *et al (*2010), the estimated anomalies of the climate variables indicated that the amount of rainfall and number of wet days varied appreciably from year to year.

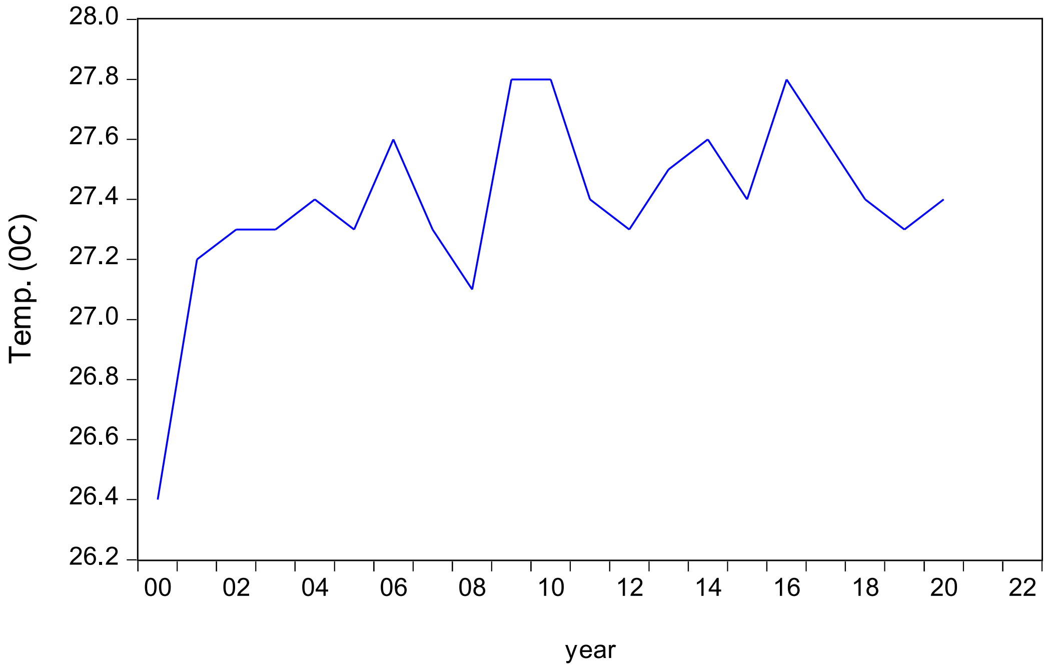

Figure 2: Trend for temperature

The trend equation for temperature is given as: Temperature = 28.40842- 0.004*t. The trend line indicates an increasing progression over the years. The graph of the mean annual temperature in the country reflects an unstable trend in Nigeria's mean annual temperature during the study period. Figure 4.5 indicates that the mean temperature in the country reached to peak in 2009. The lowest temperature was close to 26.4^{0} °C. This could affect fish production in such years. The optimal temperature for fish production was reported to be 20°C – 30^{0} °C (FAO, 2010). The trend equation is given as: 19.9213 + 0.4634t. The positive trend line indicates an increasing trend in relative humidity over the years. Relative humidity is the primary measure of atmospheric moisture, describing the degree of saturation of the air. The graph shows an upward trend in atmospheric moisture from 2000 to late 2014. This volume increased sharply within the same period, after which the country experienced an unstable level of humidity through to late 2016. A sharp decrease was experienced in 2016, followed by a stable decline.

