CLIMATE CHANGE AND FOOD PRICE INFLATION IN NIGERIA

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ABSTRACT

This study examines the impact of climate change on food price inflation in Nigeria motivated by the current cost of living crisis, problem of food availability and affordability, as well as climate-related crisis in agriculture supply chain. Rainfall, temperature, internal migration and climate change policies were used as independent variables, while food price inflation was used as dependent variable. The unit root test revealed that the variables were stationary at I(1) and I(0). Autoregressive distributed lag (ARDL) and error correction models were the methods of analysis. Findings revealed that rainfall had negative and statistically significant impact on food price inflation with a coefficient of -0.509875 and a probability value of 0.0002. Temperature revealed a positive and statistically insignificant impact on food price inflation in Nigeria with the coefficients of 0.010999 and probability value of 0.1658; internal migration also had a positive and statistically significant impact on food price inflation having a coefficient of 32.76860 and probability value of 0.2901; while climate change policy had a negative and statistically significant impact on food price inflation with the coefficient of 3.397872 and a probability of 0.2821. In conclusion, Nigeria has climate change challenges, and these have also had significant impact on food supply chain and food prices. The study recommends extension services on climate-smart agriculture; also, government needs to implement effective agriculture and food policy urgently, construct more dams, drainages and irrigational water space to curb the challenges of climate change and food price inflation in the economy.

Keywords: Climate Change, Food Price Inflation, Climate-smart Agriculture, Food Security, Policy, Cost of Living

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INTRODUCTION

Climate change is a long-term variation in weather patterns reflected as a sustained increase in the mean temperature of the earth over decades (Foye & Benjamin, 2021). This change could be anthropogenic (human induced) or biogeographical. Information by the journal of sustainable development has established that climate change is human induced (Foye, 2018). For instance, human activities in industrialized economies such as America, Germany, Italy, Britain, China, etc, burning of fossil fuels like coal, oil and natural gas through industrialization, gas flaring, agriculture and urbanization, among others resulted in the dominance and persistence of carbon dioxide (CO_2) among other greenhouse gases, such as methane, nitrous oxide, and fluorinated gases in the atmosphere (United States Environmental Protection Agency, 2018). These have altered the climate and agricultural seasons with consequences on rainfall pattern, temperature, droughts, floods; reduction in food production, food supply and persistent rise in food prices. It has been documented that climate change continues to pose a huge threat to human development and food security in the economy (World Meteorological Organization, 2021). Nigeria is vulnerable to climate change and successively hit by environmental disasters such as floods, droughts, wild winds, extreme sunshine and heat waves. Developing countries are the most vulnerable to climate change due to the structure of their agrarian economy and poor mitigation measures and implementation. Nigeria is frequently experiencing extreme weather patterns such as drought, floods, heatwaves, storms, precipitation variations and changes in sea level which seem to have devastating effects on agriculture, food security, nutrition, housing, health, infrastructure, incomes and food prices. Supply of staple foods such as rice, beans, maize, onions and other grains has reduced while demands are surging. This and other related factors such as energy costs and petroleum subsidy removal seem to have caused food inflation. Nigeria's inflation was at a 60-year high at 34% as of December 2024. Relatedly, statistics have shown that Nigeria's temperature rose from about 26.98° Celsius three decades ago to approximately 27.27 and 27.45° Celsius in the last two decades, respectively (National Bureau of Statistics [NBS], 2020). This is manifested in the current escalation in prices particularly; food prices have tripled over the past decade in Nigeria, as the consumer price index which was 110.84 in 2011 became 324.99 in 2020. In the same vein, the exchange rate of Naira to American Dollar has more than doubled over the same period from ₦153.86 to ₦1,655 per dollar between 2014 and 2024, respectively, partly due to foods and refined petroleum products imports (Central Bank Nigeria, 2020).

The government came up with policies such as the Climate Change Policy Response and Strategy (CCPRS), the National Adaptation Strategy and Plan of Action for Climate Change Nigeria (NASPA-CCN) and National Policy on Climate

Change (NPCC). However, despite these policies and measures put in place by the government, the problems of food price inflation, conflict, internal migration and food insecurity still persist in Nigeria, one of the most food insecure countries with increasing food price inflation highly affected by climate change and other policy challenges such as increased petroleum products prices. Fuel cost increases the cost of transportation of food from farm to market and from market to market, as well as the cost of food processing chain. The trend of food inflation has been expansionary: 15.9 percent in 2020, 17.5 percent in 2022, 25.09 percent in 2023 and a 30-year high of 34.8 percent in 2024. Food inflation constitutes more than 50 percent of Nigeria's inflation basket and has increased by 113 percent (NBS, 2022).

