Journal of Agriculture, Environmental Resources and Management

www.saerem.com

ISSN2245-1800(paper) ISSN 2245-2943(online)

6(5)1-800; **September.** 2024; pp88-104

Analysis of output and yield of maize in Nigeria from 1970 – 2022

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Abstract

The paper analysed the output and yield of maize in Nigeria from 1970 – 2022. Time series data was used and they were sourced from the Central Bank of Nigeria Statistical Bulletin and Food and Agriculture database. Data were analyzed using Ordinary Least Square (OLS) and Johansen method of co-integration. The exponential trend and growth rate result revealed that time was a feasible variable in determining the output and yieldof maize during the period of study. However, maize output experienced an increased growth rate of 6.74%, while that of maize yield was relatively slow at 1.61% respectively. Further result showed that, government expenditure on agriculture, quantity of fertilizer distributed, producer prices of competing crop and that of maize were the significant factors that influenced maize output and yield in the long-run, while previous year's output and yield of maize, lagged producer prices of maize and that of competing crop, lagged hectarage of maize, lagged government expenditure and rainfall affected the short-run response of maize in the short- run. The estimated dynamics of adjustment was negative and feasible at 1% level. The ECM (-1) was 219% and 119% for maize output and yield respectively. It was recommended that measures that could increase land area under cultivation should be put in place, to ensure a harmonization between output, yield and acreage cultivated and there should be continuous government support to the sector to boost maize production in Nigeria.

Keywords: Output, yield, ARDL, maize, co-integration and ECM.

Introduction: Nigeria is basically agrarian in nature with over 80% of her food requirement being produced by small scale farmers. The economy relies on the agricultural sector both as the leading foreign exchange earner and for subsistence particularly among smallholder farmers. The sector has contributed 20.98% to nominal gross domestic product (GDP) in 2016 as against 20.63% it contributed in 2015. In 2022, agriculture contributed around 21.2% of Nigeria's GDP. Crop production significantly contributed to the growth in the sector accounting for a growth share of 82.6% (National Bureau of Statistics, 2021). Despite market reforms put in place in Nigeria, bothinstitutional and structural factors had limited food supply response. The food supply response in Nigeria has been limited by structural and institutional constraints that have persisted despite market reforms. Nigeria is faced with the shortage of staple food with the attendant result of soaring prices and rising importation of these commodities. Maize is a staple food in Africa and constitutes a major part of the human diet. Among the cereals, it remains a significant staple crop in Sub-Saharan Africa (FAOSTAT, 2021). It is regarded as the benchmark for food security after cassava in terms of calorie intake but there still remains a shortage of food grains. Nigeria remains one of the leading African producers of maize, with nearly 1720MT and an estimated yield of 1.65MT per hectares (FAO, 2020). Maize has experienced an increase in output and yield overtime, due to extension of cultivated land. Its production increased from 1720metric tons to 11000metric tons from 1980 to 2018. Despite the increase in production, Nigeria is still below the 4.3tons/ha average world requirement (FAO, 2020). Production has not been able to meet up with rising food and industrial needs of the country, with inability of supplyto meet the rising demand. This is due to low yields of maize and the slow nature of farmers to adopt new techniques of maize production Onuk, Ogara, Yahaya, and Nannim (2010) pest and diseases, poor storage facilities and price fluctuation.

Over the years, several programmes have been designed to solve the problems of food supply in Nigeria (CBN, 2019). Programmes such as the National Accelerated Food Production Programmes (NAFPP, 1970), the Green Revolution (GR, 1980), Directorate of Food, Roads and Rural Infrastructure (DFRRI, 1986), Structural Adjustment Programme (SAP, 1986) and New Agricultural Policy (NAP, 1988). In spite of all the programmes and which the country acclaims to have resource advantage in production, Nigeria is still deficient in the supply of staple crops for its teeming population, relying on imports to supplement domestic production. The shortfall is influenced by prices, yield, area cultivated, types of seeds planted, method of storage/processing, government policies, availability of funds and weather.