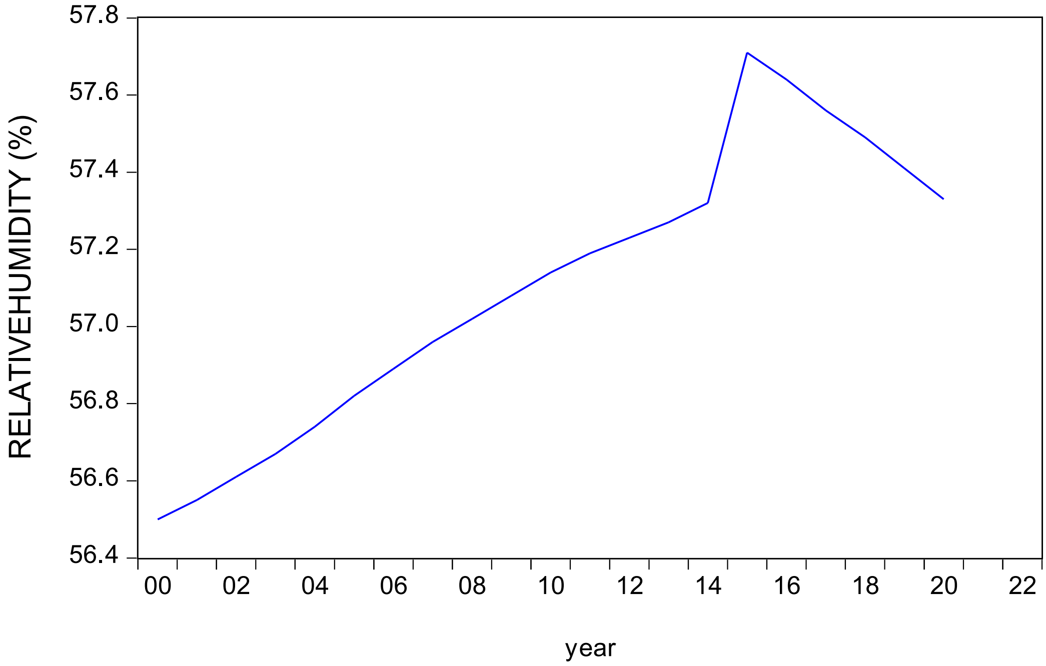

Figure 3: Trend for relative humidity

The trend equation is given as: 19.9213 + 0.4634t. The positive trend line indicates an increasing trend in relative humidity over the years. Relative humidity is the primary measure of atmospheric moisture, describing the degree of saturation of the air. The graph shows an upward trend in atmospheric moisture from 2000 to late 2014. This volume increased sharply within the same period, after which the country experienced an unstable level of humidity through to late 2016. A sharp decrease was experienced in 2016, followed by a stable decline.