The relationship between climate change and agricultural sector is well documented (Nyong, 2023), with the argument that climate change impacts negatively on agriculture through internal migration, low food input and increase herders' conflict in Nigeria (Tanure, Miyajima Magalhães, Domingues, & Carvalho, 2020). The implications of internal migration (as one of the variables of this study) and the current vibration in food prices are of great concern to this study. There is growing population and growing demand for food. Increase in food prices could move millions of Nigerians into poverty characterized by insecurity and uncertainty, welfare and investment losses, as rising food prices raise the cost of living (NBS, 2022). This signifies that much still has to be done to avoid the dangerous and irreversible consequences of climate change.

This study is organized and structured in six (6) sections. Section one is the introduction, section two is the conceptual review, section three is the review of empirical literature, and section four is the theoretical framework of the study, while section five presents the methodology and data analysis. The final section is devoted to the conclusion and recommendations.

LITERATURE REVIEW

Conceptual Review

Concept of Climate Change

Climate change is defined as the alteration in the composition of the global atmosphere and the economic environment at large, caused by the direct or indirect day to day human activities. Mkpa (2013) defined climate change as the activities of human beings which have a direct and indirect effect on the global composition of the atmosphere that lead to natural climate variability observed over a particular time period. Ngigi (2009) defined climate change as the change in climatic conditions which involves directly or indirectly economic activities of the society that lead to the deformation of the atmospheric composition of the earth which therefore led to global warming. According to Intergovernmental Panel on Climate Change (IPCC) (2007), it is defined as the change in the state and conditions of the climate which can be experienced through changes and fluctuations of the atmospheric composition and properties that persists for an extended period typically decades longer. However, a change in climate involves negative human externality that is hazardous to the economic environment which affects the atmosphere leading to global warming.

The United Nations on Environmental programme [UNEPA] (2000) defined climate change as extreme reactions of the weather phenomenon which creates negative impact to the economic environment such as the agricultural resources, water resources, human health, depletions of ozone layer, vegetations, soil and doubling of CO_2 in the ecosphere at large over a period of time. This negative impact on the society reduces crop yield, decreases water nutrient, increases human environmental hazard and forest depletion in the economy. According to Medugu (2009), climate change is an increase in the state and pattern of average global temperature which is caused by natural events and human activities in the economy, which is believed to be a major contributing factor to an increase in average global temperatures and climate conditions. However, the change in the temperate level of the atmosphere is a major indicator of human activities in the economy which negatively affect the atmosphere directly or indirectly. The definition of climate change by United Nations on Environment programme (2000) is adopted as the working definition in this study as it sees climate change as extreme weather phenomenon which creates negative impacts on the economic environment such as agriculture resources, water resources, human health, depletion of the ozone layer, vegetations, soil and doubling of the CO_2 into ecosphere at large over a period of time. Based on the aforementioned definition, this study defines climate change as the direct and indirect human activities that change the atmosphere pattern, creating a negative externality to human health, crop and animal production, water supply and the socio-economic environment over a given period of time.

Concept of Food Price Inflation

Food inflation is an essential dimension (component) of the general price level. Inflation is defined as the persistent increase in the general price level of goods and services over a particular period of time in the economy. It is an unsustainable increase in prices that is not reflecting changes in relative scarcity or constrained supply. Ojo (2000) defined inflation as a persistent increase in the prices of goods and services in an economy.

Food prices inflation refers to the average price of food across countries, regions, zones or states and also on a global scale (Max & Ritchie 2013). Food price inflation affects both the producer and the consumer. Its levels depend on the food production, including food supply, distribution and marketing which have manifestations in fluctuation in food prices in Nigeria. According to Amadeo (2020), food price inflation is the general increase in the prices of food commodities which is influenced by so many factors such as geopolitical events, global demand, exchange rates, government policy, diseases and crop yield, energy costs, availability of natural resources for agriculture, food speculations, changes in the use of soil and weather events. All these directly affect food price inflation to a certain extent and adverse price trends (Spratt, 2013). The consequences of food price inflation are multiple which include increases in food prices or hyperinflation, destabilization in consumer price index which endangers food security particularly for the core poor and most vulnerable which can cause social unrest (Winecoff & Kindred, 2020).