The quantity and quality of crops produced does not equate the investment done to the sector and as a result of this, a gap has been created between what is actually needed and supplied. However, the Nigerian government embarked on two new policies such as Agricultural Transformation Agenda (2011 - 2015) and Agricultural Promotion Policy (2016 - 2020) in order

to transform agriculture from a development oriented to an agribusiness Ajah, Etowa, Effa, Ofem, Iso, Ettah and Asuquo (2024). The Agricultural Transformation Agenda looked at ways of improving the production of seven crops in which maize is inclusive. Hence, this paper seeks to examine the trend and growth rate of maize output and yield and estimate the long and short-run effect of price and non-price variables on maize output and yield.

Theoretical and empirical framework: The study adopts the concept of supply response in agricultural production. This concept measures the extent to which the level of production varies in response to stimuli provided by variation in relevant variables. It explains the behavioural variation of producers with respect to production, consumption and exchange decision of a certain product Nkang, Ndifon and Edet (2007) and Asuquo, Agbachom and Ettah (2024). The response may be triggered by variation in hectarage, technological variations, prices, weather and market information. Basically, it deals with factors that move the supply curve (Akanmi and Okeowo, 2011).

Several approaches have been used to model supply response study. This includes the Nerlovian approach, OLS approach and co-integration approach. The Nerlovian approach used OLS to estimate the supply response. It is based on the assumption that the variables are stationary (Ajetomobi, 2010). Using OLS with non-stationary variables may result in spurious regressions (Granger and Newbold, 1974). To avoid this problem, co-integration analysis can be used(Banerjee, Glabraith and Hendry, 1993). Nkang *et al.* (2007) addressed maize supply responsiveness in Nigeria and reported that the response of real maize prices is higher in the short run and with a higher adjustment toward long-run. Nanseki and Ogundari (2008) examined the response of Maize supply to prices in Nigeria. ARDL was used as the analytical tool. Empirical result showed that price elasticity of maize supply to own price was inelastic and significantly significant. The study attributed the low response of maize supply to own price, lowadjustment speed to the effect of non price incentives on maize production. Phiko (2013) conducted a study on the response of maize hectarage in Malawi using Auto-regressive distributive lag model (ARDL). Results showed that the coefficient of fertilizer distributed and own hectarage was positive and significant at 5% and 1% respectively. Estimated elasticity for both variables was inelastic. Maize price and weather were not significant while labour was significant with a negative coefficient. Igwe, Okoye and Joe-Nkamuke (2011) analyzed the supply response of maize producer in Nigeria. Ordinary least square (OLS) was used as the analytical tool. Study results indicated that hectarage of maize and own price had a positive and significant response on maize supply. Both variables were inelastic while that of export and price of substitute was negative and inelastic. Maize import had a positive coefficient and was elastic.

Methodology: The study area is Nigeria, found in West Africa between latitudes 4^0 to 14^0 north and longitude $2^0 2^1$ and $14^0 30^1$ Ayinde, Bessler and Oni (2014). It is surrounded by Niger Republic and Chad both in the north, Benin Republic (west), Cameroon Republic (east) and Atlantic Ocean (south). It has a population of over 200 million persons (CBN, 2018). Agriculture remains the mainstay of rural communities and provides employment for work force. Maize is a major staple crop grown in thearea. Annual time series data from 1970 to 2018 were obtained from Central Bank of Nigeria bulletin and FAOSTAT and used for the study.

Analytical Procedure: The exponential trend equation was used to analyze the trends of supply (yield) of maize in Nigeria from 1970 – 2022. This followed works by Malkasuwa and Alu (2013) and Ettah *et. al.*, (2024). The model is shown as:

$$Y = \beta_0 e^{\beta_1 t} \quad (1)$$

Transforming the equation in linear form it becomes

$$LnY = \beta_0 + \beta_1 t + u_t \quad (2)$$

Where:
Y = Output and yield of maizeβ_0 =
Intercept
β_1 = Slope
t = Time trend
u_t = error term
The time trend coefficients obtained from equation (2) was used to get the growth rate (r). Theformula was shown as:

$$r = (e^{b_1} - 1) * 100 \quad (3)$$

Where:
e = Euler's exponential factor (2.71828)

Similar model was used for output and yield of maize. The dependent variable were maize output(tonnes) and maize yield (t/ha).

