ACHIEVING SELF-SUFFICIENCY IN SUGARCANE PRODUCTION IN NIGERIA: A MYTH OR REALITY?

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ABSTRACT
The research determined the measures that need to be tackled to achieve self-sufficiency in sugarcane production in Nigeria, thus curtailing the foreign reserve drain owing to excess importation of sugarcane products to balance the mismatch between supply and demand. Dated data that covered sugarcane production, area, yield and price spanning for a period of 56 years (1961 to 2017) were sourced from the FAO database. The collected data were analyzed using descriptive and inferential statistics. The empirical evidence showed that the country *viz.* the three marked out policy regimes (pre-SAP, SAP and post-SAP) failed to achieve self-sufficiency in sugarcane production owing to ineffective technology. The inter-regime analysis showed area to be the driving force behind the increase in production at the expense of technology which is the most viable option to achieve self-sufficiency in Nigerian agrarian setting which is threatened by high competing demand for land, thus leading to shrinking of land for agricultural purposes. Despite the fact that the farmers learn from past experience in avoiding convergent cobweb effect, climate change was found to be a threat to sugarcane self-sufficiency. The *ex-ante* sugarcane production trend showed a bleak future towards achieving self-sufficiency in the production of sugarcane as the forecasted production trend will be driven by an increase in area at the expense of the most viable option, the yield which will be on the decline. Therefore, to achieve the goal of self-sufficiency in sugarcane production which is aimed at containing excess importation which drains the country foreign reserve, the current good intention policy on sugarcane production expansion is not enough. Thus, the study recommends effective and factual policies on technology *viz.* increase induced and autonomous investments on sugarcane technology research to shore-up the mismatch between supply and demand in the country. If these measures are put in place the country's goal of achieving self-sufficiency will come to pass, otherwise, it will be a white elephant project.

Keywords: Growth; Forecast; Self-sufficiency; Sugarcane production; Nigeria

INTRODUCTION
Nigeria is the only country that belongs to the category of sugar importers among the 92 member countries that belong to the International Sugar Organization (ISO) (Olukunle, 2016). The country is the world's largest importer of sugar, at 1.87 million metric tonnes, as cited by a report released recently by the United States Department of Agriculture (USDA), Foreign Agricultural Service (Oseghale, 2018). In the West African sub-region, Nigeria remains the largest importer while in the African continent; it is second to Algeria, the largest importer at 2,265,000 metric tonnes.

According to the National Sugar Development Council (NSDC), sugar consumption in Nigeria stood at 1.1 million metric tonnes in 2012, 1.50 million metric tonnes in 2015, 1.56million metric tonnes in 2016, and 1.6 million metric tonnes in 2017. The local production of sugar, on the other hand, stands at a paltry 25,000 metric tonnes as at 2016, rising by 85.34 per cent from 13,488 MT in 2015. The NSDC (2012) as reported by Olukunle (2016) posited that Nigeria is the least food secured in terms of sugar in comparison with some selected sugar producing countries in West Africa. Unfortunately, Nigeria can only meet an insignificant proportion of its' domestic demand through domestic production when most of its neighbours in Africa produced substantial proportions of their sugar requirements.

Dauda (2018) reported that billions of naira was incurred in the importation of over 750,000 metric tons of raw sugar in the country. This latest import is part of the 1.87million tons booked for delivery in the year 2018, as local production may not meet the projected target under the National Sugar Master Plan. Despite the increase in the import duty and levy on the commodity, it was gathered that the country spent the cash (Dauda, 2018).

An investigation has shown that the inability of the country to boost local production by 200,000 metric tons yearly has led to massive import of raw sugar from Brazil and other countries as the country could only produce 300,000 tons in the last four years.

Inspite of the Central Bank of Nigeria (CBN) Anchor Borrowers' Programme to improve sugar production by 12.5 per cent, the percentage production change was

2.56% in 2016 and then plummeted to 0.71% in the year 2017. It was learned, that the country would still rely on 1.6 million tons of sugar from its major sellers Brazil, Thailand and United States to meet local demand (Dauda, 2018).

Despite the country's comparative advantage in sugarcane production, the domestic supply had been lagging behind the demand. Also, government's poor protection of the local industry is stifling Nigeria's sugar output, thereby leading to increased reliance on importation. Therefore, the concerted effort by the Government to curb importation of sugar has failed based on the reported billions of naira been incurred on importation. Thus, the puzzling question is can the country save its foreign exchange reserve by reducing sugar importation while targeting annual local production that will offset the demand deficit which is bridged by import? It is in view of the above that the present research aimed at tracking the possibility of achieving self-sufficiency in sugarcane production. The specific objectives were to examine the production pattern of sugarcane; to determine the source(s) of change in sugarcane production; to determine the level of instability in sugarcane production; to determine the source(s) of instability in sugarcane production; to determine sugarcane farmers' acreage response; and, to forecast the future trend of sugarcane production in Nigeria.

RESEARCH METHODOLOGY

Dated data that covered production, area, yield and price spanning for a period of 56 years (1961 to 2017) sourced from the FAO database were used. The collected data were analyzed using descriptive and inferential statistics. For proper examination, the data were stratified based on the policy regime periods that marked the economy of the country *viz.* pre-Structural Adjustment Period (pre-SAP) (1961-1984), SAP (1985-1999) and post-SAP (2000-2017). Objective 1 was achieved using descriptive statistics and growth model, objective 2 was achieved using instantaneous and Hazell's decomposition models and objective 3 was achieved using the instability indexes. The Hazell's decomposition model, Nerlovian Adjustment model and the Holt model were used to analyze objectives 4, 5 and 6 respectively.

Empirical model

Growth rate: The compound annual growth rate calculated using the exponential model is given below:

$\gamma = \alpha\beta^t$ ……………………… (1)

$ln\gamma = ln\alpha + tln\beta$ ……………… (2)

$CAGR = [Antilog\beta - 1] \times 100$ … (3)

Where, CAGR is compound growth rate; t is time period in year; γ is area/yield/production; α is intercept; and, β is the estimated parameter coefficient.

Instability index: Coefficient of variation (CV), Cuddy-Della Valle Index and Coppock's index were used to measure the variability in the production, area and yield of sugarcane. Following Sandeep *et al*.(2016) and Boyal *et al*.(2015) the CV is shown below:

$CV(\%) = \frac{\sigma}{\bar{X}} * 100$ ……… (4)

Where,

σ *is standard deviation and* $\bar{X}$ *is the mean value of area, yield or production*

The simple CV overestimates the level of instability in time series data characterized by long-term trends, whereas the Cuddy-Della Valle Index corrects the coefficient of variation by instability index as it de-trend the annual production and show the exact direction of the instability (Cuddy-Della Valle, 1978). Thus, it is a better measure to capture the instability of agricultural production and prices, and it is given below:

$CDII = CV*(1-R^2)^{0.5}$ ……….. (5)

Where CDII is the Cuddy-Della instability index; CV is the coefficient of variation; and, R^2 is the coefficient of multiple determination. In conformity with Dharke and Sharma (2009); and Debnath *et al.* (2015) the instability index was classified as low instability (≤15%) and high instability (>15%).