This study adapts the definition of Max (2013) as the working definition. He defines food price inflation as the average price level for food across Nigeria's geopolitical zones, states, cities and communities over the period of this study. The reason for the adaptation of the working definition lies in the fact that the persistent rise in the price of the foods has in so many ways led to high food price inflation in the economy.

Theoretical Framework

The Environmental Kuznet Hypothesis

The environmental Kuznet curve hypothesis was first propounded by Simon Kuznet (1955). The fundamental principle of the environmental Kuznet's curve (EKC) hypothesis proposes that concentrations or per capita emissions of various pollutants rise and then fall as per capita income increases due to economic activities (industrialization) of the society. The opportunity cost of per capita income is per capita emission of various pollutants. The hypothesis explained that at early stages of development, pollution per capita and economic growth per capita move in the same direction beyond a certain income level, emissions per capita decrease as economic growth per capita increases, thus generating an inverted-U shaped relationship between economic growth and per capita pollution. The environmental Kuznet curve hypothesis also explained that early stages of decreasing capacity of ecosystem regeneration which is as a result of the consequence of intensive use of resources led to a rising ecological footprint and pollution in the economy.

This stage was linked with relaxed environmental regulations associated with a low capacity to pay for environmental conservation in the economy. Kuznet also explained what is called the later stage as a stage that was characterized by mitigation of environmental degradation resulting from the dissemination of clean technology and innovation, society environmental awareness, and effectiveness and institutional quality associated with an increase in the level of income (Grossman & Krueger, 1991). High economic growth and development usually leads to environmental deterioration due to high industrial activities in the early stages which affect the environment. The best way to keep a healthy environment is for a country to be rich and watchful on its economic activities and investing in its environment.

The relevance of the theory to this study lies on the emphasis on economic activities in relation to climate change; if economic growth converges with less carbon emission it will reduce the high effect of carbon emission in the atmosphere and lead to a decrease in global warming. The relevance of the theory to this study further signifies that, if Nigeria can find a way of balancing its economic activities and climate change it will help mitigate the impact on food production and food price in Nigeria. The weakness of the Kuznet hypothesis is over-emphasis on economic growth and development process as the major causes of climate change without looking at natural factors, rainfall, temperature rise, drought, wild winds, extreme cold and flash floods.

Demand-Pull Theory

The theory was postulated by John Maynard Keynes in 1883. The theory emphasized on aggregate demands as the source of demand-pull inflation which implies that aggregate demand encapsulates consumption, investment, government expenditures and net export. That is, when the volume of aggregate demands exceeds the volume of aggregate supply at full employment level, inflationary gap will arise and the larger the gap between aggregate demand and aggregate supply the more rapid inflation will become. However, Keynes and his followers did not deny the fact that before reaching full employment, various factors of production and other constraints can increase the market price, and the inflation that appears quickly during prosperity is originally resulting to non-proportioned section branches and other economic resources that accounted from natural properties of the market. Therefore, according to Keynes, one policy that causes a decrease in each component of total demand is effective fiscal policy in the reduction of pressure on demand and inflation, and one reduction in government expenditures is through increase taxes and control of the volume of money which can be effective in reducing effective demands and inflation control in the economy.

The importance of the theory to the study points that government policy towards managing the activities of the economy will keep inflation low in the economy and also the interplay of government expenditure in the economy. The limitation of the theory to the study shows that an increase on taxes in the economy will create a tax burden payment on the economy and that could decrease the welfare of the citizen, thus resulting into some tax evasion on the people in the economy. The relevance of the theory to the study pointed out that fiscal policies of the government are the best possible way to combat inflation in the economy. Based on the theories reviewed, this study adopts the demand-pull theory of inflation. The reason for the adoption of the theory is the reality of the Nigerian economy, whereby government fiscal and monetary policies have not been very effective in combating inflation.

Empirical Review

The relationship between climate change and the agricultural sector has been reasonably investigated by different authors at different times and in different countries and regions. Different findings have emerged from these studies which leave a fertile ground/gap for more research. Kunawotor (2021) investigated the impacts of climate change, particularly extreme weather events, on inflation and food price inflation and their apparent implications for monetary policy in Africa over the period 1990–2017. The aim of the study was to access the relationship between climate change on inflation and food price inflation. The variables in the study are temperature rate and inflation rate. The study used a two-step dynamic system Generalized Method of Moments estimation strategy with robust standard errors. The findings of the study revealed that weather-related events may need to be large and consequential to cause a significant price hike in Africa. The result of the study also revealed that incidences of droughts and floods have a bearing on food price inflation. Furthermore, the empirical evidence using mediation analysis revealed agricultural production to be the critical transmission mechanism whereby extreme weather events affect headline inflation. As the central bank is charged with the mandate of ensuring a stable monetary environment, it recommended that monetary policy authorities consider the short and long run impacts of supply shocks caused by extreme weather events on general price levels in their policy formulation.