The general model for maize response was stated as follows;

$$LnY = \beta_0 + \beta_1 LnPP_{t-1} + \beta_2 LnPPR_{t-1} + \beta_3 LnFERT_{t-1} + \beta_4 LnRF_t + \beta_5 LnGEA_{t-1} + \beta_6 LnHAC_t + \beta_7 + \beta_8 LnY_{t-1} + u_t \quad (4)$$

LnY= Natural logarithm of output(t) and yield maize (t/ha);
$LnPP_{t-1}$ = Natural logarithm of lagged producer price of selected tuber crops (₦/tonne);
$LnPPR_{t-1}$ = Natural logarithm of lagged producer price of alternative crop (rice) in year,t(₦/tonnes)
$LnFERT_{t-1}$ = Natural logarithm of Quantity of fertilizer distributed to tuber crops farmers lagged1 year (metric tonnes)
$LnRF_t$ = Natural logarithm of weather variable (rainfall)(mm)
$LnGEA_{t-1}$ = Natural logarithm of lagged government capital expenditure on agricultureLn HA_{t-1} = Natural logarithm of lagged hectarage of selected tuber crop in year t;
LnY_{t-1} = Natural logarithm of lagged tuber crops outputB's = slope (elasticity)
β_0 = constant term or interceptu$_t$= stochastic residual term.
Ln= Natural logarithm

Model estimation procedure: The study adopted Johansen Maximum Likelihood technique of co-integration. An initial test of unit root was carried out to ascertain the integration order, followed by a test of cointegration. The presence of cointegration among the variables willpermit the estimation of a vector error correction model.

Test for unit roots: Augmented Dickey – Fuller (ADF) tests was used to test the variables forthe existence of unit root. The ADF equation is described in in equations (4)

$$\Delta Y_t = \alpha + \partial Y_{t-1} + \Sigma\gamma\Delta Y_{t-j} + e_t \quad (5)$$

Where: Y = series to be tested, ΔY_t = 1st difference of Y_t, ∂ = test difference coefficient, j = lag length, e_t = white noise and t = trend variable. From the equation, the significance of ∂ is tested against the test hypothesis. If the test hypothesis is accepted, the variables are differenced to become stationary.

Test of co-integration: Augmented Dickey – Fuller ADF and Vector Error Correction Model in equation (6) was adopted to test for co-integration. This was done using the Johansen method which uses both trace test and maximal-eigen value to ascertain the existence of co-integration. The test hypothesis of at most r co-integrating vectors was tested against the alternative. If co- integration exists; a vector error correction model is specified. VECM was stated based on the presence of co-integration among the variables. Based on this, the vector error correction mechanism (VECM) was specified as follows:

$$\Delta Z_t = \beta_0 + r_1\Delta Z_{t-1} + r_2\Delta Z_{t-2} + ... + r_{p-1}\Delta Z_{t-p+1} + \pi Z_{t-p} + \psi X_t + u_t \quad (6)$$

Where:

Z_t = vector of jointly determined dependent variable

.β_0 = vector of parameters (intercept)

ψ, π, r_i = matrix of parameters

X_t = vector of stationary explanatory variableΠ =

long- run impact matrix

α = dynamics of adjustment parameteru_t=

vector of random variables

Given the VECM in Equation (5), long-run cointegrating equation for maize was specified as:

$$\Delta LnY = \beta_{10} + \sum_{i=1}^{n}\beta_{11}\Delta LnY_{t-1} + \sum_{i=1}^{n}\beta_{12}\Delta LnPP_{t-1} + \sum_{i=1}^{n}\beta_{13}\Delta LnPP_{A-1} + \sum_{i=1}^{n}\beta_{14}\Delta LnGEA_{t-i} + \sum_{i=1}^{n}\beta_{15}\Delta LnFert_{t-1}$$

$$+ \sum_{i=1}^{n}\beta_{16}\Delta LnHA_{t-1} + \alpha_1(LnY - LnPP - LnPP - LnGEA - LnHA - LnFert)_{t-1} + LnRF + u_t \quad (7)$$