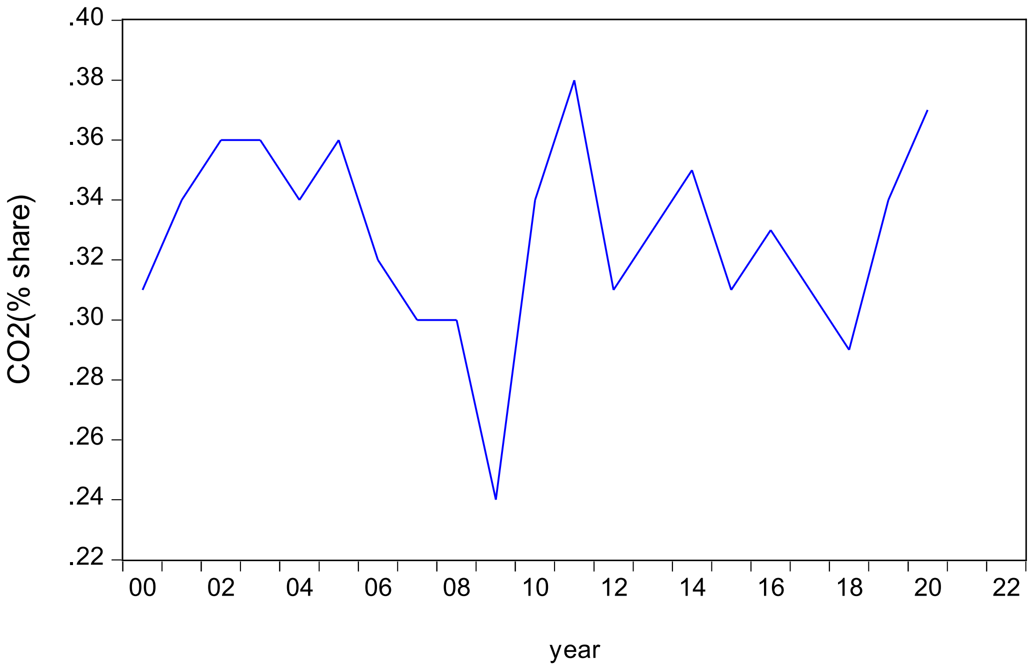

Figure 4: Trend of CO_2

The trend equation for CO_2 is given as: CO_2 = 18,309.39 + 1,184.395 t. The positive coefficient indicates an increasing trend in CO_2 emissions over the years.
Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during the consumption of solid, liquid, and gaseous fuels, as well as gas flaring. The graph of CO_2 in the country shows a significantly low level of CO_2 in the early 2000s, which persisted until 2010. The sharp decrease could be associated with government reforms and regulations regarding emissions during the Yar'Adua regime. This is followed by a sharp increase in early 2011 and a drop from 2012, to 2018., This level, although unstable, was experienced throughout the year 2012 and thus maintained an unstable trend. The volume of CO_2 in the country was at its peak in 2022. If the sharp increase in continuous fish production in the country were to be affected, high emissions could pollute the atmosphere and water bodies, with negative effects on fish quantity and quality.

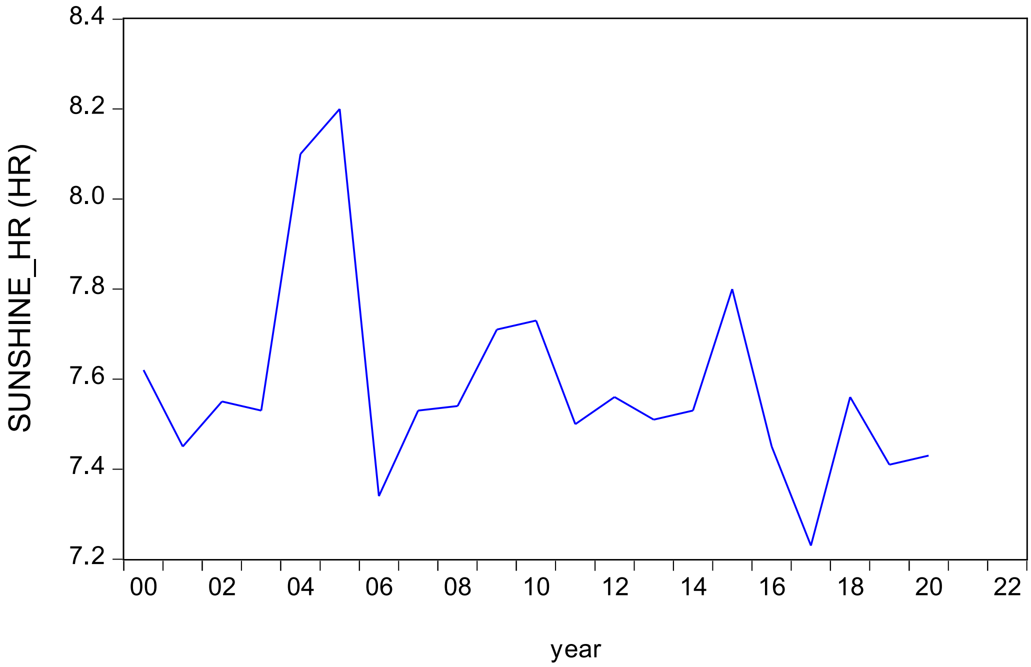

Figure 5: Trend of sunshine

The trend equation is given as: 0.32 + 0.028t. The positive trend line indicates an increasing trend in the level of sunshine over the years. A look at Figure 5 shows an unsteady change in sunshine levels, with a duration of around 7.4–7.6 hours per day from 2000 to 2001, and nearly 7 hours of sunshine per day, which rose to about 8 hours/day in 2004. A sharp decrease was observed between 2006 and however, it continued to have an unstable trend throughout.

Estimates of average fish output and climatic parameters (2000-2022)

The results of the estimates of average fish output and climatic parameters (2000-2022) and the summary statistics of variables used in this study are described in Table .2

Table 2: Summary statistics of variables analyzed in the study

Variable	Obs.	Mean	Std.Dev.	CV	Minimum	Maximum
CO_2	57	52636.08	28421.14	0.53996	3406.600	104696.5
Fish production	57	392243.9	282772.2	0.72091	55010.00	1171644.
Price/kg of fish	57	177.8754	248.1698	1.39519	0.693793	737.5301
Rainfall	57	103.1211	19.92388	0.19321	19.92388	150.1000
RLH	57	33.35307	10.24323	0.30712	19.20000	51.80000
Sunshine	57	2.295970	0.373639	0.16274	1.030000	3.130000
Temperature	57	25.67018	3.316241	0.12919	14.70000	34.40000

Source: Authors' computation,2024.