Abril-Salcedo, Melo-Velandia and Parra-Amado (2020) examined the relationship between temperature rate, oil price, exchange rate and wages in agricultural sectors in Latin America. A structural vector auto regression model and panel Granger causality test were employed using monthly data between January 2003 and December 2020 for Latin American countries. The empirical findings showed that oil price and temperature can be significant factors for increasing food inflation. According to the result of variance decomposition, in general, a considerable part of food inflation was explained by the exchange rate, but its effect did not show any significant change in the long term. The impacts of the oil price and temperature were limited in the early months, but they created larger changes over time. Impulse response function and the Granger causality test also indicated that exchange rate was a crucial dynamic in explaining food inflation in all countries except Ecuador. This country successfully mitigated the negative effect of exchange rate, but the oil price and temperature had an impact on food inflation. All results indicated that both monetary and fiscal policies are essential to controlling food prices. These countries can accomplish this by conventional policies or by radical institutional changes. Nevertheless, the oil price and temperature are external dynamics, and crucial in creating alternative policies to control food inflation.

Mukherjee and Ouattara (2021) studied the effects of temperature shocks on inflation in developed and developing countries over the period 1961–2014. The aim of the study was to investigate the effect of temperature shocks on food inflation. The variables used in the study were temperature rate and inflation rate in developed and developing countries. The study used a panel VAR method with fixed effects and a sample of developed and developing countries over the period 1961–2014. The results of the study suggested that temperature shocks lead to inflationary pressures. Worryingly, and for developing countries in particular, the study found that these effects persist for several years after the initial shocks. The findings remained unaltered by various robustness checks. The study recommended that government should put up a policy that will mitigate the danger of extreme temperature that is leading to inflation in the developing countries.

Agyei (2021) investigated the impact of the novel corona virus disease 2019 (COVID-19) outbreak on prices of maize, sorghum, imported rice and local rice in sub-Saharan Africa (SSA). The aim of the study was to determine whether COVID 19 was climate change–induced and how it affected food pricing in Sub-Saharan countries. The variables employed in the study are inflation rate, exchange rate, temperature rate and oil pricing. The study employed an estimated dynamic panel data model with controls for macroeconomic setting using general method of moment estimation. The study found that the COVID-19 outbreak led to increases in food prices of the sampled countries. The restriction on movements or lockdowns in the wake of COVID-19 was associated with an increase in the price of grains. The study found that exchange rate, inflation and crude oil prices exerted a detrimental effect on food prices. The study recommended that governments of SSA countries should invest in infrastructure that improves efficiencies in the food supply chain during pandemics. Providing adequate support to industries in the value chain will also improve food availability and food price stability, post-COVID-19.

Eregha (2022) examined asymmetric response of temperature rate, domestic prices to official exchange rate and parallel exchange rate movements in oil-dependent Nigeria. The aim of the study was to investigate the temperature rate, domestic pricing of commodities and official exchange rates in Nigeria. The variables employed are temperature rates, domestic prices and exchange rate in Nigeria. The study employed a nonlinear ARDL model for the period of 1995-2001. The findings of the study were that temperature rate and food prices symmetrically responded to parallel exchange rate movements than official rate movements. However, only domestic prices responded differently to the depreciation and appreciation of the official exchange rates in Nigeria. Consequently, the government needs to ensure some level of fiscal austerity and possibly exchange rate unification when the premium grows too big, if the intention is to insulate domestic prices from fiscal pressures. Also, the Central Bank of Nigeria needs to be aware of a possible asymmetric relationship in its decisions to ensure price stability so that it does not distort monetary policy effects.

Akanni (2020) investigated the degree and direction of temperature level in returns and volatility spillover transmission between exchange rate and domestic food prices in Nigeria. The aim of the study was to investigate the relationship and the direction of relationship between temperature rate, exchange rate and domestic food pricing in Nigeria. The variables employed for the study are temperature rate, exchange rate and domestic food pricing. The study employed weekly data from January 2010 to January 2019. Also, the study employed vector autoregressive model. The study therefore accounts that in 2016 exchange rate crash in the interconnectedness between food prices and naira to dollar exchange rate. The paper finds evidence of directional interdependence among the considered temperature rate, food prices and exchange rate based on the obtained spillover indices. In addition, exchange rate returns volatility transmission to food prices is more than it receives, particularly after the exchange rate crash.