Results and Discussion: The estimate of output and yield trend is shown in Table 1. The trend equation had a good fitwith an estimated R^2 value of 0.75 and 0.61and high and significant F-value of 130.55 and 66.43 for maize output and yield respectively. The result obtained showed that time was significant in influencing output and yield of maize. Also, a positive and rising trend of output and yield of maize was experienced within the study period. This suggests that government policies such as SAP, Agricultural Transformation Agenda (2011-2015) and Agricultural Promotion Policy (2016-2020) towards maize production have been favourable. The findings agree with Oyakhilomen and Emmanuel (2012) and Agwu, Alamba and Nwachukwu (2010). However, the growth rate for maize output and yield was 6.74 percent and 1.61percent respectively (Fig.1). This shows an increase in the growth rate of maize output but relatively low process of growth in the yield of maize during the period of study.

The slow growth rate in maize yield could be attributed to the fact that increase in hectarage did not give a corresponding increase in output see (Fig 2). This slow growth rate in yield could be ameliorated by the utilization of improved variety, improved advisory services and making inputs available tomaize farmers. Tahir (2014) conducted a study on trends of productivity of maize and sorghum in Nigeria between 1983 and 2008. Trend analyses show a decline in the growth rate for the crops of study. The current trend of productivity with respect to maize was strong at 0.678 and relatively weak for sorghum at 0.292.

Tests for stationarity

Table 2 shows the ADF and PP test on the log-level series of the variables. The ADF test result indicated that the entire variable was not stationary at I (0) but were made stationary after differencing I (1). After differencing, hectarage of maize was significant at 10%.

Co-integration tests

From the result in Table 3, it is revealed that the trace and maximum eigen value shows the presence of co-integration between maize output and yield and some of its determinants as indicated by their number of co-integrating relationship. This suggests that there is a unique long-run equilibrium relationship between maize output and yield with other exogenous variables for the selected three crops.

Maize output

Table 4 shows the results of the long-run and short-run estimates for supply response of maize output. Lagged producer price of maize and competing crop (rice) was inelastic for both short- run and long-run. Specifically, the long-run and short-run elasticity for lagged producer price of maize was 0.0897 and 0.2696, while that of competing crop (rice) was 0.2228 and 0.3250. The positive elasticity estimate obtained for producer price of rice shows that maize and rice are complementary products. The elasticity for producer price of maize was consistent with *a priori* expectation. This agrees with the statement of Mapila (2011) that maize production is both income and price inelastic'. The result shows a contrast with that of Igwe, Joe-Nkamuke and Okoye (2011) who obtained a positive and significant coefficient for producer price of maize and a negative and non-significant relationship for price of competing crop in their study.

Lagged Fertilizer distribution elasticity of maize output is -0.1735 in the long-run was significant at 1%while that of short-run was -0.0252 and not significant. The negative elasticity of fertilizer can be attributed to the substitutability nature of fertilizer in production. Conversely, the elasticity of weather variable (0.1569) is positive and statistically significant at 1%. This implies that increased rainfall will enhance increase maize output. This is in line with the findings of Nkang, Ndifon and Edet (2007) who obtained a positive and non-significant relationship between maize supply and weather variable. Elasticity estimate of lagged hectarage of maize with respect to maize output was negative for both long-run (-1.0701) and short-run (-1.3828).Its effect was significant at 1% in the short-run.

The elastic nature of this variable suggests that an increase in the area for maize cultivation will result to an increase in maize output. Similar result was obtained for lagged government capital expenditure. Elasticity estimate was negative and statistically significant for both long-run (- 0.1041) and short-run (-0.1177) at 1% and 5%. This implies that provision of infrastructure, subsidy and other inputs to maize farmers did not yield the expected increase in maize output. The approximated elasticity of the lagged output of maize is 0.8926 and statistically significant at 1%. The error correction coefficient was negative (-2.1953) and feasible at 1%. This reflects feedback of 219% of the past year's disequilibrium from long-run elasticity of maize output with price and non-price variables.