Unlike CV, Coppock's instability index give close approximation of the average year-to-year percentage variation adjusted for trend (Ahmed and Joshi, 2013; Kumar *et al*., 2017; Umar *et al*., 2019) and the advantage is that it measures the instability in relation to the trend in production (Kumar *et al*., 2017). According to Kumar *et al*.(2017), a higher numerical value for the index represents greater instability. Following Coppock (1962), the algebraic economic formula as used by Ahmed and Joshi(2013); Sandeep *et al*.(2016); Kumar *et al*.(2017); Umar *et al*.(2019) is given below:

$CII = \left(Antilog\sqrt{\log V} - 1\right) * 100$……….. (6)

$\log V = \frac{\sum\left[log\frac{X_{t+1}}{X_t} - m\right]^2}{N-1}$ ………….. (7)

Where,

$X_t = Area\ or\ Yield\ or\ Production\ in\ year\ 't'$,
$N = number\ of\ year(s)$, CII = Coppock's instability index;
$m = mean\ difference\ between\ the\ \log\ of\ X_{t+1} and\ X_t$;
and, $logV = Logarithm\ Variance\ of\ the\ series$

Source of change in sugarcane production

Instantaneous change: Following Sandeep *et al*.(2016) the instantaneous decomposition analysis model used to measure the relative contribution of area and yield to the total output change is given below:

$P_0 = A_0 \times Y_0$ ……………… (5)

$P_n = A_n \times Y_n$ …………… (6)

Where, P, A and Y represent the production, area and yield respectively. The subscript 0 and n represents the base and the n^{th} years respectively.

$P_n - P_0 = \Delta P$ …………… (7)

$A_n - A_0 = \Delta A$ …………… (8)

$Y_n - Y_0 = \Delta Y$ …………… (9)

From equation (5) and (9) we can write

$P_0 + \Delta P = (A_0 + \Delta A)(Y_0 + \Delta Y)$ ……. (10)

Therefore,

$P = \frac{Y_0 \Delta A}{\Delta P} \times 100 + \frac{A_0 \Delta Y}{\Delta P} \times 100 + \frac{\Delta A \Delta Y}{\Delta P} \times 100$ …. (11)

$Production = Area\ effect + Yield\ effect + Interaction\ effect$ ………………….. (12)

Hazell's decomposition model: In estimating the change in average production and change in the variance of production with respect to between regimes and the overall period, Hazell's (1982) decomposition model was used. Hazell decomposed the sources of change in the average of production and change in production variance into four (4) and ten (10) components as cited by Umar *et al.*(2017 and 2019). Decomposition analysis of change in production assesses the quantum of increase or otherwise of production in year 'n' over the base year that results from a change in the area, productivity or their interaction.

i. ***Changes in average production***: It is caused by changes in the covariance between area and yield and changes in mean area and mean yield. The model is shown below:

$E(P) = \bar{A}\bar{Y} + COV(A, Y$ …………… (13)

$\Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1 \Delta \bar{Y} + \bar{Y}_1 \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y} + \Delta COV(A, Y)$ …………… (14)

Table 1: Components of change in the average production

Sources of change	Symbols	Components of change
Change in mean area	$\Delta \bar{A}$	$\bar{A}_1 \Delta \bar{Y}$
Change in mean yield	$\Delta \bar{Y}$	$\bar{Y}_1 \Delta \bar{A}$
Interaction effect	$\Delta \bar{A} \Delta \bar{Y}$	$\Delta \bar{A} \Delta \bar{Y}$
Changes in area-yield covariance	$\Delta COV(A, Y)$	$\Delta COV(A, Y)$

ii. ***Change in variance decomposition***: The source of instability is caused by ten factors and shown below is the model:

$V(P) = \bar{A}^2 . V(Y) + \bar{Y}^2 . V(A) + 2\bar{A}\bar{Y}COV(A, Y) - COV(A, Y)^2 + R$…………………. (15)

Table 2: Components of change in variance production

Sources of change	Symbols	Components of change
Change in mean area	$\Delta \bar{A}$	$2\bar{Y}\Delta \bar{A}COV(A, Y) + \{2\bar{A}\Delta \bar{A} + (\Delta \bar{A})^2\}V(Y)$
Change in mean yield	$\Delta \bar{Y}$	$2\bar{A}\Delta \bar{Y}COV(A, Y) + \{2\bar{Y}\Delta \bar{Y} + (\Delta \bar{Y})^2\}V(A)$
Change in area variance	$\Delta V(A)$	$\bar{Y}^2 V(A)$
Change in yield variance	$\Delta V(Y)$	$\bar{A}^2 V(Y)$
Interaction effect I (changes in mean area and mean yield)	$\Delta \bar{A} \Delta \bar{Y}$	$2\Delta \bar{A} \Delta \bar{Y} COV(A, Y)$
Changes in area-yield covariance	$\Delta COV(A, Y)$	$\{2\bar{A}\bar{Y} - 2COV(A, Y)\}COV(A, Y) - \{\Delta COV(A, Y)\}^2$
Interaction effect II (changes in mean area and yield variance)	$\Delta \bar{A} \Delta V(Y)$	$\{2\bar{A}\Delta \bar{A} + (\Delta \bar{A})^2\}\Delta V(Y)$
Interaction effect II (changes in mean yield and area variance)	$\Delta \bar{Y} \Delta V(A)$	$\{2\bar{Y}\Delta \bar{Y} + (\Delta \bar{Y})^2\}\Delta V(A)$
Interaction effect IV (changes in mean area and mean yield and changes in area-yield covariance)	$\Delta \bar{A} \Delta \bar{Y} COV(A, Y)$	$(2\bar{A}\Delta \bar{Y} + 2\bar{Y}\Delta \bar{A} + 2\Delta \bar{A} \Delta \bar{Y})\Delta COV(A, Y)$
Residual	ΔR	$\Delta V(AY)$

Nerlovian model: Following Sadiq *et al.*(2017), the basic model which has come to be called as Nerlovian price expectation model is as follows:

$A_t = \alpha + \beta_i P_t^* + \varepsilon_t$ ……………………………… (16)

$(P_t^* - P_{t-1}^*) = \beta(P_{t-1} - P_{t-1}^*) 0 < \beta < 1$ ………… (17)

Where;

$A_t = Actual\ acreage\ under\ the\ crop\ in\ year\ 't'$

$P_t^* = Expected\ price\ of\ the\ crop\ in\ year\ 't'$

$P_{t-1}^* = Expected\ price\ of\ the\ crop\ in\ year\ 't-1'$

$P_{t-1} = Actual\ price\ of\ the\ crop\ in\ year\ 't-1'$

$\alpha = Intercept$

β = $Coefficient\ of\ price\ expectation$
ε_t = $Disturbance\ term$

The Nerlovian model depicting farmer's behavior in its simplest form is shown below:

$A_t^* = \beta_0 + \beta_1 P_{t-1} + \beta_2 PR_{t-1} + \beta_3 Y_{t-1} + \beta_4 YR_{t-1} + \beta_5 T_t + \beta_6 WI_t + \varepsilon_t$ ……………………………… (18)

$A_t - A_{t-1} = \beta(A_t^* - A_{t-1})(Nerlovian\ adjustment\ equation)$ …………………… (19)

As expected variables are not observable, for estimation purpose, areduced form containing only observable variables may be written after substituting the value of A_t^* from equation (19) into equation (18), and is as follow:

$A_t^* = \beta_0 + \beta_1 P_{t-1} + \beta_2 PR_{t-1} + \beta_3 Y_{t-1} + \beta_4 YR_{t-1} + \beta_5 T_t + \beta_6 WI_t + \beta_{10} A_{t-1} + \varepsilon_t$ ………………… (20)

The first equation is a behavioural equation, stating that desired acreage (A_t^*) depend upon the following independent variables:

Where,
A_t = $current\ area\ under\ the\ crop$;
P_{t-1} = $one\ year\ lagged\ price\ of\ sugarcane$;
PR_{t-1} = $one\ year\ lagged\ price\ risk\ of\ sugarcane$;
Y_{t-1} = $one\ year\ lagged\ yield\ of\ sugarcane$;
YR_{t-1} = $one\ year\ lagged\ yield\ risk\ of\ sugarcane$;
T_t = $time\ trend\ at\ period\ t$;
WI_t = $weather\ index\ for\ sugarcane\ at\ period\ t$;
A_{t-1} = $one\ year\ lagged\ area\ under\ sugarcane$;
β_0 = $intercept$;
β_{1-n} = $parameter\ estimates$; and,
ε_t = $Disturbance\ term$

Price and yield risks were measured by the standard deviation of the three preceding years. For the weather index, the impact of weather on yield variability was measured with a Stalling index (Stalling, 1960). The yield was regressed on time to obtain expected yield. The actual to the predicted yield ratio is defined as the weather variable. The weather effects such as rainfall, temperature etc. may be captured by this index in acreage response model (Ayalew, 2015).

The extent of adjustment to changes in the price and/or non-price factors is measured in terms of "coefficient of adjustment". The adjustment takes place in accordance with the actual planted area in the preceding year. If the coefficient of adjustment is one, farmers fully adjust area under the crop in the current year itself and there will be 'no lags' in the adjustment. But if the coefficient of adjustment is less than one, the adjustment goes on and gives rise to lags, which are distributed over time. The number of years required for 95 percent of the effect of the price to materialize is given below (Sadiq *et al*. 2017):

$(1-r)^n = 0.05$ …………………… (21)

Where;
r = coefficient of adjustment (1-coefficient of lagged area); and,
n = number of year.

In the present study, both short-run (SRE) and long-run (LRE) elasticities of the area under the crop with respect to price were estimated to examine and compare the effect of price on the responsiveness of area in the short-run as well as in the long-run. The price elasticities are given below:

$SRE = Price\ coefficient * \frac{Mean\ of\ price}{Mean\ of\ area}$ ………… (22)

$LRE = \frac{SRE}{Coefficient\ of\ adjustment}$ ………………….. (23)

Holt model

Forecasting Accuracy

For measuring the accuracy in fitted time series model, mean absolute prediction error (MAPE), relative mean square prediction error (RMSPE), relative mean absolute prediction error (RMAPE) (Paul, 2014), Theil's U statistic and R^2 were computed using the following formulae:

$MAPE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1})$ …………………… (24)

$RMPSE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1})^2 / A_{t-1}$…………………………… (25)

$RMAPE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1}) / A_{t-1} \times 100$ ……………………………………………………………… (26)

$U = \sqrt{\frac{\sum_{t=1}^{n-1}\frac{(\hat{Y}_{t+1} - Y_{t+1})^2}{Y_t}}{\sum_{t=1}^{n-1}\frac{(Y_{t+1} - Y_t)^2}{Y_t}}}$ ……………………………… (27)

$R^2 = 1 - \frac{\sum_{i=1}^{n}(A_{ti} - F_{ti})}{\sum_{i=1}^{n}(A_{ti})}$ ……………………………… (28)

Where, R^2= coefficient of multiple determination,A_t = Actual value; F_t = Future value, and T = time period

RESULTS AND DISCUSSION

Trend Pattern of Sugarcane Production

A perusal of the graph (Figure 1-4) showed an increasing production trend which was majorly driven by a steep increase in area during the pre-SAP; at the beginning a flattened and latter-on a plummeted production trend which was determined by both almost stagnant area and yield in the former and a steep decrease in the trend of yield despite increase in the area for the latter during the SAP regime. For the post-SAP period, the production trend exhibited a *zig-zag* shape with incremental change in the area been the game-changer as the yield trend was flat. However, the production trend for the overall period showed an increasing trend beyond the pre-SAP regime till the mid-SAP era with yield trend been stagnant while the area rises gently.

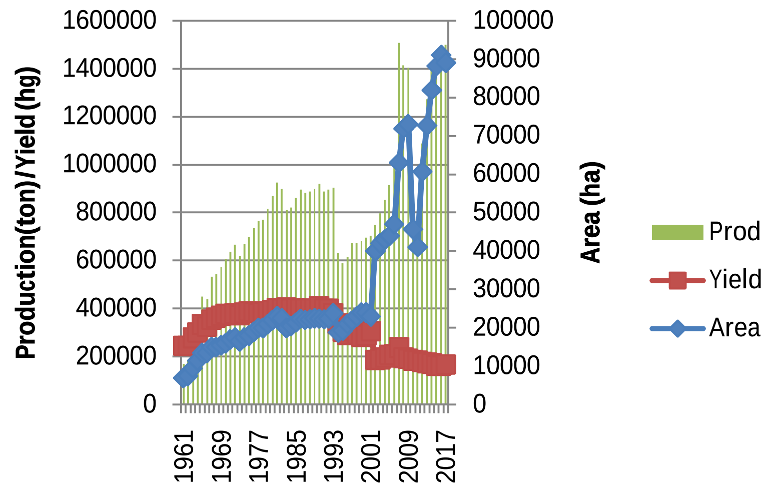

Figure 1: Production trend of sugarcane (1961-2017)

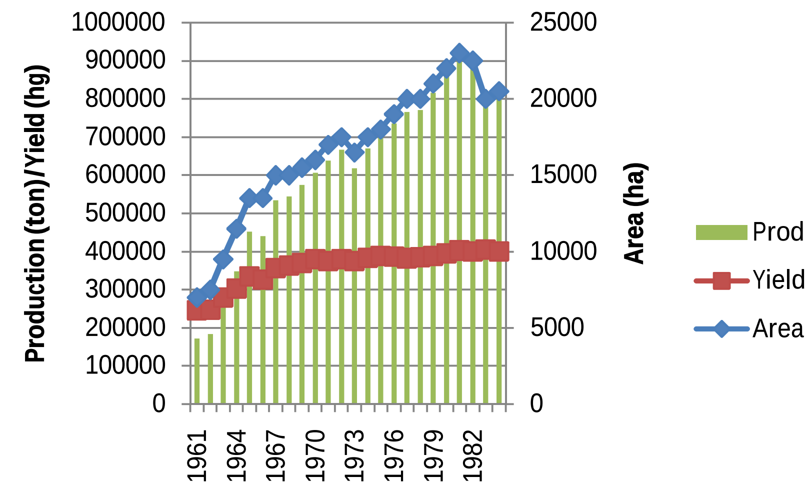

Figure 2: Pre-SAP production trend of sugar (1961-1984)