Sabola (2023) investigated the impacts of climate change on agricultural trade and food security in emerging economies focusing on Western Africa. The research employed the panel Generalized Method of Moments (GMM) using time series data for the period 2012 to 2021 obtained from a sample of 12 Western African countries selected based on data availability. The main independent variable of the research was climate change variables (temperature and precipitation). Other control variables included are population growth, food inflation and agricultural growth. The research recommended concerted efforts towards climate change adaptation and mitigation for sustainable agriculture. The study also recommended that policymakers should invest in data collection and ensure data availability to accurately assess the impacts of climate change on agricultural trade and food security. This can include establishing systems for regular data collection and monitoring, as well as promoting collaboration with international organizations to gather comprehensive and reliable data. Although the study found negative effects between climate change and agriculture, it may be beneficial to conduct further research to understand the underlying reasons and potential pathways through which these effects manifest. This will enhance our understanding of the complex relationship between climate change and agricultural trade in emerging economies and help inform targeted policies and intervention strategies. Going by all the empirical review, the conclusion is that climate change does have a relationship with agricultural production.

METHODOLOGY

This study adopts the ex-post facto research design. This research design is suitable for secondary data published by statistical agencies and those derived or computed by the researchers. Data were collected from various published sources like; CBN Statistical Bulletins, CBN Annual Reports and Statement of Accounts (various issues), National Bureau of Statistics (NBS), the United Nations data bank, as well as Academic Journals, Magazines, Serials and relevant publications. Econometrics views (EViews) was used in the estimation of the model parameters; other basic econometrics pre-tests and post-tests were employed like the Augmented Dickey-Fuller (ADF) unit root test, ARDL long run and short run bounds test, multicollinearity test, and serial correlation test, among others were carried out in the course of the study in order to avoid spurious regression results. The data used are Food Price Inflation ($FPINFL$), Annual Rainfall ($ARFLL$), Average Temperature (TPA), Internal Migration Rate ($INTMR$) and Climate Change Policy ($CLMCP$) within the period of twenty-four (24) years, from 2000 to 2023.

Model Specification

The main aim of this study is to determine the impact of climate change on food price inflation in Nigeria from the year 2000 to 2023. The model evolved from the assumption of linear regression in the literature, and theoretical underpinning of this study. The functional relationship between the dependent and independent variables is specified in equation 1:

$$FPINFL = f(ARFLL, TPA, INTMR, CLMCP) \quad (1)$$

The econometrics form of the model is specified by introducing parameters and the stochastic error term into the model thus:

$$FPINFL = \beta_0 - \beta_1 ARFLL + \beta_2 TPA + \beta_3 INTMR - \beta_4 CLMCP + \mu \quad (2)$$

Where: $FPINFL$ = Food Price Inflation rate; $ARFLL$ = Annual Rainfall in Nigeria; TPA = Average Rainfall; $INTMR$ = Internal Migration Rate; and $CLMCP$ = Climate Change Policy. β_0 = the slope of the model; β_1, β_2, β_3 and β_4 = the intercept of the model or the parameters to be estimated in line with *a priori* expectations; and μ = the stochastic error term.

Since the variables have different units of measurement, equation (2) is therefore transformed into a log-linear function. Hence, the natural logarithm form of the model is re-written as follows:

$$LogFPINFL = \beta_0 - \beta_1 LogARFLL + \beta_2 LogTPA + \beta_3 LogINTMR - \beta_4 LogCLMCP + \mu \quad (3)$$

Where: $LogFPINFL$ = Natural Log of food price inflation; $LogARFLL$ = Natural Log of annual rainfall in Nigeria; $LogTPA$ = Natural Log of average temperature index; $LogINTMR$ = Natural Log of Internal migration rate; and $LogCLMCP$ = Natural Log of climate change policy. μ = Stochastic Error term that captured the other variables not included in the model; β_0 = Constant or Intercept of the regression line; and β_1, β_2, β_3 and β_4 = Coefficient of the parameter estimates of all the independent variables.

DATA ANALYSIS AND RESULTS

Descriptive Statistics

Descriptive or summary statistics was performed on the data in order to analyse the stochastic properties of the data set. Thus, the result provides a summary of the descriptive analysis for each variable as captured in Table 1.