Maize yield: From the result in Table 4, the coefficient of ECM (-1) term is negative (-1.1866) and feasible at 1% level. This reflects feedback of 118% of past year's disequilibrium from long-run elasticity of maize yield and its influencing variables. Further result showed that, both long-run (0.2322) and short-run (0.3109) estimate for lagged producer price of maize was positive and inelastic. Estimated elasticity for both long-run and short-run was statistically significant at 10% and 5% respectively. This implies that an increase in producer price of maize will increase maize yield inboth periods. Negative elasticity was obtained for lagged producer price of competing crop (rice)for both long-run (-0.1768) and short-run (-0.4641). The short-run elasticity was statistically significant at 5%. This shows that maize and rice are competitive in terms of yield. Lagged government capital expenditure on agriculture and lagged fertilizer distribution had a negative and significant effect on maize yield in the long-run. However, in the short-run, lagged government capital expenditure on agriculture was positive and not significant, while lagged fertilizer distribution was negative and not significant. The elasticity of weather variable (rainfall) was positive (0.2395) and feasible at 1%. This suggests that increased rainfall would lead to increased maize yield. Also, previous year's maize yield had a significant and positive effect on maize yield. The elasticity estimate was positive (0.4182) and statistically significant at 10%.

Conclusion and Policy Recommendations

The study analyzed the potential drivers of output and yield response of maize supply in Nigeria. It revealed that maize output and yield exhibited an increased trend during the period of study. However, maize output witnessed an increased percentage growth rate, in contrast to that of maize yield which was relatively slow. The feasible potential drivers of output and yield of maize is own price, prices of rice, government expenditure on agriculture, hectarage and rainfall. The effect of price variables was more significant in the long-run than in the short-run. The studyrevealed that the output and yield response of maize were price inelastic in the long-run and short-run, while hectarage allocated to maize was elastic both in the long and short-run. It was concluded that that maize output and yield are more responsive to price variables and non-price variables. Based on this conclusion, the following policy recommendations were made: Policy on consolidation of smallholder land holdings to reach economies of scale should be encouraged as long as available land does not constrain efforts to increase production should be adopted. Measures that can increase land area under cultivation should be put in place, ensure a harmonization between output, yield and acreage cultivated cum ensure continuous government support to the sector to boost maize production. Policies capable of exploring the long-term agricultural package with element of priceand non-price incentives should be adopted. Policy which promotes better responses for maize producers should be adopted. The recommended fertilizer that can boost maize output and yield should be distributed to the farmers.

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Table 1: Estimated trend and growth rate of maize output and yield in Nigeria (1970-2022)

	Coefficient	**R^2**	**Fcal**	**Growth rate (%)**
		Maize output		
Constant	13.4297 (0.1508)***	0.75	130.55***	6.74
Time	0.0652 (0.0057)***			
		Maize yield		
Constant	9.1284 (0.0518)***	0.61	66.43***	1.61
Time	0.0160 (0.0020)***			

Source: Computed from FAO data (2022); Values in brackets = standard error; *** = 1% level of probability

Table 2: Estimates of ADF unit root tests

Variable at level	ADF statistic	PP statistic	Variable Diff	ADF statistic	PP statistic	Order of Integration
LnPM	-0.6818	-0.7202	ΔLnPM	-6.8251***	-6.8307***	I(1)
LnHAM	-1.4809	-1.0216	ΔLnHAM	-2.7773*	-6.3926***	I(1)
LnYDM	0.4944	-1.9353	ΔLnYDM	-5.1051***	-2.1383*	I(1)
LnPPM	-0.8159	-0.9384	ΔLnPPM	-8.4852***	-8.6519***	I(1)
LnPPR	-1.0691	-1.0705	ΔLnPPR	-7.5378***	-7.4622***	I(1)
LnGEA	-0.3849	-0.8700	ΔLnGEA	-6.7518***	-9.3624***	I(1)
LnFERT	-1.7006	-2.8317**	ΔLnFERT	-2.9546**		I(1)
LnRF	-0.9785	-0.9785	ΔLnRF	-8.2118***	-8.0271***	I(1)

Notes: ***, ** and * = Significant at 1%, 5% and 10% level; PM= output of maize; HAM = hectarage of maize, YDM = yield of maize, PPM = producer price of maize, PPR = producer price of rice, GEA= governmental capital expenditure on agriculture; FERT = fertilizer distribution; RF = rainfall

Table 3: Estimates of Multivariate cointegration tests for maize output and yield

