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IMPACT OF LAND AREA CULTIVATED ON MAIZE AND SORGHUM YIELDS IN NIGERIA: 1975-2015

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Abstract

The study was conducted to analyse the impact of land area cultivated on maize and sorghum yields in Nigeria from the period of 1975 – 2015. Annual time series data on land area cultivated and yields of maize and sorghum were collected from Food and Agriculture Organization for the analysis. The study employed the use of descriptive and inferential statistics,the meanvalue indicated a decrease in sorghum yield between 1986 – 1993 from 11.300ha to 10.400ha, though land area cultivated increased within the period. The augmented Dickey fuller unit root test showed that the variables were non-stationary at levels but became stationary after first differencing therefore integrated of order one. The Johansen cointegration model result indicated a long run relationship among land area cultivated and yield at 5% level of significance. The vector error correction result showed that land area cultivated of sorghum had a negative (-0.001119) coefficient on sorghum yield at 1% level of significance. The short run Granger causality test between land area cultivated of maize and maize yield was a unidirectional causality. It was therefore recommended that maize and sorghum farmers should give attention to variable inputs that can boost yields since increase on land area cultivated lead to yield decrease.

Keywords: Impact, Land, Maize, Sorghum, Yield,Nigeria .

Introduction

Agriculture is the engine for growth in Africa with subsistence agriculture practised by majority of small holder farmers; yield gaps are high and poor soils, amongst other constraints adds to the difficulties for sustainable farming and incomes (FAOSTAT, 2015). Agricultural productivity growth is important because it is essential source of overall growth in an economy. That is why productivity differences among countries and mainly between developed and undeveloped ones, emerged as a central issue of development economics (Mounir and Mohammed, 2009). Kolawole and Ojo (2007) contended that the growth of Nigeria's food production is 2.5% per annum, while food demand has been growing at the rate of more than 3.5% per annum due to high rate of population growth of 2.83% per annum.

Cereals are the major contributor to agriculture and food security in Nigeria,it consist of between 55-60% of subsistent farmers output and many households' diets both in the rural and urban areas (Balami *et al.,* 2011). The global trend in productivity of these cereals pose food security threat to countries like Nigeria which are food import dependent (Tahir,2013). Preliminary observation seems to suggest that Nigeria has a large expanse and rich land for the production of maize and sorghum. Idem and Showemimu (2004) noted that the Nigerian Savannah ecology accounts for about 665, 600 square kilometers.

Maize is a major food crop grown in diverse agro-ecological zones and farming systems, consumed by people with varying food preferences and socio-economic backgrounds in sub Saharan Africa (SSA). Maize forms the highest percentage of calorie intake in national diet among 22 countries in the world of which 16 are Africa (United Nations Economic Commission for Africa) (UNECA) (2015). According to Khawar*et al.* (2007), some of the uses of maize are: Its grain is a rich source of starch, vitamins, proteins and minerals. The starch extracted from maize grain is used in making confectionary and noodles. Corn syrup from maize contains high fructose and act as sweetener and retains moisture when added to foods. Edible oil is extracted from maize grains, which is an all purpose culinary oil. Maize can be used as forage feed for livestock and making silage after fermentation of corn stocks.

Sorghum is the third cereal in terms of production after maize and millet in Nigeria with more than 4.5 million tons harvested in 2010 representing 25% of the total cereal production (FAO, 2012). Among all cereal crops consumed in Nigeria over the past two decades, sorghum contributed about 30% of calorie intake per capita (FAOSTAT, 2012). The bulk of domestic production is used for household consumption and fodder (Gourichon, 2013). Increase in yield mean households will be more food secured.

Increase in crop productivity directly create more employment opportunities and improve the level of food security (Ajayi *et al.,* 2013).Unfortunately, according to UNECA, (2015) there has been low average grain yield of farmers which pose a problem to meeting the projected increase demand.

The objectives of this study are:

i. describe trends in the land area cultivated and yields of maize and sorghum in Nigeria;

ii. determine the existence of long run relationship among land area cultivated and yields of maize and sorghum in Nigeria and

iii. determine the effects of land area cultivated on maize and sorghum yields in Nigeria.

The following null hypothesis was stated and tested

H0; There is no significant relationship between land area cultivated and yield of maize and sorghum.

Methodology

Data for this study were collected from secondary sources. The data are basically annual time series data covering a period of 40 years (1975 – 2015). Data on land area cultivated and yields of maize and sorghum were obtained from Food and Agriculture Organization data base.

