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AGRICULTURAL LAND USE CHANGE AND FOOD SECURITY LINKAGE IN NIGERIA (1981-2023)

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Abstract
The study assessed agricultural land use change and food security linkage in Nigeria from 1981 to 2023. The study adopted a historical survey design using time series data spanning the period of 43 years from 1981 to 2023.Data on the variables were collected from the archives of World Bank and Food and Agriculture Organization database and analyzed using descriptive statistics such as mean, maximum and minimum with trend graphs, Autoregressive distributed lag model (ARDL) after testing for unit root, granger causality test and Autoregressive Moving Average (ARIMA) model. The Augmented Dickey-Fuller (ADF) test for unit roots indicated that agricultural land use change is integrated of order one, I(1), while food security is integrated of order two, I(2). This suggests that both variables follow a random walk, meaning their future values do not revert to their past values. The results from the Bound test for a long-run relationship between agricultural land use change and food security showed that the F-statistic value of 4.676068 exceeds the upper critical bound of 4.35 at the 5% significance level, confirming a long-run relationship between the two variables. Additionally, the pairwise Granger causality test revealed a significant causal link between agricultural land use change and food security. The trend forecast indicated that over the next decade, agricultural land use change is expected to follow a downward trend, while food security is projected to increase, assuming other factors remain constant. Based on these findings, the study suggests that the government should implement comprehensive food security monitoring systems to track changes in land use and food security indicators. Early warning systems could prove valuable in predicting and addressing potential food security challenges, particularly in light of declining agricultural productivity.
Keywords: Food, Land, Food security, Food sufficiency, Land use, Land use change, Linkage, Co-integration, ARDL

Introduction

Agricultural land use change is a significant factor that affects agricultural productivity, particularly in developing countries like Nigeria where agriculture plays a crucial role in the economy.Agricultural growth has been known to play key role in the sustenance of economic development in Nigeria (Aremu *et al.,* 2023).Agriculture has been identified as one of the major users of land resources in the world, with about 37.7% total land area either under arable cultivation or permanent plantation (World Bank, 2023). In sub-Saharan Africa, the percentage of agricultural land is put at 43.8% of the total land area (Food and Agricultural Organization, 2014). Changes in land use have been identified as a significant challenge to both global and local food security (Adamgbe& Ujo, 2012; Ali *et al.*, 2021). Recent perspectives have emerged, highlighting the evolving nature of Agricultural Land Use Change (ALUC)—the transformation of agricultural land into non-agricultural uses or the conversion of natural vegetation into agricultural land (Josea & Padmanabhan, 2016). Some studies suggest that agricultural land use is expanding (Boateng, 2013; Gutzler, 2015), while others report a decline in agricultural land availability (Alagbe *et al.*, 2013; Belay, 2014; Doso, 2015). The expansion of agricultural land has clear environmental consequences, while the reduction in agricultural land raises more serious concerns for food security.

The rate at which farmlands are being converted for other purposes such as urban infrastructures (housing and industrial structures), transportation infrastructures (mainly road construction), tourism and recreational amenities is alarming (FAO, 2014; Saleh *et al.*, 2014). Increase in soil degradation has negatively impacted on food production and this therefore necessitates sound land management practices (Ezekiel *et al.*, 2019). Consequently, these land development projects have given rise to decrease in lands that are supposed to be used for food production (Ali *et al.*, 2021).Thus, reducing the chances of crop production, this consequently has significant effect on food security. The achievement of food security has been the preoccupation of successive governments in Nigeria wherethe issue of food security recently has gained prominence among scholars (Mason *et al.*, 2020; Allee *et al.*, 2021; Alim *et al.*, 2022).This is as a result of the understanding that adequate food supply has a direct bearing on the welfare of the people (Nzeh, 2023).According to Akpan *et al.*,(2019), the distribution of sustainable allocative efficiency of resources indicates that the farmers still have a lot to learn from the sustainable resource mix that produces equality of marginal social benefit and marginal social cost.

