Technology and Agriculture in Nigeria

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Abstract
This study investigated the impact of technology on agriculture in Nigeria. Secondary data spanning from 1990 to 2021 on the percentage contribution of agriculture to GDP; Agricultural machinery (tractors) per 100 squares of arable land; Government expenditure on agriculture; and percentage of employment in agriculture and arable land were used for the study. These data were analyzed using Autoregressive Regressive Distributed Lag (ARDL) econometric technique. The results revealed that for the period under study, technology had an insignificant positive impact on Nigeria's agricultural sector performance. Based on the findings, it was recommended among other things that government should increase the amount devoted to technology to maximize its positive impacts on agriculture and the economy at large.
Keywords: *agriculture, sustainable agriculture, technology, ARDL.*

Introduction

Agriculture is the sole anchor of the food systems, providing food, income for farmers, employment, raw materials for industries and a source of foreign exchange. The sector is also a business sector consisting of a huge source of commodities that are marketable and the performance of the sector is also controlled by the existing "doing business" environment which is majorly policy-driven. Agriculture is broadly divided into four sectors in Nigeria namely: crop production, livestock farming, fishery and forestry (Oyaniran, 2020). The importance of agriculture cannot be emphasized, especially, the one that is sustainable. According to Samuel (2020), sustainable agriculture is that agriculture capable of meeting the society's needs presently without putting the ability of future generations to meet theirs at risk. It considers three objectives, namely: a healthy environment, social and economic equity as well as economic profitability. Sustainable agriculture can be achieved through methods like crop rotation, hydroponics, permaculture, urban agriculture (using backyard farms, family and community farms etc), and weed and pest management, among others (Adithya, Akash, Meenu, Mika and Nanditha, 2022). These methods improve agricultural productivity while conserving biodiversity with little or no ecological hazards. It would help to end hunger and attain food security, ensuring that all the people irrespective of location and status have access to nutritious food all year round. On the other hand, the World Bank (2014) noted that there is a high degree of latitude for farmers to significantly increase yield by adopting new modern agricultural technology.

Technology here means machinery and other equipment engineered for an applicable and novel use in agricultural, and natural resources and relating to the research and development of qualified products and projects. It entails the use of tractors, bio-fuel technology, irrigation systems, precision agriculture, agricultural drones, improved crop varieties, the achievement of hybrid rice, wheat, cotton, feeds and chemicals (pesticides, herbicides, insecticides, and fungicides) among others in agriculture (Farmsquare, 2020; FMARD, 2022). Technology is critical for increased productivity, food security and higher income (Eneji, Welping & Ushine, 2012). In line with the above, Ossai, Ojobor, Akpeji, Oroghe and Ogbola (2021) opined that for Nigeria to achieve food security and zero hunger as stipulated in the sustainable development goals (SDGs) the country has to develop sustainable ways to produce and then distribute food in large quantities. They buttressed that using technology in agricultural activities plays a vital role towards achieving that objective.

Sadly, agricultural processes in Nigeria are marked with inadequate technological inputs such as threshers, tractors, harvesters, power tillers, choppers, milkers, hay balers, crushers, improved seeds, and fertilizers among others. For instance, Nigeria's yield and fertilizer use is much below the global benchmarks, unlike economies like Ghana, China, Brazil, Indonesia and India (Schillings, Bennett and David, 2021). Shaibume, Unade and Apinega (2019) and FMARD (2022) agree that the lack of this technological inputhas decreased the amount of land area that is under cultivation and this leads to high post-harvest losses, low crop as well as low livestock production in the country.

As observed by Fowowe (2020), farmers in Nigeria are predominantly small-holder farmers, they can cultivate only less than 50% of the total cultivable land in the country and lack adequate knowledge about best practices in Agriculture. These smallholder farmers are also not able to invest in seeds and fertilizers. Little wonder Nigeria is not able to self-sufficient as regards food production. For instance, FAO (2020) submitted that only 57% of the 6.7million metric tons of rice consumed annually was locally produced giving about a 3million metric deficit which was either imported or legally smuggled into the country. Similarly, FMARD (2022) noted that even though Nigeria is the 2nd largest producer of tomatoes in Africa (producing 10.8% of tomatoes) and the 14th largest producer in the world (with 2.3million tones in 2016), she is still the 3rd largest importer of tomato paste and the 13th largest importer in the world. It is therefore the crux of this study to examine the impact of technology on agriculture in Nigeria and to examine the nature of the relationship that exists between technology and agriculture in Nigeria.