Model specification

1. **Trend analysis**

$Y_t = Y_0 + (I + r)^t$ .... (1)

Y_t = Yield of maize and sorghum in year t.

Y_0 = Yield of maize and sorghum in the base year.

r = Compound rate of growth of Y.

t = Time in chronological years

2. **Unit root test**

ACP= $K_0 + K_{it} + QACP_{t-1} + \sum_{t-1}^{P} \sigma\, \Delta ACP_{t-1} + U_t$..........................(2)

Where

ACP = aggregate maize/sorghum yield

i.e = the variables to be investigated = maize yield (MAY), land area cultivated of maize (LACMA) and sorghum yield (SOY), land area cultivated of sorghum (LACSO).

K_0 = constant

K_i = coefficient of the trend series

P = lagged order of the auto regressive

ACP_{t-1} = the lagged value of order one or past values of variables

U_t = the error term

3. Johansen co-integration test

Based on vector autoregressive (VAR) model in the absence of co-integration, it is stated as:

$$y_t = A_t Y_t - 1 + \cdots + A_p Y_{t-p\beta X_t} + \varepsilon_t \text{...}(3)$$

Where

Y_t = K – vector of non-stationary variable integrated of order one i.e. 1 (i)

X_t = d – vector of exogenous variables

i.e. MAY, LACMA, SOY, LACSO.

ε_t = vector of random shocks/innovations

The VAR can be stated as

$$\Delta y_t = \pi y_t + \sum_{i=1}^{k-1} r_{i\Delta y_t - 1} + \beta X_t + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

$$Where\ \pi = \sum_{i=1}^{p} A_i - 1, r_i = \sum_{j=i+1}^{p} A_j \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(5)$$

Y_{t-j} = Lag values of Y_t

r_i = (n x (k-i) matrix of short term coefficients

= Co-integrating vector

£$_t$ = (n x i) vector of white noise Residual

4. Error correction model

$$\Delta MAY_t = \lambda_1 + \sum_{i=1}^{p} w_{1i} \Delta MAY_{t-1} + \sum_{i=1}^{p} \gamma_{1i}\ \Delta LACMA_{t=1} + \propto KT_{t-1} + U_{t} \text{.........}(6)$$

$$\Delta LACMA_t = \lambda_2 + \sum_{i=1}^{p} w_{2i} \Delta MAY_{t-1} + \sum_{i=1}^{p} \gamma_{2i}\ \Delta LACMA_{t=1} + \propto KT_{t-1} + U_{t} \text{...........}(7)$$

Where: Δ = difference operator,

λ_1, λ_2, = constant terms

MAY_t = yield of maize in $year_t$(ton/ha)

LACMA = land area cultivated of maize (ha)

KT = error correction term

Ut = error term (other variables not included)

P = optional lag length orders of the variables

The analysis will however be carried out in VAR if the variables are not co integrated.

$$\Delta SOY_t = \theta_1 + \sum_{i=1} q_{1i} \Delta SOY_{t-1} + \sum_{i=1} z_{1i}\ \Delta LACSO_{t=1}\ + \propto KT_{t-1} + U_t \text{..............................} (8)$$

$$\Delta LACSO_t = \theta_2 + \sum_{i=1}^{P} q_{2i} \Delta SOY_{t-1} + \sum_{i=1}^{P} z_{2i}\ \Delta LACSO_{t=1}\ + \propto KT_{t-1} + U_t \text{......................} (9)$$

Where: Δ = difference operator,

θ_1, θ_2, θ_3 = constant terms

SOY_t = yield of sorghum in year t (ton/ha)

$LACSO_t$ = land area cultivated of sorghum (ha)

KT = error correction term

Ut = error term

P =Optimal lag length orders of the variables

Results and Discussion

Trend in land area cultivated and yield of maize in Nigeria

The trend in land area cultivated and yield of maize in Nigeria from 1975 – 2015 is shown on Table 1. The increase in yield before 1986 and during 1986-1993 are insignificant. The increment on land area cultivated does not tally with yield since in the three eras land area is multiplying by almost two when compared with the previous.

Table 1: Descriptive statistics on mean values of maize land area cultivated and yield.