According to the report of World Food Program (WFP) the share of those in stressed food security situations with minimally adequate food consumption is at 34% of the population in 26 states in Nigeria and the Federal Capital Territory (FCT), it further reported that the acute food insecure population has risen by 5.4 million people to 17 million over the past year(WFP, 2022).

In recent decades, advancements in land-use research have enhanced the understanding of how changes in agricultural land use negatively impact productivity, contribute to soil degradation, and lead to biodiversity loss. Studies such as Boateng (2013), who explored agricultural production, land-use change, and desertification in the West African Savannah through a political ecology lens, and Belay (2014), who examined the effects of urban expansion on agricultural land use using remote sensing and GIS in Gondar, Ethiopia, have contributed significantly to the field. However, research linking agricultural land use changes directly to food security remains limited. As a result, this study aimed to test the following null hypotheses:

Ho1: There is no long-run relationship between agricultural land use change and food security in Nigeria.

Ho2: There is no Granger causality between agricultural land use change and food security in Nigeria.

Methodology

Study Area

The study was carried out in Nigeria. Nigeria has a total geographical area of 923,768 square kilometers constituting a land area of 910768 square kilometers and water area of 13000 square kilometers respectively. It has coaster lines of 853 square kilometers and is located on the Gulf of the Guinea in West Africa. Nigeria is one of the eight most populous countries in the world, with an estimated population of around 140 million (NPC, 2006). With a population growth rate of 2.6%, it is projected to reach approximately 218.87 million by 2023 (World Bank. (2023). Situated entirely within the tropics along the Gulf of Guinea on West Africa's coast, Nigeria's topography varies from mangrove swamps along the coastline to tropical rainforests and savannahs further north. The country is located between latitudes 4°16' and 13°53' North and longitudes 2°40' and 14°41' East (Central Intelligence Agency, 2009).

The country is divided into seven agro–ecological zones. These are semi-arid, found in the northern region, savannah, found in the northern and middle region, a small high land area found in the middle and southern regions, a larger transition environment of savannah derived from the forest overlapping the southern and middle regions; mangroves in the Niger Delta; freshwater swamps in the Niger Delta and lowlands rainforest in the South. The annual rainfall in these zones varies from as low as 250mm in the extreme north-eastern part to 750mm in the southern part (Library of

Congress, 2006). Climatically, Nigeria is equatorial in the south, tropical in the centre and arid in the north. Mean maximum temperature ranges from 30-32^{0}c in the south and 33-35^{0}c in the north (Library of Congress, 2006). The climate varies with equatorial in south, tropical in centre and in the north. There are two seasons – the wet season (April-October) and the dry season (November-March). In terms of employment, at least 60% of Nigeria'spopulation is estimated to be engaged or employed in agriculture (mainly small holders). The major crops produced in the country include millet, sorghum, rice, maize, cassava, yam, groundnut, cocoa amongst others.

Data Collection and Data Analysis Techniques

The study relied on the use of time series data spanning from 1981 to 2023. Data on the variables for the study were collected from the archives of World Bank and Food and Agriculture Organization database. Data for this study were analyzed using both descriptive and inferential statistics. In this study, various analytical techniques were employed, including descriptive statistics, the Autoregressive Distributed Lag (ARDL) model, the Granger Causality Test, and the Autoregressive Moving Average (ARIMA) models.

Results and Discussion

Preliminary Analysis

Summary statistics of the variables

Table 1. Summary Statistics of Variables

	Agricultural Land Use	Food Security
Mean	64087.20	244915.8
Median	65705.68	88757.38
Maximum	69902.80	1047458.
Minimum	56649.00	1853.140
Std. Dev.	4284.746	296372.6
Skewness	-0.579788	1.100461
Kurtosis	1.876613	3.082238
Jarque-Bera	4.670182	8.691061
Probability	0.096802	0.012965
Sum	2755750.	10531379
Sum Sq. Dev.	7.71E+08	3.69E+12
Observations	43	43

Source: Data analysis, 2024.