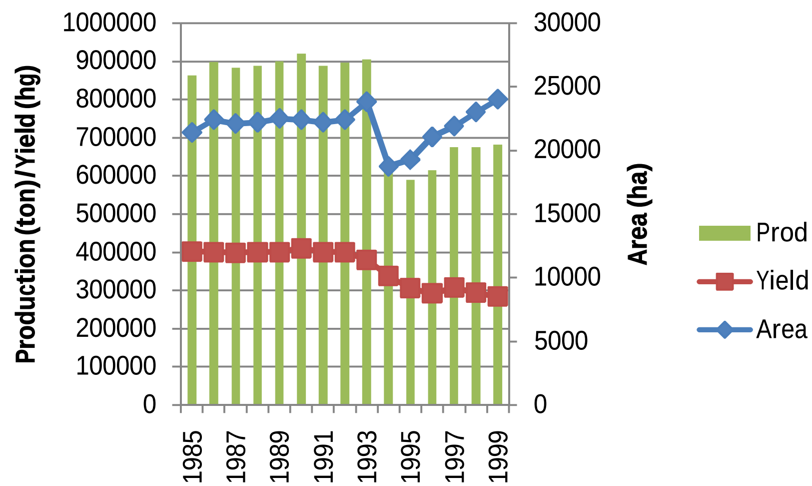

Figure 3: SAP production trend of sugar (1985-1999

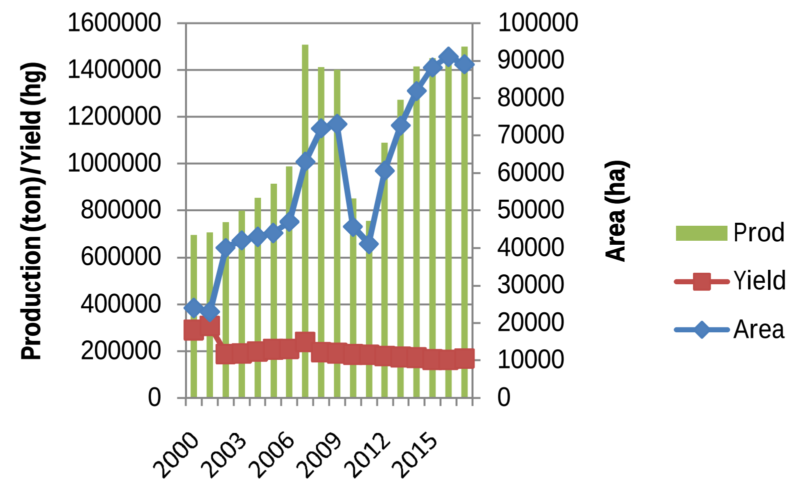

Figure 4: Post-SAP production trend of sugar (2000-2017

Furthermore, it was observed that sugarcane production increased by almost two-fold across the regimes, likewise the yield. However, the incremental increase in the area between the pre-SAP and SAP was very marginal (difference of 445.28hectares) and thereafter plummeted to 200,559.20 hectares during the post-SAP era (Table 3). Therefore, it can be inferred that the incremental change in the area was the major driving force behind the production trend of sugarcane in the country throughout the policy regimes.

A cursory review of the growth trend pattern showed positive annual growth (5.8%) in the production of sugarcane during the pre-SAP era which owes majorly to an annual increase in the growth rate of area (4.1%) when compared to the annual yield growth rate (1.7%). During the SAP era, the annual production growth rate was below the trough (-2.9%) which is due to a negative yield growth rate as the area annual growth rate was zero (0%). For the post-SAP era, it was evident that sugarcane production in the country was marked by an annual increase in the growth rate (4.2%) with increase in the annual area growth rate (6.8%) been the major driving force as annual yield growth rate (-2.6%) was observed to be below the trough. Besides, the same scenario that play-out during SAP regime was observed for the overall period (Table 3).

Table 3: Growth pattern of sugarcane production

Variables	Pre-SAP	SAP	Post-SAP	Overall
Area (ha)	360524.8(4.1)***	360970.1(0.0)^{NS}	200599.2(6.8)***	310139.2(3.4)***
Yield (hg)	617791.7(1.7)***	793800(-2.9)***	1102096(-2.6)***	817048(-1.4)***
Production (ton)	16604.17(5.8)***	21958.2(-2.9)***	57835.5(4.2)***	31033.54(2.0)***

Source: Authors' computation, 2019

Note: Figure in parenthesis is CAGR

*** ** * $^{\&\ NS}$ means significant at 1, 5, 10% and Non-significant respectively.

Change in Sugarcane Production

The decomposition analysis of the intra-regime source of change in the production showed area effect to be the major factor responsible for percentage incremental change in the production of sugarcane during the pre-SAP, post-SAP and the overall periods with the percentage contribution incremental changes to sugarcane output been 66.78%, 180.79% and 149.72% respectively. However, for the SAP regime, evidence showed a yield effect to be the major driving force in the percentage incremental change in the production of sugarcane. The result revealed a paradigm shift in the causal factor responsible for production increase from area effect during the pre-SAP to yield effect during the SAP period and thereafter area effect during the post-SAP regime. This outcome did not come as a surprise owing to the fact that despite the total shift in priority to black gold during the SAP era there wasan investment in technological advancement, thus the reason for yield effect. The reason for the area effect during the pre-SAP era owed to poor integration of the country's economy into the global trade due to the over-bearing effect of colonial policies which affected the managerial efficiency of the country (Table 4a).

Table 4a: Sources of change in sugarcane production (Intra-wise %)

Source of change	**Pre-SAP**	**SAP**	**Post-SAP**	**Overall**
Area effect	66.7801618	-35.5914	180.7944	149.7146
Yield effect	29.483829	143.0534	-55.9943	-37.5558
Interaction effect	3.73610169	-7.46215	-24.8002	-12.1589
Total change	**100**	**100**	**100**	**100**

Source: Authors' computation, 2019

Further investigation of the source of change in production between two regimes (inter) showed area effect to be the major source of change between pre-SAP and SAP (107.97%), and, SAP and post-SAP (352.31%) (Table 4b). This empirical evidence showed that the country was not self-sufficiency in the production of sugarcane, thus the reason for the high importation of refined sugar products into the country which drained Nigeria's foreign reserve to the tune of millions of dollars. In addition, these results showed the reason for the comatose and low capacity efficiency of the existing sugarcane refineries in the country.

Table 4b: Sources of change in average production of sugarcane(Inter-regime wise %)

Source of change	**Pre-SAP to SAP**	**SAP to Post-SAP**
Area effect	107.97	352.31
Yield effect	0.41	-95.80
Interaction effect	0.13	-156.53
Covariance effect	-8.52	0.01
Total change	**100**	**100**

Source: Authors' computation, 2019

Instability in Sugarcane Production

Using the simplest method to measure instability in the production of sugarcane, the result showed production instability to be moderate during the pre-SAP and post-SAP periods as evident from their respective CV indexes of 35.12% and 28.98% respectively, which were higher than the benchmark value of 20% but less than 40%. However, for the SAP era, production instability was low with very low instability in yield been the major factor. Also, for the overall period, sugarcane production was marked by moderate instability with moderate instability in yield been the causal factor (Table 5).

A cursory review of the exact direction of instability in sugarcane production showed a low instability in the production of sugarcane during the three regimes, as evident by their respective production, area and yield CDII indexes which were lower than 20%. Though, a moderate instability level in sugarcane output (24.88%) was observed for the overall period with area instability (29.16%) been the major causal factor as evidence showed yield instability to be low (19.99%)(Table 5). The low instability may be attributed to the country's goal of self-sufficiency in sugarcane production. Therefore, it can be inferred that sugarcane production in the country during the three regimes was within the comfort zone.