Period	1975 – 1985	1986 – 1993	1994 – 2015
Variable			
Yield (ton/ha)	12.4	12.8	15.8
Landarea cultivated(ha)	7,76, 000	4,220,000	4,470,000

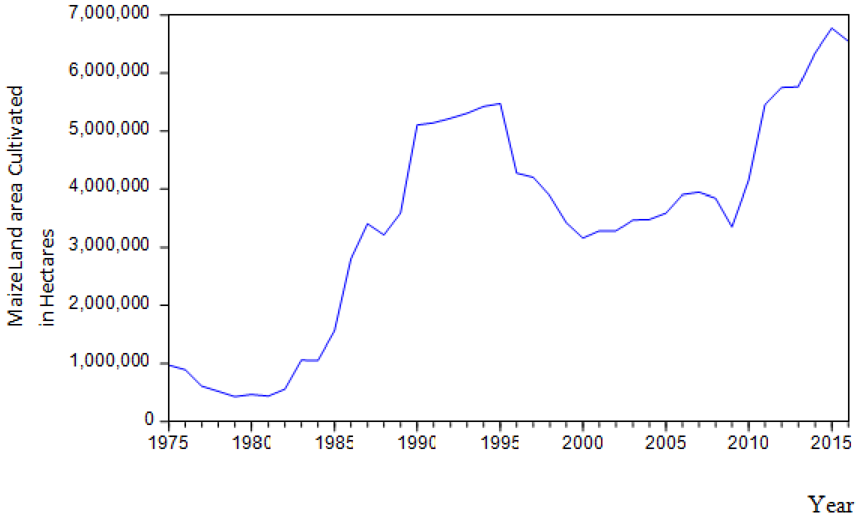

Fig 1: Trend in Land Area Cultivated of Maize

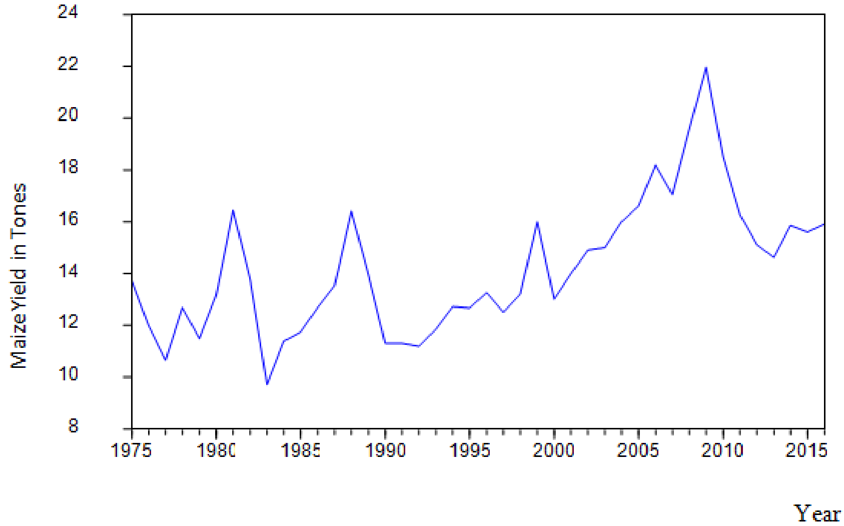

Fig 2: Trend in Yield of Maize

Trend in land area cultivated and yield of sorghum in Nigeria

Table 2 presented the result of trend of land area cultivated and yield of sorghum from 1975 – 2015. There was a yield decrease between 1986-1993 from 11. 300ha to 10. 400ha. This period happens to be during Structural Adjustment Programme (SAP) which failed. Since available literature have noted that it was not able to "restructure and diversify the productive base of the economy in order to reduce dependence on the oil sector and on imports" as one of its stated objectives. Hence, a drastic decrease in the yield of a major contributor to agriculture and food security. There was a continual increment in land area cultivated which did not reflect on yield. The findingsdisagreeswith Sekoli *et al.*(2016) who found persistent decline in the area planted and harvested of Lesotho sorghum production.