Unit Root Test

Model Specification

Autoregressive Distributed Lag (ARDL) Model

The study utilized the Autoregressive Distributed Lag (ARDL) approach to co-integration to investigate the long-run relationship between agricultural land use change and food security in Nigeria from 1981 to 2023. The ARDL bound test method is increasingly favored in economic and finance research, offering an alternative to traditional co-integration methods such as those developed by Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990).

The ARDL model can be expressed as follow:

$$\Delta FST_t = \beta_O + \beta_1 \sum_{i=1}^{n} \Delta FST_{t-i} + \beta_2 \sum_{i=0}^{n} \Delta ALUC_{t-i} + \beta_3 FST_{t-i}$$

Where:

Δ denotes the first difference operator, FST represents food security, and ALUC stands for agricultural land use change. The variable t indicates the time period, while Ln refers to the natural logarithm. α0 represents the drift component, u is the error term, and k signifies the lag length. The parameters β1, β2, β3, and β4 represent the long-run coefficients.

As an essential preliminary test, the Augmented Dickey-Fuller (ADF) test for unit roots was conducted to assess the stationarity of the variables and determine their order of integration. The results (Table 2) showed that agricultural land use change is integrated of order one, becoming stationary after the first differencing, while food security is integrated of order two, achieving stationarity after the second differencing. This suggests that both variables follow a random walk (unit roots), meaning their future values do not revert to past values.

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

Variables	Level				First Difference				Second Difference				
	ADF	1%	5%	10%	ADF	1%	5%	10%	ADF	1%	5%	10%	Inference
ALUC	-1.95	-3.61	-2.94	-2.61	-9.78***	-3.61	-2.94	-2.61					I(1)
FDSEC	10.96	-3.60	-2.93	-2.60	1.54	-3.62	-2.94	-2.61	-5.45***	-3.62	-2.94	-2.61	I(2)

ALUC = Agricultural Land Use Change; FDSEC = Food Security *** Significant at 1%;
Source: Data Analysis, 2024.

Lag Length Selection Criteria

Table 3 contains the result of the lag length selection criteria for this study. A VAR model was applied to the time series data to determine the suitable lag structure for the analysis. The optimal lag length was selected based on six different criteria, with the Akaike Information Criterion (AIC) being chosen due to its lowest value of -1.257059 at lag 3. As a result, lag 3 was determined to be the most appropriate lag for the model.

Table 3: Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-97.83229	NA	0.035341	5.170886	5.298853	5.216800
1	34.24833	237.0678	6.43e-05	-1.140940	-0.629075*	-0.957287*
2	41.05010	11.16187	7.26e-05	-1.028210	-0.132446	-0.706818
3	54.51265	20.02122*	5.91e-05*	-1.257059*	0.022604	-0.797927

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: Data Analysis, 2024.

Long Run Relationship among Agricultural Land Use Change and Food Security in Nigeria

Since the Augmented Dickey-Fuller (ADF) test for unit roots indicated that the variables are stationary after first and second differencing (i.e., I(1) and I(2)), the Autoregressive Distributed Lag (ARDL) approach was used to examine the potential long-run relationship between the variables. One of the key benefits of applying the ARDL method in this case is its ability to address the biases arising from the mixed order of co-integration and to provide long-run coefficients within the same model. The results of the long-run relationship between agricultural land use change and food security are shown in Table 4. The findings indicate that the F-statistic value of 4.676068 exceeds the upper critical bound value of 4.35 at the 5% significance level. This suggests that a long-run relationship exists between agricultural land use change and food security in Nigeria. Consequently, the null hypothesis, which proposed no long-run relationship between these variables, is rejected.

Table 4: ARDL Bounds Test for Long Run Relationship between Agricultural Land Use Change and Food Security

Test Statistic	**Value**	**K**
F-statistic	4.676068	3
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

Source: Data Analysis, 2024.