Contrary, examination of sugarcane production instability in relation to the price trend showed instability in sugarcane output across the three regimes and the overall period to be high as evident from the CII values which were 58.70% (pre-SAP), 43.62% (SAP), 49.59% (post-SAP) and 57.26% (overall period) (Table 5).

Table 5: Instability indices in sugarcane production

Regimes	**Variables**	**CV**	**CDII**	**CII**
Pre-SAP	Production	0.35117	16.47133	58.70409
	Area	0.26963	11.90654	50.82722
	Yield	0.13089	7.169141	42.59656
SAP	Production	0.16194	10.43225	43.61993
	Area	0.064767	6.4767	39.34397
	Yield	0.13908	6.297115	42.53906
Post-SAP	Production	0.28982	19.02685	49.58605
	Area	0.37828	18.95179	55.95212
	Yield	0.19951	12.52313	43.91615
Overall	Production	0.38258	24.88241	57.26406
	Area	0.71781	29.15758	67.9509
	Yield	0.28235	19.98512	50.55275

Source: Authors' computation, 2019

Sources of Instability in Sugarcane Production

A cursory review of the sources of instability between the regimes (inter-regime) in descending order showed changes in area variance (58.73%), change in residual (53.28%) and change in area yield covariance (49.52%) to be the major source of instability in sugar production between pre-SAP and SAP regimes. Between the SAP and post-SAP regimes, the major source of fluctuation in the output of sugarcane was change in the area variance (345.62%). Also, change in the area variance was found to be the major source of instability in the output of sugarcane in the country for the overall period (Table 6). These imply that during the former transition both risk and uncertainty were the threats to sugar self-sufficiency while the risk was the major threat to self-sufficiency of sugar production in the country during the latter transition and across the three regimes.

Table 6: Sources of instability in sugarcane production

Source of variance	Pre-SAP to SAP	SAP to Post-SAP	Overall
Change in mean yield	-50.14	-0.06	1.31
Change in mean area	-24.80	40.16	45.79
Change in yield variance	-1.70	-6.78	-11.33
Change in area variance	58.73	345.62	511.19
Interaction between changes in mean yield and mean area	-0.02	0.04	-38.19
Change in area yield covariance	49.52	0.05	-22.42
Interaction between changes in mean area and yield variance	-1.27	-40.26	-41.55
Interaction between changes in mean yield and area variance	0.15	-238.89	-410.04
Interaction between changes in mean area and yield and change in area-yield covariance	16.25	0.02	44.54
Change in residual	53.28	0.08	20.70
Total change in variance of production	**100**	**100**	**100**

Source: Authors' computation, 2019

Farmers' Acreage Response

Of the four functional forms subjected to the specified equation, the linear functional form was found to be the best fit as it satisfied the economic, statistical and econometric criteria, thus chosen as the lead equation. It is worth to mention that the exponential function had more parameter estimates that were significant but unfortunately it failed the test of serial correlation as evident by the Durbin-Watson statistics which is less than 1.50 (Table 7a).

The diagnostic statistics showed the absence of serial correlation, arch effect and heteroscedasticity as indicated by their respective t-statistics which were not different from zero at 10% degree of freedom. Beside, chow test results across the three regimes showed no evidence of a structural break in the trend as indicated by their respective t-statistics which were not different from zero at 10% degree of freedom. Furthermore, evidence showed that the model specification is adequate and there is no change in the estimated parameters captured by the model as indicated by RESET and CUSUM (Figure 5)t-statistics respectively, which were not different from zero at 10% degree of freedom. However, the residual failed the normality test as indicated by the Chi^2t-statistic which was different from zero at 10% probability level. Though, non-normality in the distribution of the residual is not considered a serious problem as data in their natural form are not normally distributed.

The empirical evidence showed that 94.16% of the variation in the current acreage was influenced by the explanatory variables included in the model as indicated by the coefficient of multiple determination (R^2). It was observed that farmers' decision on the current acreage allocation was determined by weather index, one year lagged yield risk, time trend and one year lagged area as indicated by their respective coefficients which were different from zero a 10% degree of freedom. The negative significant of the weather index implies that weather vagaries *viz.* dry spell and flood reduced the current acreage allocated to sugarcane production. Thus, the marginal, SRE and LRE implications of an increase in the weather vagaries in the studied area will lead to a decrease in the current sugarcane area by 30084.30 hectares, 0.93% and 3.76% respectively. This showed that the farmers' acreage allocation decisions in the SR and LR were inelastic and elastic in response to an increase in the weather vagaries in the studied area. The negative significant of the one year lagged yield risk coefficient showed how poor yield of the immediately preceding year owing to dry spell, flood and spread of pest and diseases makes farmers reduce the current area allocated to sugarcane production in Nigeria. In response to low yield in the lagged period, the farmers were inelastic both in the SR and LR in making current area allocation to sugar production. The marginal, SRE and LRE implications of a unit increase in the immediate lagged year yield risk by 1kg of sugarcane output loss will make the farmers decrease the current area allocated to sugarcane by 0.184 hectare, 0.054% and 0.239% respectively. Though the price coefficient is not significant, evidence of cobweb effect owing to convergent cyclical fluctuation of sugarcane price impacted negatively on the current acreage allocation decision of the farmers. Besides, this proves that Nigeria's sugarcane farmers learn from past experience. Thus, the effect of change in output price on framers' responsiveness to current area allocation decisions is inelastic both in the SR and LR. Since the LR price elasticity of the crop was very low, the impact of the price policy on sugarcane would be very low. In addition, the farmers are facing not much constraint concerning technology and the institutions as indicated by the 2.14 years required for 95% of the price effect to materialize (Table 7b). The lower the constraints, the less is the time required for adjustment and vice versa. In achieving the desired change in the supply of a crop, the instrument of pricing policy is more effective if the time required for adjustment is small. It is worth to mention that negative acreage response owing to negative own price coefficient is not uncommon as earlier studies reported similar coefficient (e.g Sadiq *et al*., 2017; Sadiq *et al*., 2019; Jain *et al*. 2005)..

The positive significant of the lagged area coefficient coupled with the coefficient been less than one implies that the farmers partially adjusted the current acreage under sugarcane production and the adjustment goes on and gives rise to the lags which are distributed over the time. The positive significant of the trend coefficient indicates a positive response of sugarcane supply to favourable economic policies *viz.* induced and autonomous investment on infrastructure, expenditure on agricultural research and extension, technological innovations-application of modern techniques. Also, the positive non-significant of the efficiency parameters showed poor managerial efficiency of the farmers in making rational decisions on current acreage allocation to sugarcane in the country.