Table 1: Summary of Descriptive Statistic results

	$LNFPINFL$	$LNARFLL$	$LNTPA$	$LNINTMR$	$LNCLMCP$
Mean	10.81900	1.283714	4.401048	3.924813	5.865309
Median	10.94744	1.252502	4.408406	3.928970	5.896308
Maximum	11.23544	1.619388	4.750084	4.015301	6.030204
Minimum	10.09476	0.912283	4.029273	3.832763	5.683920
Std. Dev.	0.374013	0.170595	0.230727	0.061411	0.144870
Skewness	-0.621969	0.205264	-0.129572	-0.093349	-0.087633
Kurtosis	2.016920	2.641431	1.737198	1.641886	1.171581
Jarque-Bera	2.513828	0.297105	1.661824	1.879331	3.373833
Probability	0.284531	0.861955	0.435652	0.390759	0.185089
Sum	259.6559	30.80914	105.6252	94.19551	140.7674
Sum Sq. Dev.	3.217376	0.669364	1.224408	0.086739	0.482709
Observations	24	24	24	24	24

Source: Authors' Computation from EViews 10

It is observed from Table 1 that $LNARFLL$ has the least average value of 1.283714. $LNFPINFL$, on the other hand, has greater average value; its mean value is 10.81900 which implies approximately 100 percent relationship of $LNFPINFL$ with $LNARFLL$. Similarly, $LNFPINFL$ has the greatest median and maximum values of 10.94744 and 11.23544 respectively, followed by $LNTPA$ with median and maximum values of 5.896308 and 6.030204, respectively; other variables such as $LNINTMR$ has 4.408406 and 4.750084 of median and maximum value and $LNCLMCP$ has median and maximum value of 3.938970 and 4.015301, respectively. The implication of this low variability is that the estimates produced from these variables are not spurious. This implies that the level of significance for negative changes in those variables is less than the normal. The overall descriptive statistics result revealed that the estimates from these variables produced reliable outcomes.

One of the basic assumptions of testing normality from model is that the error term is normally distributed. Therefore, Table 1 tested normality of the ARDL model with the following hypothesis:

H_0 = the error term is normally distributed
H_1 = the error term is not normally distributed

If the Jarque-Bera statistic is greater than the probability value, we accept the null hypothesis and conclude that the error term is normally distributed in the model. The Jarque-Bera statistics for all the variables except $LNARFLL$ exceed their respective probability values and thus their error terms are normally distributed. The error term for $LNARFLL$ is not normally distributed.

Correlation Matrix Analysis

The results of the correlation analysis were examined and integrated in line with the model specified to test the strength of the relationship that exists among the variables of interest. The closer the correlation coefficient value is to 1, the stronger the correlation. Likewise, the closer the correlation coefficient is to 0, the weaker the correlation. The correlation results are presented in Table 2a.

Table 2a: Correlation Matrix

	$FPINFL$	$ARFLL$	TPA	$INTMR$	$CLMCP$
$FPINFL$	1				
$ARFLL$	-0.75178	1			
TPA	-0.50114	0.378306	1		
$INTMR$	-0.07164	-0.13142	0.215977	1	
$CLMCP$	-0.11142	0.03031	-0.07921	-0.301	1

Source: Authors' Computation from EViews 10

The correlation coefficient between these variables suggested that there is the absence of serious multicollinearity between the variables. It is observed from Table 2b that $ARFLL$ has the least average value of 94.252. $INTMR$, on the other hand, has smaller average value; its mean value is 0.323. Similarly, TPA has the greatest standard deviation and maximum values of 222.627 and 608.440, respectively, followed by $ARFLL$ with standard deviation and maximum values of 13.321 and 125.560 respectively; for other variables, $CLMCP$ has 0.510 and 1.000 as standard deviation and maximum value, respectively, and $FPINFL$ has a standard deviation and maximum value of 8.242 and 30.000, respectively. The implication of this descriptive statistics is that the estimates produced from these variables are not spurious.

Table 2b: Descriptive Statistics

	$FPINFL$	$ARFLL$	TPA	$INTMR$	$CLMCP$
Mean	14.927	94.252	246.184	0.323	0.450
Standard Deviation	8.242	13.321	222.627	0.057	0.510
Kurtosis	-0.453	0.509	-1.010	-0.234	-2.183
Skewness	0.957	0.288	0.549	-0.687	0.218
Minimum	5.100	70.480	15.620	0.203	0.000
Maximum	30.000	125.560	608.440	0.404	1.000
Count	20	20	20	20	20

Source: Authors' Computation from EViews 10

Unit Root Test

Time series data are generally characterized by stochastic trend which can make the result of the analysis spurious but can be removed by differencing. Unit root test was, therefore, used to test the stationarity or non-stationarity of the time series data in the model. This was done in order to examine if the relationship between climate change and food price inflation in Nigeria is spurious or not.