Causal Relationship Between Agricultural Land Use Change and Food Security in Nigeria

To investigate the causal relationship between agricultural land use change and food security in Nigeria, a pairwise Granger causality test was conducted using an optimal lag length of three. The results, presented in Table 5, indicate a significant relationship between the two variables. Specifically, the findings suggest a unidirectional causality from agricultural land use change to food security at the 10% significance level. This means that past values of agricultural land use change can be used to predict future food security levels. As a result, the null hypothesis, which posited no Granger causality between agricultural land use change and food security, is rejected.

The causal relationship between these variables in Nigeria is interconnected, as the loss of arable land—driven by factors such as urbanization, industrialization, and deforestation—reduces the land available for crop cultivation. This decline in available land has contributed to a decrease in food production, leading to higher food prices and making it increasingly difficult for many Nigerians to access affordable and nutritious food, which are essential components of food security. This is in line with the findings of Adeyemo (2019) who reported that the conversion of agricultural land for industrial development has resulted in the loss of fertile land and reduced agricultural productivity, leading to food insecurity in affected communities.

Table 5: Granger Causality Test of the Relationship among Agricultural Land Use Change, Cereal Crops Production and Food Security in Nigeria

Null Hypothesis:	**F-Statistic**	**Prob**	**Decision**
LNAGRIC_LAND does not Granger Cause LNFOOD_SEC	3.00875	0.0568	Rejected
LNFOOD_SEC does not Granger Cause LNAGRIC_LAND	0.19332	0.8251	Accepted

Source: Data Analysis, 2024.

Forecast of the Trend of Agricultural Land Use Change and Food Security in Nigeria in the Next Decade

The ARIMA model was employed to forecast the trends in agricultural land use change and food security in Nigeria over the next 10 years. The forecasted trend for agricultural land use change (Figure 1) indicates a decline from 2023 to 2026, reaching its lowest point. Following this, an upward trend is expected for the next two years, and from 2028 onwards, agricultural land use change is projected to stabilize until 2033. Overall, agricultural land use change is anticipated to follow a downward trajectory over the next decade, assuming other factors remain constant. This aligns with the findings of Eberechukwu *et al.,* (2019), which reported an increasing trend in built-up areas and a corresponding decrease in agricultural lands between 1980 and 2015. Additionally, Figure 2 presents the forecasted trend for food security over the coming decade. The results suggest that food security will improve, with a steady increase starting in 2023, peaking in 2027, and then remaining relatively stable through 2033. In general, food security is expected to rise over the next decade compared to current levels. This indicates promising prospects for improving food security in Nigeria, provided that effective policies and programs are implemented to address the decline in cereal crop production and the changing patterns of agricultural land use.