		Trace	**Maximum**	**Eigenvalue**			
			Maize output				
None *	0.8170	173.5963	125.6154	None *	0.8170	73.0343	46.2314
At most 1 *	0.5284	100.5620	95.7537	At most 1	0.5284	32.3176	40.0776
At most 2	0.4802	68.2444	69.8189	At most 2	0.4802	28.1386	33.8769
At most 3	0.4249	40.1058	47.8561	At most 3	0.4249	23.7914	27.5843
At most 4	0.1785	16.3144	29.7971	At most 4	0.1785	8.4535	21.1316
At most 5	0.1317	7.8608	15.4947	At most 5	0.1317	6.0698	14.2646
At most 6	0.0408	1.7909	3.8415	At most 6	0.0408	1.7909	3.8415
			Maize yield				
None*	0.5435	87.2274	95.7537	None*	0.5434	33.7178	40.0775
At most 1	0.4287	53.5096	69.8188	At most 1	0.4286	24.0721	33.8768
At most 2	0.2751	29.4375	47.8561	At most 2	0.2750	13.8338	27.5843
At most 3	0.1809	15.6038	29.7971	At most 3	0.1809	8.5836	21.1316
At most 4	0.1499	7.0201	15.4947	At most 4	0.1499	6.9852	14.2646
At most 5	0.0008	0.0349	3.8415	At most 5	0.0008	0.0349	3.8415

Source: Computed from Eview result; * = non-acceptance hypothesis at 5% level.

Table 4**:** Long-run and short-run vector error correction model estimates of maize outputand yield

Regressor	Coefficient(maize output) Long-run estimates	Regressor	Maize yield Coefficients
LnPM	1.000000	LnYDM	1.000000
LnPPM	0.0897 (0.0732)	LnPPM	0.2322 (0.1260)*
LnPPR	0.2228 (0.0896)**	LnPPR	-0.1768 (0.1287)
LnHAM	-1.0701 (0.0386)	LnFERT	-0.1325 (0.0345)***

LnFERT	-0.1735 (0.0236)***	LnGEA	-0.0586 (0.0239)**
LnGEA	-0.1041 (0.0124)***		
	Short-run estimates		
Error correction	Δ(PM)	Error correction	Δ(YDM)
ECM(-1)	-2.1953 (0.3898)***	ECM(-1)	-1.1866 (0.3341)***
ΔLnPM(-1)	0.8926 (0.2251)***	ΔLnYDM(-1)	0.4182 (0.2229)*
ΔLnPPM(-1)	0.2696 (0.1260)	ΔLnPPM(-1)	0.3109 (0.1435)**
ΔLnPPR(-1)	0.3250 (0.1649)*	ΔLnPPR(-1)	-0.4641 (0.1703)**
ΔLnHAM(-1)	-1.3828 (0.3186)***		
ΔLnFERT(-1)	-0.0252 (0.0685)	ΔLnFERT(-1)	-0.0952 (0.0761)
ΔLnGEA(-1)	-0.1177 (0.0544)**	ΔLnGEA(-1)	0.0398 (0.0482)
ΔLnRF	0.1569 (0.0491)***	ΔLnRF	0.2395 (0.0813)***
Diagnostics:		Diagnostics:	
R^2	0.6894	R^2	0.6926
Adjusted R^2	0.5284	Adjusted R^2	0.5669
S.E	0.1690	S.E	0.1965
DW	1.7510	DW	1.8637
log-likelihood	28.6394	log-likelihood	-28.3197
Akaike AIC	4.3505	Akaike AIC	5.3962

Figures in parenthesis are standard error, ***=1%, **=5% and *=10%; DW = Durbin Watson; SE = Standard Error of estimates