The result of the growth model of the variables presented was positive with a low R-squared and statistically significant meaning that there is progression in the yield of maize and sorghum overtime.This continuing demand is reflected in the trend for increasing area under sorghum and millets in Africa over the last fifty years but crop productivity has not kept pace with this increasing demand. This is due to both a lag in crop improvement efforts in these crops and the extreme environmental conditions and the low input agriculture under which these crops are grown thus it is immediately evident that crop improvement efforts combined with improved agronomic practices is a must for these crops in Africa, especially in view of the reducing arability of land (UNECA)

Table 2: Descriptive statistics on mean values of sorghum land area cultivated and yield

Period / Variable	1975 – 1985	1986 – 1993	1994 – 2015
Yield(ton\ha)	11.3	10.4	11.7
Landarea cultivated(ha)	3,310,000	5,100,000	6,280,000

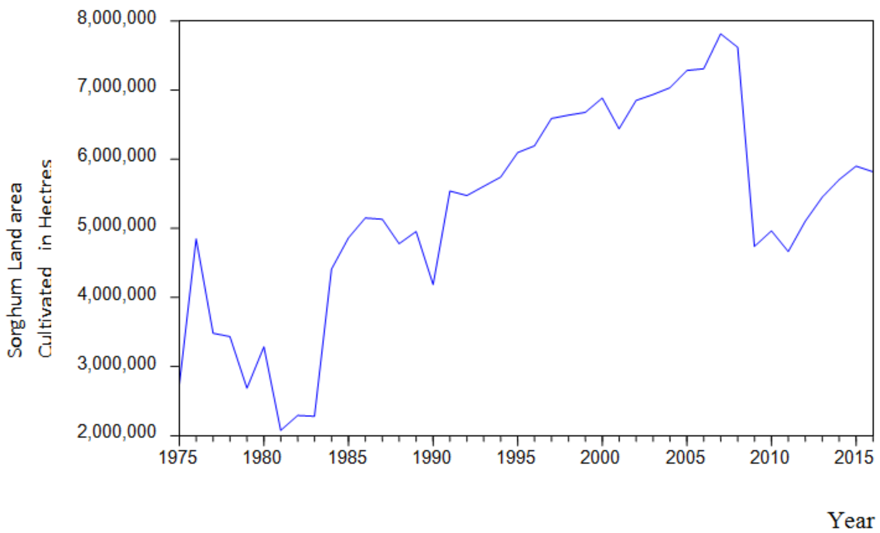

Fig 3: Trend in Land Area Cultivated of Sorghum

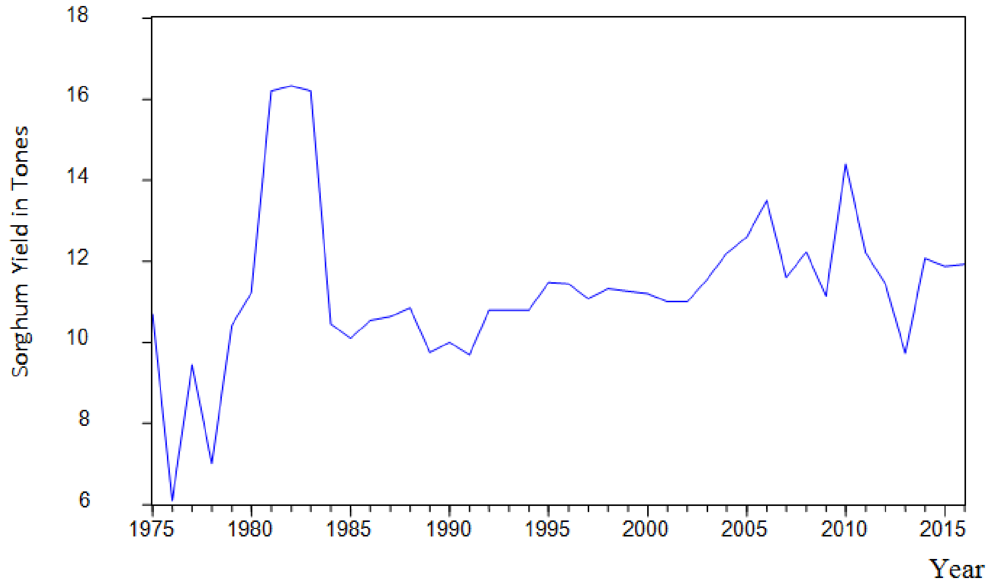

Fig 4: Trend in Yield of Sorghum

Augmented Dickey-Fuller (ADF) test of stationarity for land area cultivated and maize yield

This Unit root test was employed to each of the variables [Land Area cultivated of maize (LACMA) maize yield (MAY)] under study for a period of forty years. This is a requirement in dealing with time series data to avoid spurious regression. The test is presented on Table 3. All estimations were carried out using the standard version of the Eviews Econometrics software. The results of the ADF indicated that all the variables under study are not stationary at level. That is to say the variables exhibit random walk or their mean cannot be predicted. However, on first differencing the series were found to become stationary, therefore integrated of order one i.e 1(1).

