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IMPACTS OF LAND USE CHANGE AND CLIMATE CHANGE ON FISH SPECIES IN NIGERIA FROM 1981 TO 2022: BASED ON AUTOREGRESSIVE DISTRIBUTED LAG APPROACH

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Abstract
The study assessed the impacts of land use change and climate change on fish species in Nigeria from 1981 2022 based on Autoregressive Distributed Lag Approach. The study adopted a historical survey design using time series data spanning from 1981 to 2022. Data for the study were collected from the archive of National Bureau of Statistics (NBS), NIMET, Food and Agriculture Organization (FAO) and various editions of Nigeria National Biodiversity Report. Data for the study were analyzed using descriptive statistics such as mean, maximum and minimum fish species and Autoregressive Distributed Lag Model (ARDL). The result of the analysis revealed mean land use change, rainfall, temperature relative humidity and were 161334.6 sq/km, 1266.28mm, 27.23515^{o}C, 81.3% respectively. While fish species had a mean value 476.50 species. The result of Augmented Dickey Fuller (ADF) test for unit root indicated that all the variables were found to be integrated of order zero except temperature that was found to be integrated of one and became stationary on first differencing. The result further shows that the computed statistics of fish (10.34262) was greater than the upper bound critical values at 0.05 levels. Therefore, co-integration exists among the variables which implied a long run relationship exists among land use change, climate change and fish species in Nigeria. Based on the confirmation of long run relationship among land use change, climate change and fish species, ARDL approach was further applied. The result of the ARDL revealed that there is a short and long run impact of land use change and climate change on fish species in Nigeria. The study therefore recommends that the federal government should provide strong adaptive strategies and capacity such as construction of receiving dams to mitigate the effects of a changing climate such as flooding which may affect the fish species among others.
Keywords: Land, Biodiversity, Climate, Humidity, Greenhouse and Species

Introduction

Nigeria's economy and society are heavily dependent on land, with agriculture constituting the largest industry and the main source of employment. Land in economics entails all natural resources endowed to a country by nature. These natural resources also include water and its contents. Some of these water resources like fishes have largely been on the decline and extinction due to human induced factors especially in developing countries like Nigeria.

These diverse changes in land use have led to changes in climatic conditions. In recent times, variations in climatic conditions have resulted in undesirable effects on land use and aquatic life (Borokini, 2014). Unfortunately, the country has very weak adaptive strategies and capacity to mitigate the effects of a changing climate. Presently, the impacts of rising temperatures and rainfall variability on biodiversity are being felt across major agro-ecological zones in Nigeria (Ayanlade *et al.*, 2018).

Several species of fish have been reported in several part of Nigeria (Emma–Okafor, Ibeawuchi and Obiefuna, 2010). For instance, FRN (2015) reported the presence of 648 fish species in Nigeria. Fishes have been widely studied in surface water resources in several water resources in Nigeria (Emma–Okafor, Ibeawuchi and Obiefuna, 2010). 41 to 45 fish composition frequently found in surface water includes both shelled and fin fish depending on the habitat. Amos, Ali and Abubakar (2020) reported that in the present situation the fish composition, diversity and abundance is on the decreasing trend especially in surface water resources with high level of human interference. They further found a decrease in the mean size of individual fish species and in the value of the catches. They revealed that *Gymnarchus niloticus* was the highest fish species endangered with 21.28% while the lowest was *Malapterurus electricus* with 0.53%. Moreover, the use of poison accounted for the highest proportion of threats at 30.94%, while the use of fishing gear of inappropriate size represented the lowest at 1.1%. Other factors, such as overfishing, can also have detrimental impacts on aquatic flora and fauna by disrupting the food web and ecological chain, potentially leading to the disappearance of numerous fish species from their natural habitats