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

The coefficient of variation represents the ratio of the standard deviation to the mean. It indicates the level of instability in the variables of interest over a study period (Oni, 2000). The higher the coefficient of variation, the greater the level of dispersion around the mean. Without units, it allows for comparison between distributions of values whose scales of measurement are not comparable. From Table .2, the CV relates the standard deviation of the estimate to the value of this estimate. The lower the value of the coefficient of variation, the more precise the estimate. Table 2 shows that temperature (0.12) has the lowest CV. By implication, there was a low level of temperature instability during the study period. Furthermore, the coefficient of variation for prices and exchange rates was slightly high with values of 1.39 and 1.43, respectively. Over time, changes in these variables were more pronounced. Table 2 also shows the level of instability of fish production (supply). According to the results in Table 2, variables with higher degrees of instability (high values of the coefficient of variation) tend to exhibit more progressive movement compared to variables with a low level of instability. This is attributed to the fact that all the included variables were increasing over time.

Table 3: Influence of climate change on fish production

Variable	A	B	R^2	Growth rate
Fish output	11.3521 (176.82)***	0.0438 (22.70)***	0.9036	4.38
Rainfall	4.6251 (69.18)***	-0.0005 (-0.24) NS	0.0010	0.05
Temperature	3.3512 (95.18)***	-0.0040 (-3.77)***	0.2051	0.40
Relative Humidity	3.1116 (61.49)***	0.0123 (8.07)***	0.5423	1.23
Sunshine	0.8093 (15.71)***	0.0002 (0.14) NS	0.0003	0.02
CO_2	9.5147 (51.74)***	0.0373 (6.75)***	0.4534	3.73

Source: Author's computation, 2024

*** = Coeff. Sig. at 1%. The figures in parentheses are the t-values.

The significant climatic variables affecting fish production in the country are presented in Table 2. These variables are temperature, relative humidity, and CO_2 emission. The instantaneous (annual) growth rates, which reflect the average growth rates for a particular year, were obtained by multiplying the coefficients of the exponential trend equation in Table 2 by 100 (Gujarati, 2004). The result presented in Table 2 showed that fish production in the country recorded a positive and significant (at 1%) growth during the period under study. A growth rate of 4.38% implies that the output of fish in MT has been growing. Despite this growth rate, a demand-supply gap still exists in the fishing sub-sector. This may indicate the need for concerted efforts from all relevant stakeholders to increase local fish production. Nigeria's total annual fish demand in 2016 was estimated at 2.7 million metric tonnes (mmt). Just 30% of this demand is met domestically, resulting in huge billions of naira spent on fish imports.

The coefficient of temperature exhibited a negative and significant relationship at a 1% level, with a growth rate of 0.4%. The negative coefficient indicates a decrease in the output, specifically the growth rate of fish production, with an increase in temperature. Studies have indicated that temperature increases have a varying degree of impact on fish output, depending on the species. This finding aligns with Béné *et al.* (2016), who suggest that a rise in sea temperatures leads to coral bleaching, thereby escalating the fish mortality rate due to habitat loss.

The coefficient of relative humidity exhibited a positive and significant relationship at 1% with a growth rate of 1.23%. By implication, an increase in relative humidity, all things being equal, increases the output of fish in the country. Relative humidity, as a climatic variable, can act alone or in association to have different effects on fishery stocks. Literally put, humidity is a measure of the amount of moisture in the air. It tells you how comfortable it is to be outside, and if there is enough moisture to create clouds and rain. It has a remarkable impact on fish production. However, relative humidity is dependent on air temperature.