Literature Review

Agriculture is the cultivation of crops and, the rearing of animals and birds for consumption and trade. This sector has the potential of ensuring food security sustainably through the utilization of sustainable agricultural practices. Sustainable agriculture is that agriculture capable of meeting the society's needs presently without putting the ability of future generations to meet theirs at risk (Samuel, 2020). According to Adithya, et al (2022), sustainable agriculture can be achieved through methods like crop rotation, hydroponics, permaculture, urban agriculture (using backyard farms, family and community farms etc.), and weed and pest management, among others. These methods improve agricultural productivity while conserving the biodiversity with little or no ecological hazards. For this study, sustainable agriculture is perceived as any activity involving the cultivation of the soil, rearing of animals and birds using practices, methods, processes and techniques that does not pose any harm to the environment, society and economy both now and in the future. Use of technology in agriculture helps in producing improved seeds and plant varieties through plant breeding or genetic engineering (Farmsquare, 2020). The international Institute of Tropical Agriculture (IITA) has for instance developed a number of improved plant varieties for cassava, maize, cowpeas, among others. Modern technologies in agriculture like hydroponics technology use large greenhouse agricultural areas or tunnel-like green houses to bring about a sustainable environment. Hydroponics simply means a garden in the absence of soil. This technology can increase agricultural productivity even in areas of water scarcity, limited fertile land and harsh climatic conditions (Khan, Akram, Janke, Qadri, Al-Sadi & Farooque, 2020).

Agriculture and Technology in Nigeria

In a bid to boost the growth of agriculture sector, the Nigerian government has put in place different policies, plans, projects and programmes at different times. Some of such include: Operation Feed the Nation (OFN) (1976); Green Revolution (GR) (1980); Agricultural Transformation Agenda (ATA) (2011); Agricultural Promotion Policy (APP) (2016-2020); National Agricultural Technology and Innovation Policy (NATIP); National Development Plan (NDP) (2021-2025); among others. These policies cannot be said to have brought optimal improvements in the agricultural sector. Technology adoption and utilization is likely to boost productivity and growth of the sector. Inadequate technological input has decreased the amount of land area that are under cultivation which have resultantly led to high post-harvest losses, low crop as well as low livestock production in Nigeria (FMARD, 2022).

However, in recent times, bodies like International Institute of Tropical Agriculture embark on initiatives to use aeroponics, vine-cutting technology, high-quality seed yam tuber, improved cowpea varieties, drought tolerant maize varieties etc for increased food production (Faalodun, 2019). There are also companies that process foods and provide transportation for farmers. The use of technology in agriculture contributes to better soil, nutrient, pesticide and water use efficiency while increasing food production and eliminating environmental and health concerns (Parke, 2013).

Some studies have been carried out on technology and agriculture. For instance, a study on adoption and impacts improved maize production technology: A case study of the Ghana grains development project (GGDP) was carried out by Michael, Robert and Dankyi in 2000. They found out that adoption of GGDP-generated technologies was associated with significant increase in farm level productivity and income earned from sale of maize. They recommended that more GGDP-generated technologies should be adopted for higher gains.

Also, Yusuf (2014) examined role of agriculture in economic growth and development: Nigeria perspective. The study revealed that agriculture plays a significant role in economic development of the nation. In addition, the sector has been neglected to the extent that its contribution to the GDP has been dwindling since 90’s. It was recommended that Agricultural friendly government policies and policy orientation must be put in place, among others. Nwalieji, Uzuegbunam & Okeke (2015) carried out research on assessment of growth enhancement support scheme among rice farmers in Anambra State, Nigeria and evidenced that the scheme had very low performance indices in redemption of inputs and the Scheme made great changes in food productivity. It was recommended that more awareness and adequate training be given to farmers for them to participate actively and for other farmers to join the scheme, among others.