In addition to that, the highest rates of biodiversity in the world are found in tropical regions populated by developing countries including Nigeria, which do not have adequate technical and financial resources to manage all these species, thereby making these species to be furtherthreatened by various factors such as land use and climatic changes. Despite these apparent declines, there is almost no systematic monitoring of biodiversity trends in Nigeria (Magurran *et al.*, 2010; Barshep *et al.*, 2017; Cresswell *et al.*, 2020). Therefore, there is the need for setting priorities for conservation efforts for fish species, with more attention to those whose biodiversity have reduced drastically, species with narrow range of bio-geographical distribution, endemic species and those whose species are drastically been extinct. Thus, the need to find the impacts of land use and climate changes on fish species in developing countries especially Nigeria.

Methodology

Study Area

The study was carried out in Nigeria. Nigeria is located on the Gulf of the Guinea in West Africa with a geographical area of 923,768 square kilometers. It is one of the eight most populous countries in the world with a population of about 140 million (NPC, 2006). With a population growth rate of 2.6%, Nigeria has an estimated population of about 210.87 million in 2021 (www.statista.com). Nigeria lies wholly within the tropics along the Gulf of Guinea on the western coast of Africa. The topography ranges from mangrove swampland along the coast to tropical rain forest and savannah to the north. The country has two major rivers – River Niger and River Benue which provides that citizens with abundant water resources. Nigeria is located between latitude 4°16 and 13°53 North and longitude 2°40 and 14°41 East (CIA Fact Book, 2009). Because Nigeria has a highly diversified agro-ecological climate, agriculture is one of the most important sectors of the Nigeria economy. The climate varies with Equatorial in South, Tropical in Centre and in the North. In the North, the vegetation is grassland savannah and, in the south, forest.

Data Collection and Data AnalysisTechniques

The study relied on the use of time series data spanning from 1981 to 2022. Data on rainfall and temperature were collected from the National Bureau of Statistics (NBS), data on humidity were collected from NIMET, data on land use were collected from the records of Food and Agriculture Organization (FAO) while data on fish species were collected from various editions of Nigeria National Biodiversity Report. Data for the study were analyzed using both descriptive and inferential statistics. Specifically, descriptive statistics such as mean, maximum and minimum was used for the mean of the variables, Bounds Tests from Autoregressive distributed lag model (ARDL) was used to test the existence of relationship between the variables while Autoregressive distributed lag model (ARDL) was used to estamate the effects of land use change and climate change on fish species.

Model Specification

Autoregressive Distributed Lag (ARDL) Model

To find the relation between fish species and independent variables (land use change, temperature, rainfall and relative humidity) ARDL model was employed. This model was constructed as:

$$\text{FISt¼} = \alpha_0 + \alpha_1\text{LUC} + \alpha_2\text{RAF} + \alpha_3\text{TMP} + \alpha_4 RHD + E_t \ldots$$

By converting all variables of Equation (1) into the natural log, the model is designed below:
ln

$$\text{FISt¼} = \alpha_0 + \alpha_{1\ln}\text{LUC} + \alpha_{2\ln}\text{RAF} + \alpha_{3\ln}\text{TMP} + \alpha_{4\ln}\text{RHD} + \text{E}_t \ldots\ldots\ldots (2)$$

Equation (2) can be written in ARDL and ECM general form as follows:

$$\Delta\ln\text{FIS}_t = \alpha_0 \sum_{k=1}^{n} a_1 \Delta\ln\text{LUC}_{t-k} + \alpha_0 \sum_{k=1}^{n} a_2 \Delta\ln\text{RAF}_{t-k} + \alpha_0 \sum_{k=1}^{n} a_3 \Delta\ln\text{TMP}_{t-k} + \alpha_0 \sum_{k=1}^{n} a_4 \Delta\ln\text{RHD}_{t-k} + \emptyset\text{ECM}_{t-1} + \text{E}_t \ldots\ldots\ldots\ldots (3)$$

Where: FIS is the values of fish species, LUC, RAF, TMP and RHD are the values of land use change, rainfall, temperature and relative humidity which were used to estimate the values of the dependent variables, Et is the error term, α_0 represent the drift component, Δ shows the first difference while $\emptyset$ shows the coefficient of ECM for short run dynamics. ECM shows the speed of adjustment in the long-run equilibrium after a shock in the short-run.