Regarding CO2, a positive and statistically significant relationship was observed at the 1% level, with a growth rate of 3.73%. By implication, an increase in this variable will increase fish output. This finding is not surprising as several authors have stated that marine fish are likely to be less affected by an increase in oceanic CO_2 and a corresponding decrease in pH compared with invertebrate groups, such as molluscs and corals (Feely *et al*., 2004; Orr *et al.,* 2005; Fabry *et al*., 2008). However, laboratory studies have shown that manipulating pH and CO_2 can have significant consequences for the physiology, metabolism, and reproductive biology of fish, with egg fertilization and the survival of early developmental phases being primarily affected (Ishimatsu *et al.,* 2005). It is therefore worth noting that a higher level of CO2 increase is detrimental to the fishing population. Mortality may be high when temperature conditions reach extreme values.

CONCLUSION AND RECOMMENDATION

Conclusion

The study, therefore, concludes that climatic factors did not exhibit a stable trend during the period under review, but rather various patterns of instability in trend were observed for all climatic factors considered for the study. Additionally, temperature, relative humidity, and CO_2 have statistically significant effects on fish production in Nigeria, whereas rainfall and sunshine do not have statistically significant effects. Furthermore, the study reports a growth rate of 4.38% for fish output. However, despite this growth rate, a demand-supply gap still exists in the fishing sub-sector.

Recommendations

Based on the findings of this study, the following recommendations have been made.

1. The country should intensify efforts aimed at reducing the global temperature increase. Such policies as encouraging technologies that reduce temperature increase.
2. The imposition of tax on entities involved in the use of technologies that pollute the environment by increasing greenhouse gas emissions.
3. Awareness creation for fish farmers to adopt improved methods of fish farming and processing, helping to save the environment for both present and future generations.
4. There should be enforcement of existing government reforms and regulations regarding emissions.

REFERENCES

Action, S. I. (2020). World Fisheries and Aquaculture. *Food and Agriculture Organization. (2020).* 1-244.

Adeosun.O.,Taiwo, A.,Adelodun O., Bankole, A.F. (2020). Commonly patronized fish species in Iseyin Local Government Area, Iseyin, Oyo State. Agricultural anf Food Sciences, Environmental Science.DOI: 10.31248/JASP2020.195:225893764

Akinsorotan, A. M., Akinsorotan, O. A., Jimoh, J. O., Adene, I. C., & Akiwowo, U. A. (2019, August). Offshore aquaculture practice; a potential for meeting Nigeria fish demand–a review. In *Journal of Physics: Conference Series* (Vol. 1299, No. 1, p. 012111). IOP Publishing.

Anyanwu, P. E., Umunna, M. O., & Egbuche, C. T. (2019). A review of the effects of anthropogenic activities on fish population in Anambra River, Nigeria. International Journal of Fisheries and Aquatic Research, 4(2), 22-27.

Fabry, V. J., Seibel, B. A., Feely, R. A., & Orr, J. C. (2008). Impacts of ocean acidification on marine fauna and ecosystem processes. Limnology and Oceanography, 81-99.

Food and Agriculture Organisation (FAO). (2018). The State of the World Fisheries and Aquaculture 2018: meeting the sustainable development goals.

Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. &
Bene, C., Barange, M., Subasinghe, R., Pinstrup-Andersen, P., Merino, G., Hemre, G. I. & Williams, M. (2016). Feeding 9 billion by 2050 – Putting fish back on the menu. Food Security.

Busari, A. O., & Ayanboye, A. O. (2022). Effects of Macro-Economic Variables on Fisheries Supply in Nigeria (1980-2019). *Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development*, *22*(1).

Chan, C. Y., Tran, N., Pethiyagoda, S., Crissman, C. C., Sulser, T. B., & Phillips, M. J. (2019). Prospects and challenges of fish for food security in Africa. *Global food security*, *20*, 17-25.

Emam, M. A., Leibrecht, M., & Chen, T. (2021). Fish exports and the growth of the agricultural sector: The case of south and southeast asian countries. *Sustainability*, *13*(20), 11177.

Fakoya, K. A., Abiodun-Solanke, A. O., & Mangai, E. O. (2021). Implications of production, post-harvest and consumption of fish on food and nutrition security: Nigeria as a focal country. *Food Security and Safety: African Perspectives*, 355-374.