Osabohien, Osabuohien and Urhie (2018) investigated food security, institutional framework and technology: Examining the nexus in Nigeria using ARDL. They found out that technology exert a positive and significant influence on average value of food produce while institutional framework exerted a negative influence. They recommended that efforts in reducing corruption in Nigeria should be strengthened to boost food security. Schillings, Bennett and David (2021) examined exploring the potentials of precision livestock farming (PLF) technology to help address farm animal welfare. The study investigated how PLF can improve productivity in livestock farming. It adopted the Five Domain Model (FDM). They found that PLF technology reduced the occurrence of diseases and injuries in livestock farming system and boosted productivity. They recommended that investments be made into PLF to boost productivity.

Taghizadeh (2021) carried out a study on assessing the potentials of hydroponics farming to increase self-sufficiency: The case of lettuce production in Sweden. The study aimed to examine the advantages of hydroponics through lettuce production in Sweden. The result showed that using hydroponics in lettuce production enhanced productivity and self-sufficiency. It was therefore recommended that this system be adopted in agricultural practices to boost productivity. Ogunsolu (2021) studied technological transformation of the Agricultural sector in Nigeria using exploratory research method. The result showed technology transformed and boosted the growth of the agricultural sector. Similarly, Yu, Ikpe-etim and Khan (2019) and Bola, Aliou, and Omonona (2012) found out that technology improved agricultural growth in Nigeria.

It can be deduced that most of the previous studies reviewed employed a different methodology from the present study except that of Osabohien, Osabohien, and Urhie (2018). However, Osabohien, Osabohien, and Urhie investigated food security, institutional framework and technology. But the present study examined agriculture and technology. Agriculture is broader in scope than food security. The present study also utilized different variables that seem better for the Nigerian situation. This therefore justified the present study.

Theoretical Framework

This study is based on Solow's growth model which provides a useful framework for theoretical underpinning of the Solow growth model, which has technical progress as basic explanatory variables that could explain production capacity of a country, especially in the agricultural sector. The introduction of technology in the model is what impacts on labour and capital to improve productivity. The solow's growth model is represented as:

$Y = AK^{\alpha}L_{(1-\alpha)}$ -------------------------(i)

Where: Y = output; A = technology; K= capital and L = labour

Model Specification

The model used in this study results from the theoretical framework of the study. Some variables used were adopted from the model specified in Osabohien, Osabohien, and Urhie (2018) in their study on food security, institutional framework and technology: Examining the nexus in Nigeria. The model is adopted for this study as it embodies some variables of interest in this study. The functional form of Osabohien, Osabohien, and Urhie's model is stated as:

FoodsectK= *f*(tech, lucp, insfram, epdl, gdpgr) (ii)

Where:

Foodsect – Indicator for food security

tech – Technology usage in the agriculture is proxied by two indicators, namely: Agricultural Machinery and tractors (AMT) and agricultural machinery (tractors) per 100 square of arable land (AMTL).

lucp – land tenure system: the availability of land under food crop production. Arable land helps to increase food production thereby increasing the availability of food.

aveinst – Institutional framework

However, this study modified the model thus:

AGDP =*f*(AMTL,GEXA, EMA, AL) (iii)

This is to eliminate variables that are irrelevant to the study and include relevant one.

Given the functional form for this study, the following general econometric/stochastic model is derived:

$$AGDP = \beta_0 + \beta_1 AMTL + \beta_2 GEXA + \beta_3 EMA + \beta_4 AL + \varepsilon \quad \text{(iv)}$$

Where;

AGDP –% contribution of agriculture to GDP

AMTL – Agricultural machinery (tractors) per 100 square of arable land (proxy for technology)

GEXA – Government expenditure on agriculture (proxy for capital)

EMA – % employment in agriculture (proxy for labour)

AL – Arable land (control variable)

ε - Random disturbance/error term

β_0 – Intercept/constant

$\beta_{1\ldots4}$ – Slope coefficients for AMT, AMTL, GEXA, EMA and AL respectively

Estimation Technique and Procedure

This study employed the Autoregressive Regressive Distributed Lag (ARDL) framework for co-integration analysis. Augmented Dickey-Fuller (ADF) unit test was used to assess the data for stationarity. Using the ARDL framework, we estimated the model and tested for co-integration among the variables using the bounds test for co-integration to check if there is long-run or equilibrium relationship between the dependent variable and independent variables. This study employs secondary yearly macroeconomic data extracted from the World Bank's World Development Indicators. The data used to carry out the study spans from 1990 to 2021.