Results and Discussion

Mean Land Use Change, Climate Change and Fish Species in Nigeria

The mean of land use change, climate change and fish species is presented in Table 1. The result showed that land use change range between 139975.2 and 171421 square kilometers within 1981-2022 in Nigeria with a mean of 161334.6 square kilometers. The high diversity between the maximum and minimum land use change and high mean may be attributed to urbanization and increase in agricultural activities which put Nigeria land into several uses to meet human wants.

Result further revealed a maximum and minimum annual rainfall,temperature, and relative humidity values of 1596 mmand 1046mm, 27.8575ºC and 26.1882ºC, 85.0% and 78.4% with means of 1266.28mm, 27.23515ºC and 81.3%, respectively. This indicated that there was a high incidence of climate change in Nigeria during the period. This high change in climate may be considered a global phenomenon due to high industrialization leading to accumulation of inorganic substances in the atmosphere.

Table 1: Summary of Statistics of Variables

	FISH	LUC	RHD	RAF	TMP
Mean	476.50	161334.6	81.3	1266.28	27.23515
Maximum	782.00	139975.2	85.0	1596	27.8575
Minimum	181.00	171421	78.4	1046	26.1882
Std. Dev.	263.25	10917.14	1.746137	103.4055	0.432165
Skewness	0.327	-0.844569	0.079407	0.412105	-0.747655
Kurtosis	-2.206	2.104901	2.076191	4.348147	2.771644
Jarque-Bera	72.96014	6.242918	1.501017	4.265404	3.908834
Probability	0	0.044093	0.472126	0.118517	0.141647
Sum	3812	6614720	3334.732	51917.5	1116.641
Sum Sq.	2301528	4.77E+09	121.9597	427707.5	7.470649
Observations	41	41	41	41	41

RMD = relative humidity; LUC = Land use change; TMP = Temperature.
Source: Data Analysis, 2023

Additionally, result on biodiversity revealed a minimum and maximum valuers of fish species of 782.00 and 181.00 with a mean of 476.5 species. This could be attributed to high level of fishing activities in the country with high exploitation rate leading to extinction of several species. This findings differs from the report of FRN (2015) that there is presence of 648 fish species in Nigeria.

Unit Root Test

As shown in table 2, a necessary preliminary test, the Augmented Dickey Fuller (ADF) test for unit root was employed to test whether or not a variable is stationary and also determine the order of integration of the variable. The result indicated that all the variables (fish, land use change, relative humidity and rainfall) were found to be integrated of order zero except temperature that was found to be integrated of order one which later became stationary on first differencing. This indicates that the variables exhibit random walk (unit roots) or the future values of these variables do not converge from their past values.

Table 2: Results of Augmented Dickey-Fuller (ADF) Test

Variable		**Level**						**First Difference**	
	ADF	**1%**	**5%**	**10%**	**ADF**	**1%**	**5%**	**10%**	**Inference**
FISH	-4.2437***	-3.6056	-2.9370	-2.6069					I(0)
RAINFALL	-4.6640***	-3.6056	-2.9370	-2.6069					I(0)
HUMIDITY	-3.5308***	-3.6056	-2.9370	-2.6069					I(0)
TMP	-2.5813	-3.6105	-2.9390	-2.6080	-8.5498***	-3.6105	-2.9390	-2.6080	I(1)
LUC	-4.8268***	-3.6056	-2.9370	-2.6069					I(0)

TMP = Temperature; LUC = Land use change;*** Significant at 1%
Source: Data Analysis, 2023

Bounds Test for Long Run Relationship between Land Use Change, Climate Change and Fish species