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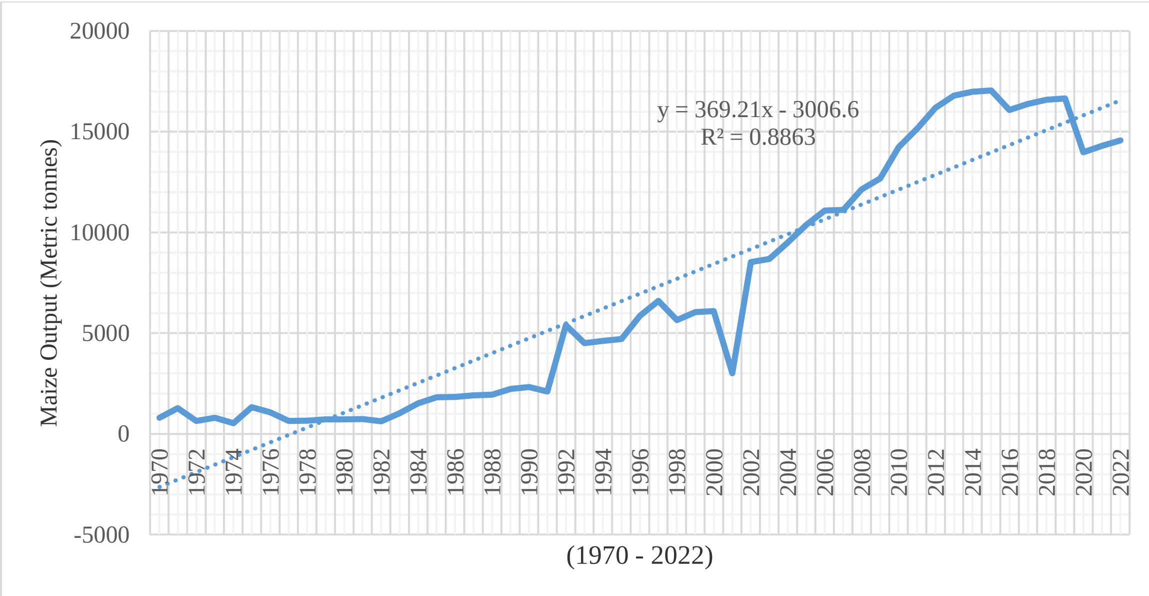

Fig. 1: Maize Output in Nigeria (1970 – 2022)

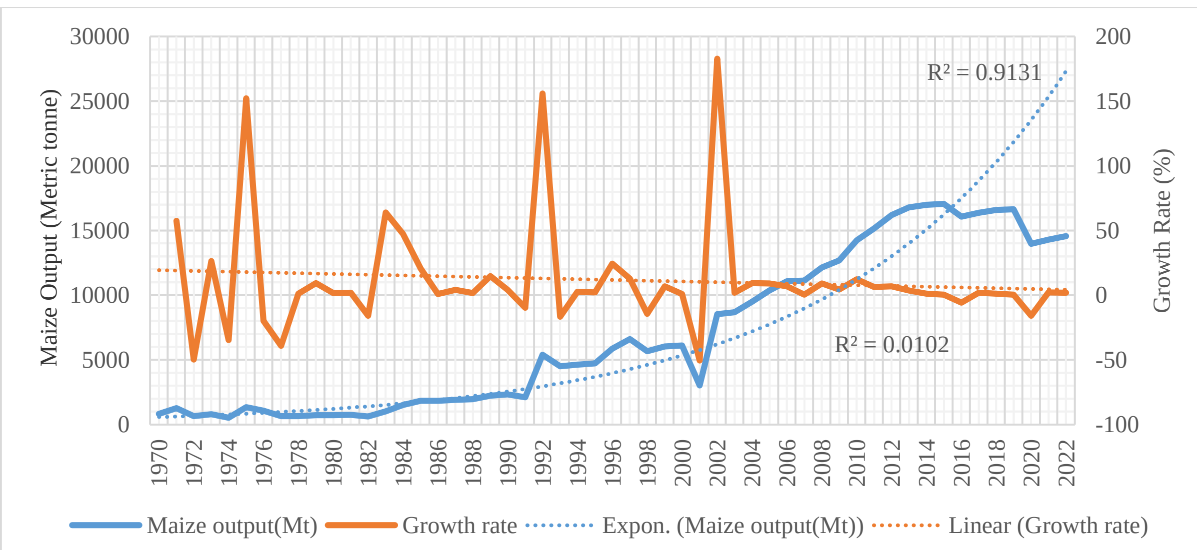

Fig. 2: Maize Output growth rate in Nigeria (1970 – 2022)