Table 3: Augmented Dickey Fuller (ADF) Test of StationarityLand ar ea cultivated and Maize yield

Variable	Order	ADF	Critical Value			Prob.
			1%	5%	10%	
Land area cultivated	Level	-1.079475	-3.605593	-2.936942	2.606857	0.7146
	1st Difference	-4.559747	-3.605593	-2.936942	-2.606857	0.0007
Yield	Level	-2.263216	-3.600987	-2.935001	-2.605836	0.1883
	1st Difference	-6.481907	-3.605593	-2.936942	-2.606857	0.0000

Augmented Dickey-fuller (ADF) Test of Stationarity for Land Area Cultivated and Yield of Sorghum

The unit root test was also employed to each of these variables land area cultivated of sorghum (LACSO) and sorghum yield (SOY) for a period of 40 years. The variables under study were not stationary at level but become stationary on first differencing, therefore integrated of order one i.e. 1(1).

Table 4: Augmented Dickey Fuller (ADF) Test of Stationarity for Land area cultivated and Sorghum yield

Variable	Order	ADF	Critical Value			Prob.
			1%	5%	10%	
Land area cultivated	Level	-2.135213	-3.600987	-2.935001	-2.605836	0.2325
	1st Difference	-8.119002	-3.605593	2.936942	-2.606857	0.0000
Yield	Level	-3.402810	-3.600987	-2.935001	-2.605836	0.1665
	1st Difference	-5.835387	-3.615588	-2.941145	-2.609066	0.0000

Effect of Land Area Cultivated on Maize Yield in Nigeria

Johansen co-integration test of long run relationship among maize land area cultivated and yield in Nigeria

The co-integration test shown on Table 5 which is based on trace statistics model with intercept and linear deterministic trend assumption reveals that there is no existence of co integration between maize land area cultivated and yield at various probability level. This means that each of the variables may not deviate from their long run direction. In the short run, their relationship has an unstable and unpredictable long run direction. Thus, based on the decision rule, we reject the null hypothesis. Hence, no long run equilibrium relationship exists between the land area cultivated and yield of maize.

Table 5: Johansen co-integration Test of Long run relationship among Maize Yield and Land Area Cultivated

Hypothesized No. of (E (S)	Eigen Value	Trace Statistic	Critical Value 5%	Prob.
None	0.402124	27.57418	29.79707	0.8883
At most 1	0.280335	11.62866	15.49471	0.1756
At most 2	0.045099	1.430592	3.841466	0.2317

Trace test indicates no cointegration
Mackinnon-Haug-Michelis (1999) P-values

Effect of Land Area Cultivated on Sorghum Yield in Nigeria

Johansen Co-integration test of long run relationship among sorghum land area cultivated and yield in Nigeria

The co-integration test presented on Table 6 based on trace statistics model with intercept and linear deterministic trend assumption shows that there exist a co-integration between land area cultivated and sorghum yield at 5% probability level. This means that though each of the variables may deviate from their long run direction, in the short run their relationship has a stable and predictable long run direction. Thus based on the decision rule that 0.0494 is significant at 5%, we fail to reject the null hypothesis. Therefore,land area cultivated and yield of sorghum are co-integrated.

Table 6: Johansen co-integration Test of Long Relationship among, land area cultivated and Sorghum Yield in Nigeria

Hypothesized No. of (E (S)	Eigen Value	Trace Statistic	Critical Value 5%	Prob.
None	0.467028	29.84138	29.79707	0.0494**
At most 1	0.241307	12.85065	15.49471	0.1204
At most 2	0.181098	5.394366	3.341466	0.0203

Trace test indicates 1 cointegration(s) at the 0.05 level
**denotes failure to rejection of the hypothesis at the 0.05 level
Mackinnon-Haug-Michelis (1999) p-values

The Vector Error Correction Model of long and short run relationship between land area cultivated and sorghum yield

Table 7 shows the long run impact of sorghum yield and the independent variable. The result indicates that the LACSO is statistically significant at 1% probability level with a negative coefficient (-0.000119). This implies that in the long run a unit increase in LACSO will lead to a decrease of SOY by -0.000119. The decrease in yield may be attributed to non improvement in the agronomical practices by the farmers making the land infertile. This may also be because sorghum is still largely cultivated as a subsistence crop under non-mechanization system.