In the first step of the ARDL analysis, the presence of long-run relationships was tested as stated in the methodology. Bounds test was used to determine whether a linear combination of non-stationary variables is stationary. Regressing a non-stationary series on another non-stationary series yields spurious regression, but if a linear combination of the series is stationary, the variables are said to be co-integrated and the regression is no longer spurious. The result of the bounds test for fish species (Table 3) shows that the computed statistics 10.34262 is greater than the upper bound critical value, 4.01 at 0.05 level. Therefore, co-integration exists among the variables. This implies that a long run relationship exists among fish species, land use change, temperature, humidity and rainfall. This could be attributed to increase in greenhouse gases which negatively affect some climatic phenomenon such as rainfall leading to decrease in water level, which its associate negative effects on marine lives. This is in line with Obayelu (2014) who reported that climate change affects all aspects of biodiversity from individual organisms, within populations and species both in the short and long-run.

Table 3: Bounds Test for Co-integration between Land Use Change, Climate Change and Fish Species

Test statistics	**Value**	**Significance (%)**	**1(0)**	**1(1)**
F	10.34262	10	2.45	3.52
K	4	5	2.86	4.01

	2.5	3.25	4.49
	1	3.74	5.06

Source: Data Analysis, 2023.

Impacts of land use change and climate change on fish species in the Short and Long Run

Table 4. Short and long run effects of land use change and climate change on fish species

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Short run estimates				
FISH_SP(-1)	0.072825	0.455174	0.159995	0.8781
FISH_SP(-2)	-0.553286	0.513725	-1.077009	0.3229
FISH_SP(-3)	0.187749	0.453549	0.413956	0.6933
FISH_SP(-4)	-0.497158	0.3477	-1.429848	0.2027
LNLUC	32.64353	38.4135	0.849793	0.428
LNLUC(-1)	-78.16895	56.70476	-1.378525	0.2172
LNLUC(-2)	9.99148	58.81652	0.169875	0.8707
LNLUC(-3)	-146.5299	47.83938	-3.062955***	0.0121
LNLUC(-4)	71.34807	40.58556	1.757967	0.1293
LNRAINFALL	365.0953	367.8921	0.992398	0.3593
LNRAINFALL(-1)	-119.9067	543.9115	-0.220453	0.8328
LNRAINFALL(-2)	909.9688	577.6246	1.575364	0.1662
LNRAINFALL(-3)	658.1057	538.7647	1.221508	0.2677
LNRAINFALL(-4)	906.1364	359.8553	2.518057**	0.0454
LNTEMP	5362.553	3152.999	1.700779	0.1399
LNTEMP(-1)	958.9389	2270.443	0.422358	0.6875
LNTEMP(-2)	-3410.079	2263.33	-1.506665	0.1826
LNHUMIDITY	5243.664	1632.907	3.211246***	0.0183
LNHUMIDITY(-1)	2475.568	2189.062	1.130881	0.3013
LNHUMIDITY(-2)	-1523.628	2204.082	-0.691275	0.5152
LNHUMIDITY(-3)	2248.046	2879.092	0.780817	0.4646
CointEq	-1.789870	1.068567	-1.675019	0.1450
Long run estimates				
LNLUC	-61.856884	36.993368	-2.672104**	0.0355
LNRAINFALL	1519.328243	583.033846	2.605901**	0.0403
LNTEMP	1626.606028	2179.72487	0.746244	0.4837
LNHUMIDITY	4717.466833	1753.399845	2.690468**	0.036
C	-36593.92541	12393.40571	-2.952693**	0.0255
R-squared	0.912267	Mean dependent var		46.28571
Adj. R-squared	0.60512	S.D. dependent var		120.3925
S.E. of regression	75.6464	Akaike info criterion		11.521
Sum squared resid	34334.27	Schwarz criterion		12.56773
Log likelihood	-139.294	Hannan-Quinn criter.		11.841

F-statistic	2.970905***	Durbin-Watson stat	2.306789
Prob(F-statistic)	0.090225		

* = Significant at 10%, ** = Significant at 5%, *** = Significant at 1%
Source: Data Analysis, 2023

Consequent upon the existence of co-integration among the variables, indicating the existence of a long run relationship among the variables, the conditional error correction model based on the ARDL approach was estimated (Table 4). The model shows the short run and long run impacts of land use change and climate change on fish species.