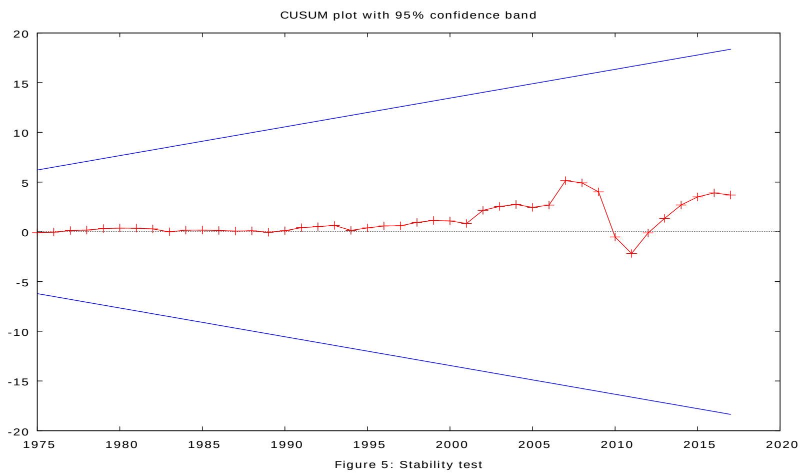

Figure 5: Stability test

Table 7a: Farmers' acreage response

Variables	**Parameters**	**t-stat**	**Mean**	**SRE**	**LRE**
Intercept	28831.2(19351.8)	1.490^{NS}	-	-	-
P_{t-1}	−5.732(7.811)	0.733^{NS}	1040.189	-0.180	-0.729
PR_{t-1}	5.655(36.900)	0.153^{NS}	51.25829	0.0087	0.036
Y_{t-1}	0.0081(0.04847)	0.167^{NS}	306965.7	0.075	0.304
YR_{t-1}	−0.1837(0.0747)	2.458**	9753.485	-0.054	-0.219
T_t	604.31(350.60)	1.724*	26.5	0.484	1.959
WI_t	−30084.3(14360.5)	2.095**	1.022521	-0.930	-3.762
A_{t-1}	0.75278(0.08745)	8.608***	32451.17	0.739	2.988
R^2	0.9415				
F-stat	98.94{2.08E-24}***				
Durbin-Watson Stat	2.432				
Arch effect	5.39{ 0.248}^{NS}				
Heteroscedasticity	41.77{0.200}^{NS}				
Normality	24.4{4.8E-6}***				
Chow Test (1984)	0.31{0.95}^{NS}				
Chow Test (1999)	1.65{0.145}^{NS}				
Chow Test (2016)	0.099{0.905}^{NS}				
Chow Test (1991)	0.41{0.90}^{NS}				
CUSUM Test	0.564{ 0.575}^{NS}				
RESET Test	0.077{0.925}^{NS}				

Source: Authors' computation, 2019

Note: *** ** * ^{NS} means significant at 1%, 5%, 10% probabilities and Non-significant respectively.
Values in ( ), [ ] and { } are standard error, t-statistic and probability level respectively.

Table 7b: Time required for the price effects to materialize

Crop	Price elasticity		Adjustment coefficient		Time (yr)
	SR	LR	SR	LR	
Sugarcane	-0.180	-0.729	0.739	2.988	2.14

Source: Authors' computation, 2019

Production Forecast of Sugarcane

Test of the unit root on the variables *viz.* production, area and yield showed the variables were non-stationary at level but after first difference they became stationary, thus indicating the absence of a trend in the time series variables (Figure 6-8). In other words, at the level the presence of autocorrelation for all the variables was evident but after the first difference, the autocorrelation was eliminated as evident from the spikes which were below the boundary line. Therefore, these variables are reliable for the sugarcane production forecast owing to the absence of a random walk. Holt model was used to forecast the future trend of sugarcane production in Nigeria as it performed better than the ARIMA model when validation or *ex-post* prediction power was carried out.

To determine the predictive power of the fitted Holt model, one step-ahead forecast of the variables along with their corresponding standard errors using the naïve approach for the period 2013 to 2017 were computed. The validation of the model was done through the sample periods to investigate how closely they could track the path of the actual observations (Table 8a).

Table 8a: One step ahead forecast of sugarcane production

Period	Production		Area		Yield	
	Actual	Forecast	Actual	Forecast	Actual	Forecast
2013	1272034	1104113	72689	61770	174998	172372
2014	172372	1287478	81872	73821	172649	168164
2015	1449963	1429081	88135	83011	164516	166027
2016	1487173	1465560	90988	89278	163447	158464
2017	1497757	1502791	89017	92132	168255	157103

Source: Authors' computation, 2019

Furthermore, in measuring the forecasting ability of production, area and yield; the mean absolute prediction error (MAPE), root mean square error (RMSE), Theil's inequality coefficient (U) and the relative mean absolute prediction error (RMAPE) were used (Table 8b). A cursory review of the results showed the RMAPE and Theil's coefficient values to be less than 5% and 1 respectively. Thus, the implication of the results is that the predictive error associated with the model in tracking the actual data (*ex-post* prediction) were very low and insignificant, hence could be used for *ex-ante* projection with high projection validity and consistency.

Table 8b: Validation of models

Variable	R^2	RMSE	RMSPE	MAPE	RMAPE (%)	Theil's U
Production	0.977039	57988.08	2373.884	32699	2.294748	0.861316
Area	0.972155	4554.148	246.1495	2354	2.805498	0.873004
Yield	0.977355	5858.255	204.2924	3821.8	2.271207	1.009096

Source: Authors' computation, 2019

The computed one-step-ahead out of the sample forecasts for the production (ton), area (hectare) and yield (hg) of sugarcane spanning from 2018-2027 are presented in Table 11c and depicted in Figures 9 to 11. A cursory review of the graph showed a bleak future ahead for sugarcane production i.e. the country will not achieve self-sufficiency in sugarcane production and will continue to rely on sugarcane importation to meet the demands of its populace. This is evident from the forecasted trend of the production which will be driven by a gentle rise in the area as the forecasted yield will plummet till the end of the study period. Therefore, the government presents good intention on self-sufficiency on sugarcane production aimed at cutting the excess importation which drained heavily its foreign reserve is not enough. At present land an important resource is shrinking owing to high competing demand for many purposes other than agriculture and the consequence of climate change, thus leading to loss of lives and properties viz. farmers/herders clashes, communal conflicts, etc. The government needs to invest heavily in technology to drive sugarcane production in the country in order to achieve self-sufficiency or else any policy on the ban of sugarcane importation will be a mirage and a catastrophe on the nutritional status of the populace as the future supply cannot match the ever-growing population of the country.

Table 8c: Out of sample forecast of the variables

Year	**Production**			**Area**		
	Forecast	**LCL**	**UCL**	**Forecast**	**LCL**	**UCL**
2018	1513372	1257579	1769164	90159	77982	102335
2019	1528986	1167079	1890893	91301	74074	108528
2020	1544600	1101149	1988052	92443	71335	113550
2021	1560215	1047917	2072513	93584	69201	117967
2022	1575829	1002788	2148870	94726	67454	121998
2023	1591443	963407	2219480	95868	65981	125755
2024	1607058	928375	2285740	97010	64714	129305
2025	1622672	896781	2348563	98152	63612	132691
2026	1638286	867992	2408580	99293	62644	135943
2027	1653901	841549	2466252	100435	61787	139083
2028	1669515	817103	2521927	101577	61026	142128
2029	1685129	794386	2575872	102719	60347	145091
Year	**Yield**					
	Forecast	**LCL**	**UCL**			
2018	162255	119405	205105			
2019	157587	97665	217509			
2020	152919	77351	228487			
2021	148251	57530	238971			
2022	143582	37827	249338			
2023	138914	18055	259773			
2024	134246	-1891	270382			
2025	129578	-22070	281226			
2026	124910	-42523	292342			
2027	120241	-63271	303754			
2028	115573	-84331	315477			
2029	110905	-105711	327521			

Source: Authors' computation, 2019

CONCLUSION AND RECOMMENDATION

The empirical evidence showed a bleak future for sugarcane production which will owe to poor policy on technology, as the area will be the driving force for production increase as the future forecasted yield trend will observe steep decline. Though the producers of the crop learn from past experience to forestall the effect of convergent cobweb effect, unfortunately, area risk a production risk is a major threat to self-sufficiency. Besides, a review of the inter-regime policies showed area risk and uncertainty to be the stumbling block to sugarcane production self-sufficiency between pre-SAP and SAP regimes while area risk stand against self-sufficiency of sugarcane production between the SAP and post-SAP regimes. Furthermore, evidence revealed that the change in sugarcane production across the policy regimes was driven by area and not yield, thus a clear indication that the inability of the country to achieve self-sufficiency in sugarcane production was due to poor implementation of policy concerned with sugarcane technology in the country. Therefore, the study recommends the need for effective and factual policies especially policy aimed at technology advancement in order to achieve self-sufficiency in sugarcane production as the current good policy intention on sugarcane production in Nigeria is not enough to contain the excess foreign reserve drain due to high importation bills on refined sugarcane products into the country.