The null hypothesis for this test is that the variables are non-stationary, meaning that, there is a presence of unit root. A variable is said to be non-stationary if its test statistic is less than its critical value at various levels of significance when considered in its absolute value.

Table 3a: Unit Root Test for INTMR

Null Hypothesis: INTMR has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2013
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 5 (Automatic - based on Schwarz information criterion, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.417157	0.4316
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Table 3b: Unit Root Test for D(INTMR)

Null Hypothesis: D(INTMR) has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2008
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 5 (Automatic - based on Schwarz information criterion, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-44.40667	< 0.01
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Table 3c: Unit Root Test for TPA

Table 3c: Null Hypothesis: TPA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2017
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 4 (Automatic - based on Schwarz information criterion, maxlag=5)

		t-Statistic
Augmented Dickey-Fuller test statistic		-14.74372
Test critical values:	1% level	-4.949133
	5% level	-4.443649
	10% level	-4.193627

*Vogelsang (1993) asymptotic one-sided p-values.

Thus, from tables 3a to 3d, each time series was tested for unit roots employing Augmented Dickey-Fuller (ADF) techniques to test and verify the unit root property of the series and stationarity of the model as presented in Table 3. According to Gujarati and Porter (2009), the ADF rule states that ADF statistic must be higher than the critical values in absolute term for it to be stationary. From the unit root test results, there was a mixture of I(1) and I(0) that led to using ARDL.

Table 3d: Unit Root Test for FPINFL

Null Hypothesis: FPINFL has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 5 (Automatic - based on Schwarz information criterion, maxlag=5)

		t-Statistic
Augmented Dickey-Fuller test statistic		-2.631579
Test critical values:	1% level	-4.949133
	5% level	-4.443649
	10% level	-4.193627

*Vogelsang (1993) asymptotic one-sided p-values.

DISCUSSION OF FINDINGS

The detailed ARDL estimated result is presented in Table 4, while the summary of the result is presented below Table 4. The results showed that rainfall has a negative and statistically insignificant impact on food price inflation in Nigeria over the period under study. The null hypothesis that rainfall has no significant impact on food price inflation was rejected. The implication of the findings is mixed and implies that an increase in rainfall will thereby impact crop growth by increasing agricultural yield, due to changes in growing seasons which increases food production, food security and food availability, leading to a fall in food price inflation in Nigeria. This means that as rainfall increases in the economy it will enhance agricultural productivity by making food readily available for consumption. This will lead to a decrease in food price inflation in the economy. However, excessive rainfall leading to sea level rise has resulted to flooding which damages agricultural production. Similarly, climate change policy ($CLMCP$) impact on food inflation was negative and statistically insignificant. This implies that poor implementation of climate change policies has a significant impact on food inflation in Nigeria. The implication of the findings is also that changes (inconsistencies) in climate change policies led to food price inflation in Nigeria.

Table 4: ARDL Estimated Result

Dependent Variable: FPINFL
Method: ARDL
Date: 08/03/24 Time: 11:37
Sample (adjusted): 2001 2023
Included observations: 23 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): ARFLL TPA INTMR CLMCP
Fixed regressors:
Number of models evalulated: 16
Selected Model: ARDL(1, 1, 0, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
FPINFL(-1)	0.977036	0.078888	12.38516	0.0000
ARFLL	-0.004148	0.064316	-0.064486	0.9494
ARFLL(-1)	0.090170	0.055889	1.613370	0.1275
TPA	-0.004306	0.003727	-1.155294	0.2660
INTMR	-71.41364	56.91966	-1.254639	0.2288
INTMR(-1)	61.44355	51.88347	1.184261	0.2547
CLMCP	-1.894886	1.433051	-1.322273	0.2059
CLMCP(-1)	-2.353578	1.335179	-1.762743	0.0983

R-squared	0.949062	Mean dependent var	18.93652
Adjusted R-squared	0.925291	S.D. dependent var	10.79124
S.E. of regression	2.949556	Akaike info criterion	5.269395
Sum squared resid	130.4982	Schwarz criterion	5.664349
Log likelihood	-52.59804	Hannan-Quinn criter.	5.368725
Durbin-Watson stat	2.574503		