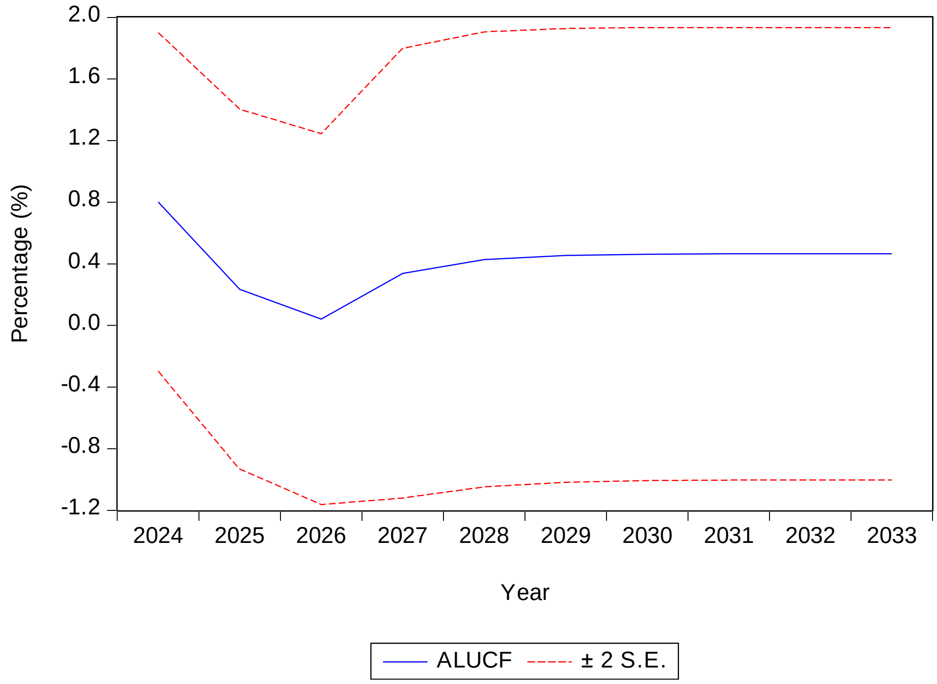

Figure 1. Forecast Plot of Agricultural Land Use Change from 2024 to 2033

Source: Data Analysis, 2024.

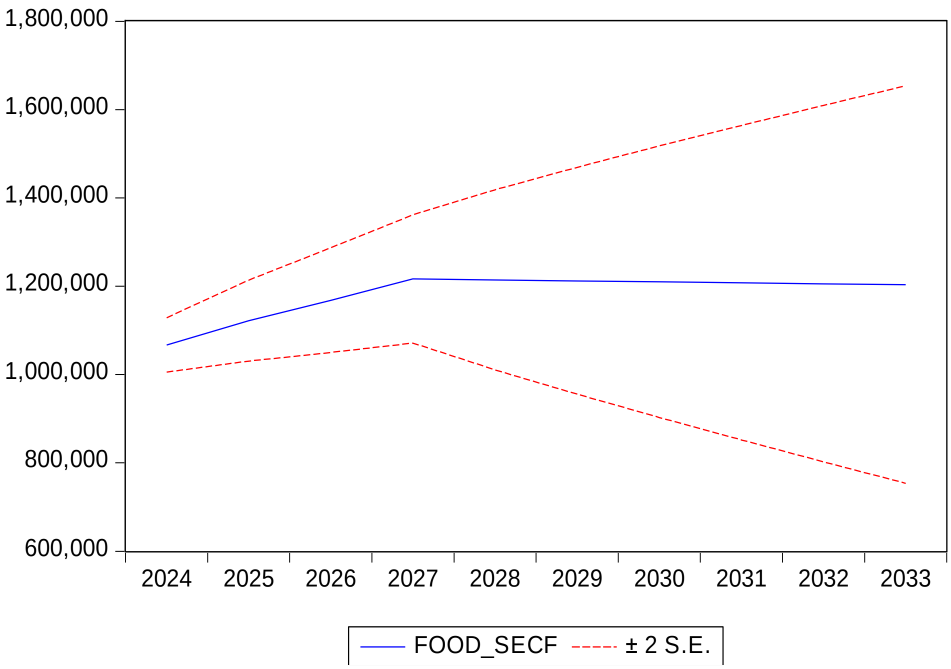

Figure 2. Forecast Plot of Food Security from 2024 to 2033

Source: Data Analysis, 2024.

Conclusion and Recommendations

The study assessed agricultural land use change and food security linkage in Nigeria from 1981 to 2023. The study reveals a significant relationship between agricultural land use changeand food security in Nigeria long run. The analysis indicates that agricultural land use change has a causal influence on food security, with long-run relationships evident among the variables. However, the future forecast suggests a potential decline in agricultural land use which could pose a threat to food security despite the expected increase in food security trends. The study underscores the importance of sustainable agricultural practices and efficient land use to ensure food security in the coming years.

The following recommendations were made:

i. Efforts should be made by all stakeholders to encourage the adoption of sustainable farming techniquessuch as crop rotation, conservation tillage, and organic farming that can help to maintain soil fertility and increase crop productivity over time;

ii. Policy makers should develop and enforce policies that prevent the conversion of agricultural land to non-agricultural uses, ensuring that sufficient land remains available for crop production. This is essential for maintaining food security in the long term; and

iii. Government should establish robust food security monitoring systems to track trends in land use, and food security indicators. Early warning systems can help anticipate and mitigate potential food security crises, especially in the face of declining agricultural productivity.

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