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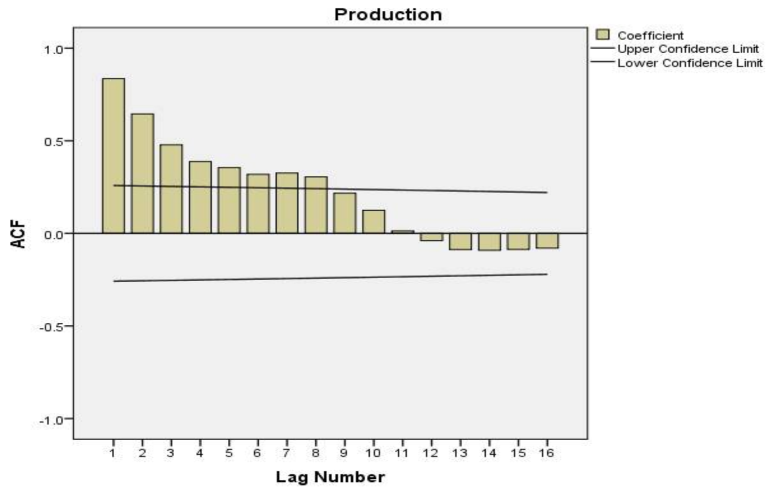

Figure 6a: Production Autocorelation at level

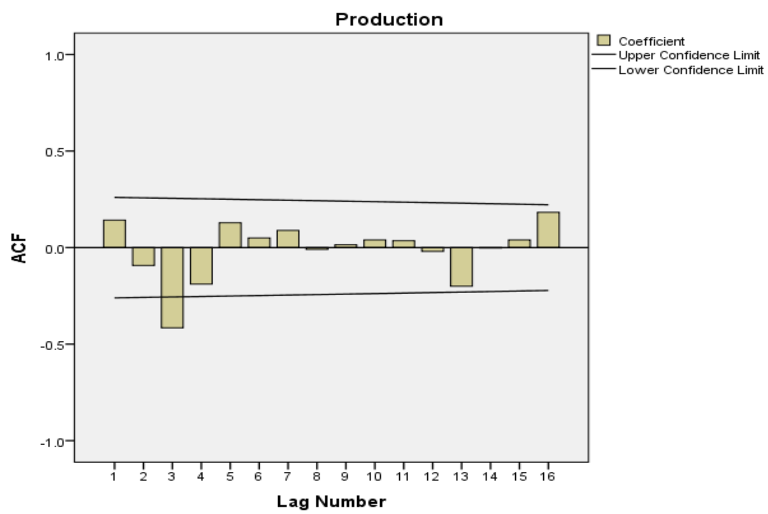

Figure 6b: Production Autocorelation at 1st difference

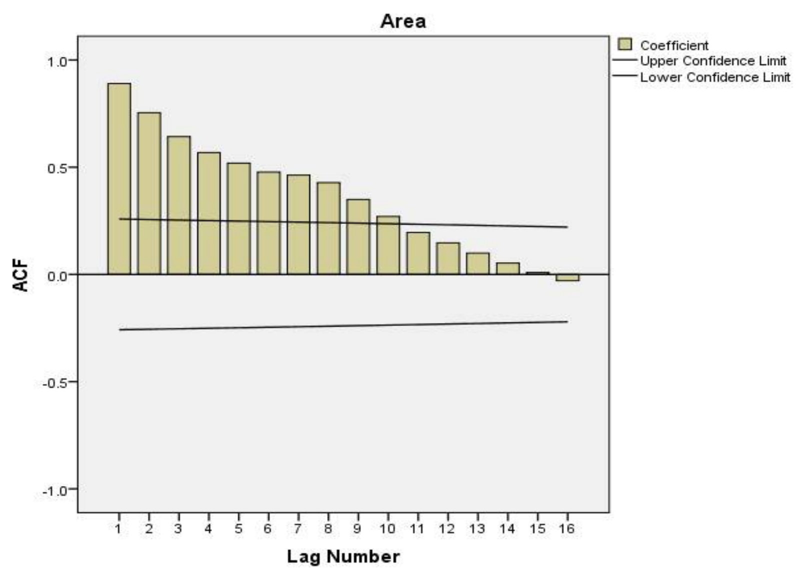

Figure 7a: Area Autocorelation at level

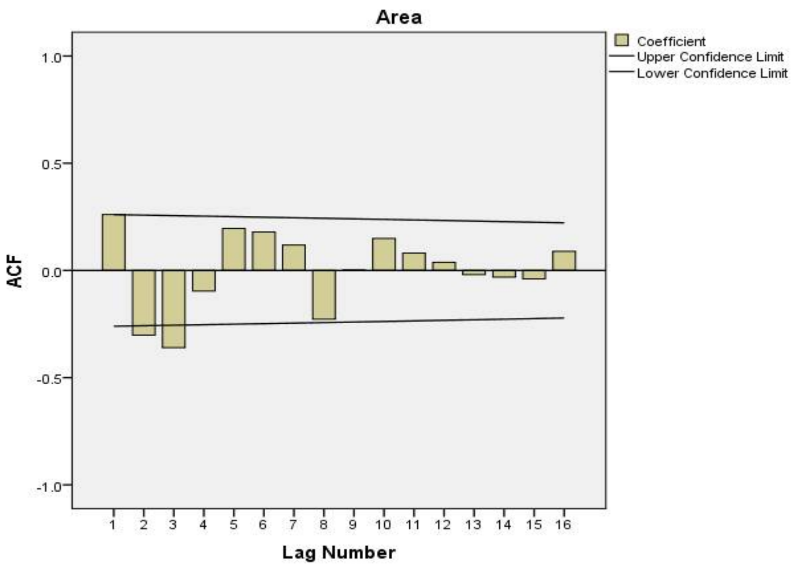

Figure 7b: Area Autocorelation at 1st difference

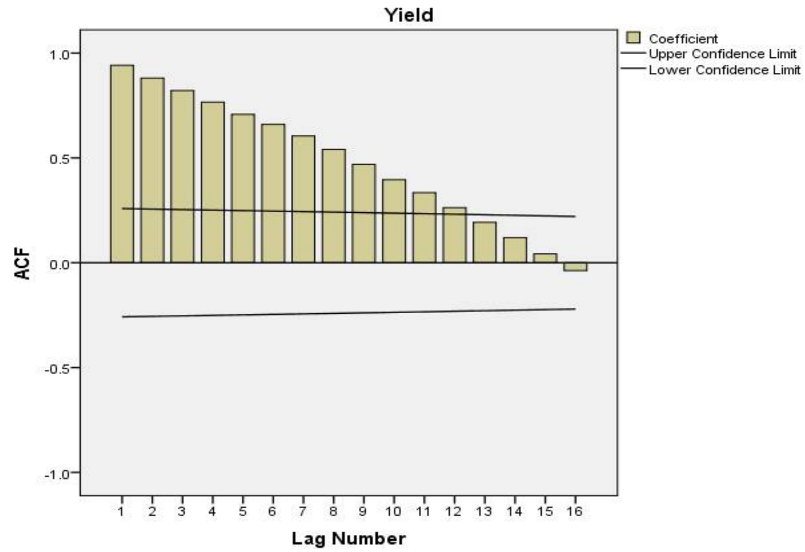