RESULTS

A summary of the Augmented Dickey-Fuller test carried out on each variable is shown in Table 1 below.

Summary of Unit Root Test

	Level		1st Difference		
Variable	Critical Value @ 5%	ADF Statistic (Probability)	Critical Value @ 5%	ADF Statistic (Probability)	Order of Integration
AGDP	-3.568379	-3.275684 (0.0897)	-3.574244	-6.161406 (0.0001)	I(1)
AMTL	-3.562882	-3.248665 (0.0938)	-3.568379	-6.137440 (0.0001)	I(1)
GEXA	-3.562882	-4.805135 (0.0028)	-3.574244	-6.188344 (0.0001)	I(0)
EMA	-3.562882	-3.134429 (0.1163)	-3.568379	-7.269073 (0.0000)	I(1)
AL	-3.568379	-2.637643 (0.2676)	-3.568379	-4.801187 (0.0030)	I(1)

Source: Author's computation using Eviews 10

Table 4.2 indicates that in first difference, the Augmented Dickey-Fuller test's null hypothesis that the variables have a unit root is rejected at 5% level of significance for all variables in the model excluding GEXA given that each variable's ADF test statistic (in absolute terms) is greater than the critical value of the ADF test (in absolute terms) at 5% level of significance. The variable, GEXA, is itself stationary at level given that, at level, GEXA's ADF test statistic (in absolute terms) is greater than the absolute value of critical value of the ADF test at 5% level of significance.

DESCRIPTIVE STATISTICS OF VARIABLES

	AGDP	AMTL	GEXA	EMA	AL
Mean	24.36563	6.484375	26.50293	43.75594	37.24837
Median	24.00000	6.550000	20.17712	44.50000	38.42902
Maximum	37.00000	8.300000	76.60099	51.00000	40.62497
Minimum	20.00000	4.800000	0.208700	34.53000	30.93426
Std. Dev.	3.813018	1.112425	24.66369	5.713624	2.338259
			0.587916	-0.288800	-
Skewness	1.498472	0.005698			1.015779
Kurtosis	5.5627006	1.661614	2.074123	1.573351	3.381805
Sum	779.7000	207.5000	848.0938	1400.190	1191.948

Source: Author's computation using Eviews 10

The table 2 shows descriptive statistics of the variables. In the model established in the study, there is one dependent variable and four independent variables. All these variables have different value for mean, sum of variable, minimum, maximum, median and standard deviation which were shown above.

Result of the Co-integration Test

The results of the ARDL bounds test for co-integration is shown in Table3 below.

SUMMARY OF THE ARDL BOUNDS TEST

K	5	
F-statistic	5.159053	
	Critical Value Bounds	
Significance Level	I(0)	I(1)
10%	2.08	3
5%	2.39	3.38
2.5%	2.7	3.73
1%	3.06	4.15

Source: Author's computation using Eviews 10

The ARDL bounds test's null hypothesis of no co-integration is rejected if the F-statistic is greater than the upper bound (I(1)) critical value. As shown in table3 above, the F-statistic of 5.159053 is greater than the 5% significance level's upper bound critical value of 3.38. Ultimately, this result shows there is a long run relationship between the dependent variable and the independent variables. With this, only a short run error correction model can be estimated.

EMPIRICAL RESULTS OF THE ERROR CORRECTION MODEL (ECM)

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(AMTL)	1.782248	3.330443	0.535139	0.5988
D(GEXA)	0.018343	0.022037	0.832374	0.4155
D(EMA)	0.948645	0.615591	1.541030	0.1398
D(AL)	-0.393440	0.390852	-1.006621	0.3268
CointEq(-1)*	-0.798078	0.122278	-6.526733	0.0000

R-squared	0.647860	Mean dependent var	0.058065
Adjusted R-squared	0.577432	S.D. dependent var	3.133026
S.E. of regression	2.036630	Akaike info criterion	4.432456
Sum squared resid	103.6966	Schwarz criterion	4.710002
Log likelihood	-62.70306	Hannan-Quinn criter.	4.522929
Durbin-Watson stat	1.384290		