*Note: p-values and any subsequent tests do not account for model selection.

$$\begin{aligned}\text{FPINFL}(-1) = {} & \underset{(0.078888)}{0.977036} - \underset{(0.064316)}{0.004148\text{ARFLL}} + \underset{(0.055889)}{0.090170\ \text{ARFLL}(-1)} \\ & - \underset{(0.003727)}{0.004306\text{TPA}} - \underset{(56.91966)}{71.41364\text{INTMR}} + \underset{(51.88347)}{61.44355\text{INTMR}(-1)} \\ & - \underset{(1.433051)}{1.894886\text{CLMCP}} - \underset{(1.335179)}{2.353578\text{CLMCP}(-1)} \qquad (4)\end{aligned}$$

R^2 = 0.949062; Adjusted R-squared = 0.925291

Table 5: ARDL Long Run Form and Bounds Test

Dependent Variable: D(FPINFL)
Selected Model: ARDL(1, 1, 0, 1, 1)
Case 1: No Constant and No Trend
Date: 08/03/24 Time: 11:40
Sample: 2000 2023
Included observations: 23

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FPINFL(-1)*	-0.022964	0.078888	-0.291094	0.7750
ARFLL(-1)	0.086023	0.051796	1.660798	0.1175
TPA**	-0.004306	0.003727	-1.155294	0.2660
INTMR(-1)	-9.970096	12.29231	-0.811084	0.4300
CLMCP(-1)	-4.248464	2.092409	-2.030417	0.0604
D(ARFLL)	-0.004148	0.064316	-0.064486	0.9494
D(INTMR)	-71.41364	56.91966	-1.254639	0.2288
D(CLMCP)	-1.894886	1.433051	-1.322273	0.2059

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 1: No Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ARFLL	3.746029	12.45335	0.300805	0.7677
TPA	-0.187495	0.577726	-0.324540	0.7500
INTMR	-434.1667	1664.641	-0.260817	0.7978
CLMCP	-185.0074	635.6803	-0.291038	0.7750

$$EC = FPINFL - (3.7460 * ARFLL - 0.1875 * TPA - 434.1667 * INTMR - 185.0074 * CLMCP)$$

The findings also revealed that annual temperature rate (TPA) had negative and statistically insignificant impact on food price inflation in Nigeria. Changes in temperature and precipitation patterns, coupled with frequent flooding and droughts have led to declining crop yields, soil degradation and loss of biodiversity. The finding of this study is inconsistent with *a priori* expectation and corroborates Ladan and Badaru (2022). The internal migration rate ($INTMR$) from the findings has also impacted food availability and affordability, evident in the middle belt where violent farmer-herder clashes have claimed many lives and damaged crops and animals. This is in line with the findings of Nyong (2023).

CONCLUSION

The study examined the impact of climate change on food inflation in Nigeria for the period 2000 to 2023. The results specifically revealed the level to which rainfall, temperature rate, internal migration and climate change policies have contributed to food price inflation in Nigeria. Climate change is, therefore, a critical component of Nigeria's food security and development agenda. It has a role in exacerbating Nigeria's food security threat through increased internal migration rate leading to competition for resources between farmers and herders. Weather-related events (rainfall, droughts, floods, temperature rise) are large, consequential and significant to cause food scarcity and food price hikes in Nigeria. Though there are other factors such as monetary policy, insurgency, subsidy removal and fuel costs, that are debated to impact on inflation in Nigeria, these are outside the scope of this study. The result of this study revealed that incidences of droughts and floods have a bearing on food price inflation. Climate change policy implication is required to solve the problem.

RECOMMENDATIONS

This study offers the following key recommendations to combat food price inflation arising from climate change impacts in Nigeria:

1. Government needs to construct more dams, drainages and irrigational water space to accommodate challenges of changing rainfall. These dams, drainages and irrigational facilities will help manage changing rainfall and enhance water conservation for all season farming that will contribute to curb food price inflation in Nigeria.
2. Internal migration in Nigeria should be planned by the government by eliminating internal crisis leading to internally displaced persons so as to increase labour demand for agriculture, increasing agricultural productivity, thereby keeping food price inflation low in Nigeria.
3. Government should work on climate change policies that enhance the resilience of farmers so as to strike a balance in reducing increasing food prices and food availability so as to curb the issue of food inflation in the economy.
4. It is crucial for farmers to adopt climate-smart agricultural practices such as improved crop varieties, efficient water management techniques, and soil conservation methods to enhance resilience against climate change impacts.

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