Figure 8a: Yield Autocorelation at level

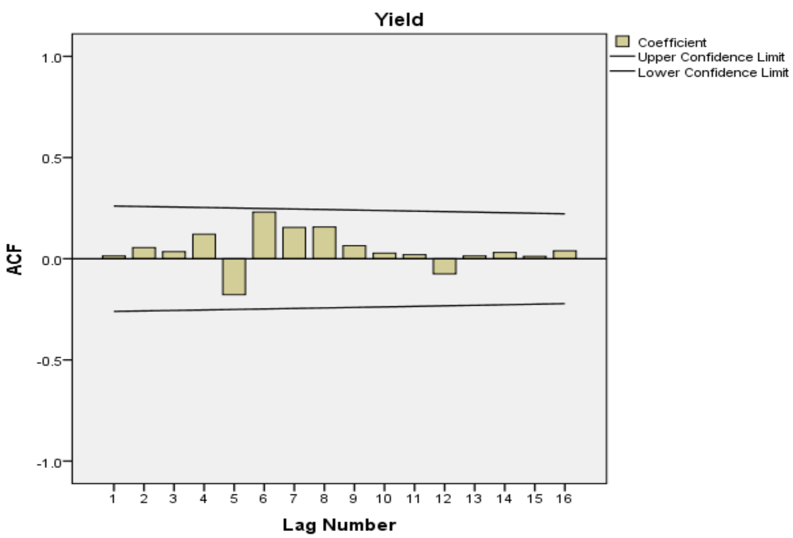

Figure 8b: Yield Autocorelation at 1st difference

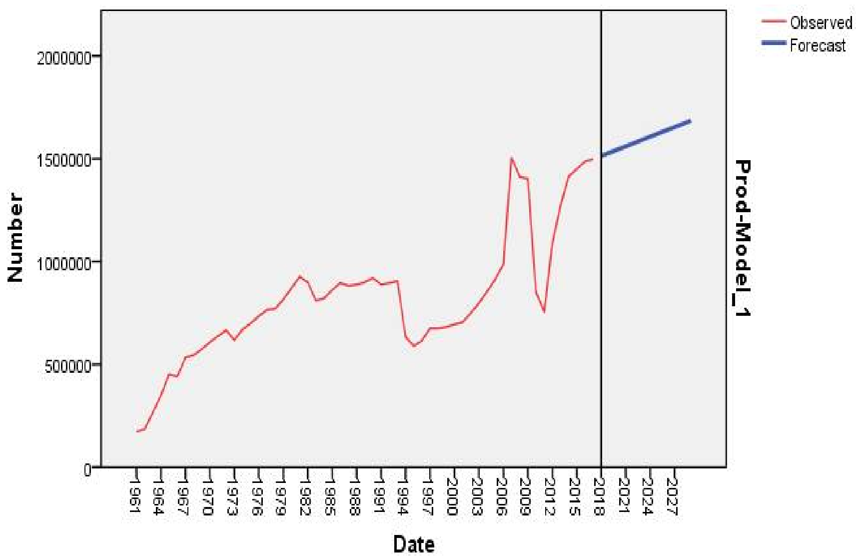

Figure 9: Production forecast of sugarcane (2018-2027)

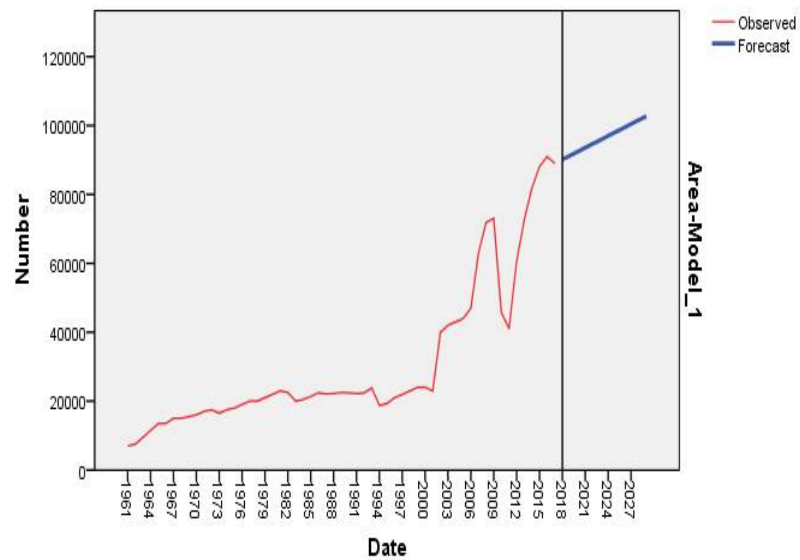

Figure 10: Area forecast of sugarcane (2018-2027)

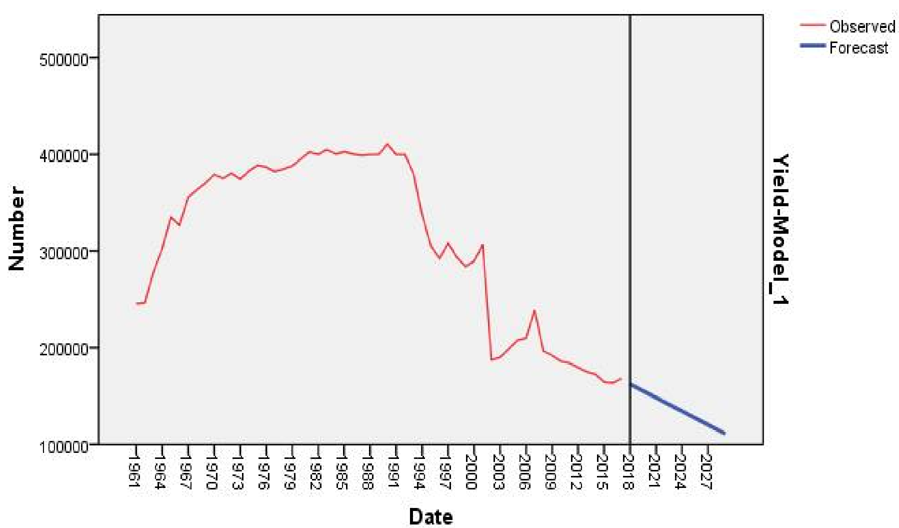

Figure 11: Yield forecast of sugarcane (2018-2027)