The error correction model was carried out to examine parameters estimates. In testing this hypothesis, Agricultural machinery tractors per 100 square meters of arable land (AMTL), Government expenditure on agriculture (GEXA), Percentage employment in agriculture (EMA) and Arable land (AL) were regressed against percentage contribution of agriculture to GDP (AGDP). The result of the regression analysis represents the model for ‘‘Agriculture and technology in Nigeria.’’ The empirical result also shows that the coefficient of agricultural machinery tractors per 100 square meters of arable land (AMTL) had a positive relationship with agricultural output (AGDP), but the impact was insignificant, as the observed values of t – statistics (0.535139) was less than its critical value (2.056). Furthermore, the result shows that the coefficient of government expenditure on agriculture (GEXA) had positive relationship with agricultural output (AGDP), however, the impact was insignificant as the observed values of t – statistics (0.832374) was less than its critical value (2.056). Percentage employment in agriculture (EMA) had a positive relationship with agricultural output (AGDP), but the impact was insignificant as observed values of t – statistics (1.541030) was less than its critical value (2.056). Also, as observed from the table above, Arable land (AL) had a negative relationship with agricultural output (AGDP), however, the impact is insignificant as the observed values of t – statistics (-1.006621) was less than its critical value (2.056). The result of the F – statistical test shows that the overall regression of the variables was statistically significance. This is because observed values of the F – statistics (4.624952) was greater than its critical value (2.74). Again, our empirical result also shows that the R squared (R^2) is 0.65 which shows that the explanatory variables employed in the study explains 65% of the variation in the dependent variable during the sample period (1990 – 2021) and that the model has goodness of fit. The ECM statistics was (-0.79). The ECMt-1 result indicates that 79% numbers of errors have been corrected from short run adjustment to the long run. In other words, ECM statistics shows that the model has 79 percent degree of adjustment from short-run to long-run equilibrium.

RESULT OF RAMSEY RESET TEST

Ramsey RESET Test			
Equation: UNTITLED			
Specification: D(AGDP,1) D(AMT,1) D(AMTL,1) D(GEXA,1) D(EMA,1) D(AL,1) C ECM-1			
Omitted Variables: Squares of fitted values			
	Value	Df	Probability
t-statistic	0.910548	25	0.3712
F-statistic	0.329098	(1, 25)	0.8712
Likelihood ratio	1.044028	1	0.3069
F-test summary:			
	Sum of Sq.	Df	Mean Squares
Test SSR	7.486472	1	7.486472
Restricted SSR	233.2279	26	8.970302
Unrestricted SSR	255.7414	25	9.029656
LR test summary:			
	Value		Df
Restricted LogL	-77.18651		26
Unrestricted LogL	-76.66450		25

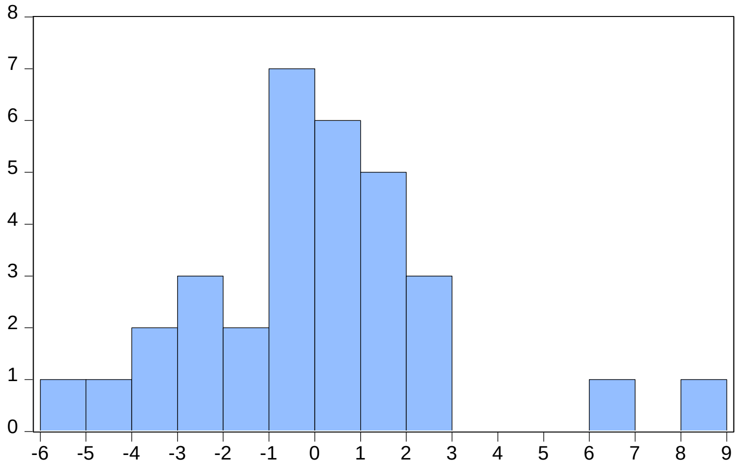
Source: Author's computation using E-views

This second order test checks whether the model of the study suffers model specification error. The null hypothesis; there is model specification error. The Ramsey reset test showed that there was no specification error because its F-statistics (0.329098) is less than Probability value (0.8712). It means that model include core variables in the model, and did not include superfluous variables, the functional form of the model was very well chosen, there is no error of measurement in the regressand and regressor.

Histogram Normality Test

Normality test is done to check if the residuals of the error term have a normal distribution. Normality test is conducted using Jacques-Bera (JB) test. In testing for normality, approach used by Paavola (2006) for testing normality using Jacques-Bera test was adopted.