FAO. (2020). The State of World Fisheries and aquaculture

FMARD. (2020). Federal Ministry Of Agriculture and Rural Development Annual Report

Huang, M., Liuyong, D., Jun, W., Chengzi, D., and Juan, D. (2021) The impacts of climate change on fish growth: A summary of conducted studies and current knowledge. Elsevier. Available online at: https://doi.org/10.1016/j.ecolind.2020.106976

Ipinjolu, J.K. I., Magawata and Shinkafi, B.A. (2014). Potential Impact of Climate Change on Fisheries and Aquaculture in Nigeria. *Journal of Fisheries and Aquatic Science, 9: 338- 344.*

National Climate Assessment. (2016). Impact Of Climate Change on Biodiversity , ecosystems, ad ecosystem services

Nwilo, P. C., Badejo, O. T., & Atagbaza, A. O. (2018). Impacts of climate change on the coastal areas of Nigeria. In Handbook of Climate Change Communication (pp. 101-116). Springer.

Nwuba, L. A., Ude, E. F., & Ogbonnaya, H. F. (2022). Current Trends in Fisheries and Aquaculture. *International Journal of Agriculture, Food and Biodiversity*, *1*(1), 64-69.

Odioko, E., & Becer, Z. A. (2022). The Economic Analysis of The Nigerian Fisheries Sector: A Review. *Journal of Anatolian Environmental and Animal Sciences*, *7*(2), 216-226.

Oparinde, L. O. (2019). Fish output and food security under risk management strategies among women aquaculture farmers in Ondo State, Nigeria. *AGRIS on-line Papers in Economics and Informatics*, *11*(665-2019-3999), 93-105.

Osei, A. A. A., Etuah, S., Aidoo, R., Fialor, S. C., & Adams, F. (2023). Drivers of smoked marine fish prices and challenges along the value chain. *International Journal of Social Economics*, *50*(2), 242-259.

Oyebanji, O., Saloko, G., Nneji, L.M., Oladipo, S.O. (2020). Impact of Climate change on the spatial distribution of endemic legume species of the Guineo-Congolian forest, Africa. Ecological Indicators 122:1470-160.DOI: 10.1016/j.ecolind.2020.107282

Pearson, P.N.,Ditchfield, P.W., Singano, J., Harcourt-Brown, K.G.,Nicholas C.J.,Olsson,R.K., Shacklenton, N.J.,Hall, M.A (2001). Warm tropical sea surface temperatures in the Late Cretaceous and Eocene epochs. DOI: 10.1038/35097000:4;413(6855):481-7:11586350

Population Reference Bureau. (2021). 2021 world population data sheet. https://interactives.prb.org/2021-wpds/ (18.08.2021).

Poulain, F., eds. 2018. *Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options.* FAO Fisheries and Aquaculture Technical Paper No. 627. Rome, FAO. 628 pp.

Rabo, P.D., Zarmai, D.U., Jwanya, B.A. & Dikwahal, S.H. (2014). The role of fisheries resources in national development: a review. *International Letters of Natural Sciences*, *18*, 20-28.

Sahya, M., Oliver, J.H., Lloyd, H.H., Concillia, M., Confred, G.M., Timothy, H.M., Brian, P.M., Kanyembo, J.P., Jean, D.M. (2021) Climate Change Effects on Aquaculture Production: Sustainability Implications, Mitigation, and Adaptations . Front. Sustain. Food Syst., 12 March 2021 Sec. Climate-Smart Food Systems Volume 5 - 2021 | https://doi.org/10.3389/fsufs.2021.609097

Subasinghe, R. P., Siriwardena, S. N., Byrd, K. A., Chan, C., Dizyee, K., Shikuku, K. M., Tran, N., Adegoke, A., Adeleke, M., Anastasiou, K., Beveridge, M., Bogard, J., Chu, L., Fregene, B.T., Ene-Obong, H., Cheon,g K.C., Nukpezah, J., Olagunju, O., Powell, A., Steensma, J., Williams, G., Shelley, C. & Phillips, M. J. (2021). Nigeria fish futures. Aquaculture in Nigeria: Increasing income, diversifying diets and empowering women. Report of the scoping study.

TrendEconomy. (2021). Annual international trade statistics by country (HS02).

UNDP. (2018). Human Development Report: Climate Change and Human Development

WorldFish, (2018). WorldFish Nigeria Strategy 2018-2022.