The result of the ARDL as shown in Table 4 indicated that in a long run, the coefficient of land use change (-61.856884) was negative and statistically significant at 5% probability level. This implies that a unit change in land use will decrease fish species by 61.856884 units in the long run *ceteris paribus*. More so, the coefficient of rainfall (1519.328243) was positive and statistically significant at 5% probability level. This implies that a unit increase in rainfall will increase fish species by 1519.328243 units in the long run *ceteris paribus*. Similarly, the coefficient of relative humidity (4717.466833) was positive and statistically significant at 5% probability level. This implies that a unit increase in temperature will increase fish species by 4717.466833 units in the long run *ceteris paribus*. Therefore, there is a long run impact of land use and climate change on fish species in Nigeria.

The short run result indicated that the conditional error correction term or speed of adjustment, ECM (-1) is negative (-1.789870) and not statistically significant. The coefficients of land use change (-146.5299) was negative and statistically significant at 1% probability level during the third lagged period. This implies that a change in land use will decrease fish species by 146.5299units *ceteris paribus*. Similarly, the coefficient of rainfall (906.1364) was positive and statistically significant at 5% probability level during the fourth lagged period. By implication this means that a unit increase in rainfall will increase fish species by 906.1364 units in the short run *ceteris paribus*. Furthermore, the coefficient of relative humidity (5243.664) was positive and statistically significant at 1% probability level. This implies that a unit increase in relative humidity will increase fish species by 5243.664units *ceteris paribus*. This shows the existence of short run effect of land use change and climate change on fish species in Nigeria.

The short and long run positive relationship between rainfall, relative humidity and fish species could be attributed to the fact that increase in rainfall and relative humidity may result in increase in water level which may be favourable for aquatic organisms such as fishes. This is line with earlier study by Mustapha (2013) who reported that massive rainfall and extreme climatic conditions may result in river overflow which have impacts on the fishes in the long run. While the negative relationship between land use change and fish species may be as a result of human activities on land such as mining, deforestation amongst others which have negative effects on the climatic parameters in the long run which affect fish diversity. Obayelu (2014) also reported that climate change induced by human activities affects all aspects of biodiversity leading to decline in water quality, water resources and increased risk of floods and droughts in Nigeria.

Conclusion and Recommendations

The study analyzed the impacts of land use change, climate change on fish species in Nigeria 1981 to 2022 using Autoregressive Distributed Lag Approach. The study found that there is existence of co-integration between land use change, climate change and fish species. Therefore, it was concluded that a long run relationship exists among land use change, climate change and fish species. Consequent upon the existence of co-integration among the variables, indicating the existence of a long run relationship among the variables, the conditional error correction model based on the ARDL approach was estimated which indicated both long run and short run effects of land use change and climate change on fish species. Hence, the study further concluded that there is a short and long run impact of land use change and climate change on fish species in Nigeria. Based on the findings of the study, it was therefore recommended that:

i. The federal government should provide strong adaptive strategies and capacity such as construction of receiving dams to mitigate the effects of a changing climate such as flooding which may affect the fish species.

ii. Government at both the Local, State and Federal level should enact enabling laws against activities such as indiscriminate hunting, bush burning and habitat destruction/degradation that leads to climate change which virtually has short and long run effect on biodiversity.

iii. There should be more public enlightenment campaign on the importance of biodiversity as this will enlighten most citizens especially the rural dwellers on the need to protect biodiversity.

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