FIGURE 4.1. NORMALITY TEST FOR EACH OF THE DISTRIBUTION



Series: Residuals	
Sample 1990 2021	
Observations 32	
Mean	1.78e-15
Median	-0.191104
Maximum	8.472969
Minimum	-5.008815
Std. Dev.	2.742896
Skewness	0.840756
Kurtosis	4.868215
Jarque-Bera	8.423618
Probability	0.014820

Source: E-views 10

Jarque-Bera (JB) test is statistics that compute both skewness and Kurtosis. Skewness shows the degree symmetry (normal distribution). The normal measurement is zero/0. Kurtosis is a statistic that computes degree of peakedness. The normal measurement is three/3. A distribution is skewed if one of its tails is longer than the other. A skewed distribution can be positive or negative. Positive skewed distribution means that it has a long tail in the positive direction. Negative skewed distribution means that it has a long tail in the negative direction.

The null hypothesis is that there is no skewness and Kurtosis in the model. We reject the null hypothesis because the Jarqua-Bera statistics (8.423618) is greater than probability value (0.000). We reject null hypothesis and accept the alternative that there is no skewness and Kurtosis in the model. The skewness is normal because the value was 1.498472. The model of the study produced positive skewed distribution meaning that it has a long tail in the positive direction. The kurtosis was 4.219787 meaning that the degree of peakedness was high that normal value of three (3). This implies that the standardized residuals from the estimated model in the regression framework is normally distributed, which is consistent with the OLS assumption.

Discussion of the Findings

Based on the results of this study, the null hypothesis of no impact of technology on agriculture was rejected, meaning that technology an impact on Nigeria's agriculture. This finding conforms with the findings by Ossai, *et al* (2021), Taghizadeh (2021), Ejemeyovwi, *et al* (2021), Schillings, Bennett and David (2021), Ehui and Tsigas (2009) and Khan, *et al* (2020).

The study also revealed that technology had a positive relationship with agriculture in Nigeria. This is consistent with the findings by FMARD (2022), Adithya, *et al* (2022), Osabohien, Osabohien and Urhie (2018) and Taghizadeh (2021). The finding also provides support for the theoretical foundation of the study that technology is one of the key components that drive growth, in this context, agricultural growth. However, the positive relationship between technology and agriculture in Nigeria was found to be insignificant. This is not surprising given the low utilization of technology in agricultural practices in Nigeria. Little wonder World Bank (2014) submitted that the low level of technology in Nigeria limits the amount of land that can be cultivated and limits the productivity of farmers. Similarly, FMARD (2022) revealed that Nigeria's tractor density is put at 0.27 hp/hectare which is far behind the FAO's stipulated tractor density of 1.5 hp/hectare. It is worth noting also that GEXPA and EMA had a positive relationship with agricultural output but this positive relationship was insignificant. This is not at all surprising because in Nigeria, though the amount of money allotted to the sector is still inadequate. Similarly, though agriculture is about the highest employer of labour when compared to other sectors, FMARD (2022) submitted that the sector employs about 36% of the labour force. The result implies that the sector ought to absorb greater number of people to cause the positive relationship to be significant. Again, AL was found to have a negative relationship with agricultural growth.no wonder Fowowe (2020) noted that despite the ample agricultural cultivable land in Nigeria, less than 50% of this, is been utilized by small-holder farmers that make use of outdated technology which lowers the yield. This is to say that greater portion of the arable land in Nigeria should be utilized using relevant technologies to bring about a positive impact.

Conclusion

This study examined the impact of technology on agriculture in Nigeria. It also investigated the nature of relationship between technology and agriculture in Nigeria from 1990 to

2021. From the findings of the study, it can be concluded that technology has an impact on agriculture. Similarly, the study reasonably concluded that there is a positive but insignificant relationship between technology and agriculture in Nigeria.

Recommendations

The following recommendations are given:

Since technology has an impact on agriculture, farmers should sensitize and encouraged to utilize technology maximally in their agricultural practices in sustainable ways.

Since technology has a positive but insignificant relationship with agriculture, it is recommended that government invest heavily on technology to increase the utilization of technology in agricultural practices. This will likely make technology cause significant positive effects on agricultural output in Nigeria

The government can strengthen relationships with other countries to adopt technologies used in enhancing agricultural output. However, any technology adoption must be viewed through the lens of sustainability.

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