The negative relationship between sorghum yield and land area cultivated may be as a result of low technical knowhow of farmers which could arise from labour, diseases and pest, relative humidity, etc. The result agrees with Mohammed *et al.*(2016) who found that increase in land by 1% on rice farming lead to a decrease of yield by 37%.This result also agrees with findings of Onu *et al.*(2010) who observed that maize has not been produce to meet food and industrial needs of Nigeria because of low productivity from maize farms.

Table 7: The Vector Error Correction Model of Long Run and Short Run Relationship among, Land Area Cultivated and Sorghum Yield

Variable	Cointegration Coefficient	Standard Error	t-statistics
SOY (ton)	1.0000	-	-
LACSO (ha)	-0.000119	8.90000	-1.33630*
Constant	-9918.377	-	-
ECT	Yield	Land Area Cultivated	
Coint. Eq1	-1.739318	-12.38432	
	(0.25883)	(245.442)	
	[-6.71985]*	[-0.05046]*	
D(YIELD_SORGHUM(-1))	0.676182	100.7939	0.006476
	(0.19697)	(186.777)	(0.00811)
	[3.43296]	[0.53965]***	[0.79815]***
D(YIELD_SORGHUM(-2))	0.564438	171.5687	0.006359
	(0.16621)	(157.607)	(0.00685)
	[3.39601]	[1.08859]	[0.92878]***
D(AREA_CULTIVATED_SORGHUM(-1))	-0.000671	0.235323	1.37E-05
	(0.00022)	(0.21033)	(9.1E-06)
	[-3.02662]*	[1.11883]	[1.49851]
D(AREA_CULTIVATED_SORGHUM(-2))	-0.000402	0.075750	1.81E-06
	(0.00020)	(0.19159)	(8.3E-06)
	[-1.99203]*	[0.39538]***	[0.21691]***
C	167.2141	-2969.003	
	(120.445)	(114213.)	
	[1.38831]	[-0.02600]*	
R-squared	0.826422	0.482121	
Adj. R-squared	0.754948	0.268876	
Sum sq. resids	5742555.	5.16E+12	
S.E. equation	581.2034	551133.6	
F-statistic	11.56266	2.260883	
Log likelihood	-189.7802	-361.1460	
Akaike AIC	15.82242	29.53168	
Schwarz SC	16.21246	29.92172	
Mean dependent	91.00000	13805.36	
S.D. dependent	1174.085	644557.1	
Determinant resid covariance (dof adj.)	4.97E+19		
Determinant resid covariance	1.56E+19		
Log likelihood	-658.8532		
Akaike information criterion	54.86826		
Schwarz criterion	56.18464		

Standard errors in ( ) and t-statistics in[ ]
* *** significant at (1%) (10%)
SOY = Sorghum yield; LACSO = Land area cultivated sorghum;

Short run Granger causality test between land area cultivated and maize yield

The result presented on Tables 8 indicated both unindirectional and bidirectional causal relationship among the variables. The result shows that there exists a unindirectional causality between maize yield (MAY) and land area cultivated maize (LACMA). This means that any past value of MAY present land devoted to maize cultivation or the present value of maize can predict land devote for cultivation in future. The hypothesis was therefore rejected.

Table 8: Granger Causality Test for Maize

Null Hypothesis:	F-Statistic	Prob.
Area_Cultivated_Maize does not Granger Cause Yield_Maize	0.38578	0.0683
Yield_Maize does not Granger Cause Area_Cultivated_Maize	2.08159	0.1399

Short run Granger causality test between land area cultivated and sorghum yield

The Granger Causality test shown on Table 9 also indicated both unidirectional and bidirectional causality among sorghum yield and the independent variable. A unidirectional causality exist between sorghum yield (SOY) and land area cultivated sorghum (LACSO). This can be explained that as SOY increases the amount of land that is devoted to sorghum cultivation also increases. The hypothesis was therefore rejected.

Table 9: Granger Causality Test for Sorghum

Null Hypothesis:	F-Statistic	Prob.
Area_Cultivated_Sorghum does not Granger Cause Yield_Sorghum	0.16755	0.8464
Yield_Sorghum does not Granger Cause Area_Cultivated_Sorghum	1.69813	0.1978

Conclusion and Recommendations

Trend in the land area cultivated and yields of maize and sorghum has no definite pattern. The yield of sorghum decreased significantly between 1986 and 1993. Land area cultivated thought to be the main determinant of yield increase but findings prove otherwise. The study indicated that increase in land area cultivated of sorghum in the long run lead to decrease yield.

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