ROADMAP TO SELF-SUFFICIENCY OF COWPEA PRODUCTION IN NIGERIA

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ABSTRACT

Food security is a necessity since time immemorial, as loss of health owing to malnutrition is worse than loss of wealth. It is in view of the foregoing that this research was conceptualized to chart a roadmap for self-sufficiency in cowpea production in Nigeria using FAO sourced dated data which covered production, area and yield; spanning from 1961 to 2017. The collected data were analyzed using both descriptive and inferential statistics. Empirical evidence showed that the production trend of cowpea was majorly driven by area across the policy regime periods observed in the country. However, incremental changes in the output level between regime shifts were influenced by the technological effect. Furthermore, uncertainty was found to be the major factor threatening self-sufficiency in the production of cowpea in the studied area. Though, the impact of pricing policy on cowpea production is very low owing to low LRE of owned price. However, the short time adjustment period required for the price effect to materialize will make the price policy instrument to be effective in bringing the desired change in the short-run. Furthermore, the future trend of cowpea production is not promising in terms of cowpea food security, thus the need for policymakers to look towards technology advancement (e.g. high yielding improved varieties) so that the country will be self-sufficient in cowpea production.

Keywords: ***Trend; Growth; Instability; Acreage response; Cowpea; Nigeria***

INTRODUCTION

Nigeria is the largest producer of cowpea worldwide,as it accounts for 58% of worldwide production, yet the country is still the largest consumer of the crop (Agriculture Nigeria, 2019). To supplement its production, a substantial quantity of cowpea is imported from Cameroon, indicating that the country is not self-sufficient.

In most parts of the country, the product is been processed into various dishes such as *moin-moin*, bean cake, bean soup etc. It contains 20%-25% of protein and 64% carbohydrate and has the potential for poverty alleviation and malnutrition amongst the poor. In addition, all parts of the crop are useful; its vegetative part is a good feed for cattle (Agriculture Nigeria, 2019). This shows that all over the country, the crop is consumed in so many forms, thereby increasing the demand for it.

From the perspectives of poverty alleviation, income and employment generation, agriculture remains a key sector in Nigerian economy as it serves as the main source of livelihood to the majority of its people. Inspite of the enormous impact of the sector on the peoples' livelihood, it is still affected by various kinds of risks. These risks are related mainly to climate, inputs, outputs and prices. The degree of risk depends on the personal characteristics of farmers and the probabilities of an event. Therefore, the degree of risk involved in any enterprise affects farmers' decisions on acreage allocation and the growth performance of the farm economy. Thus, the success of any policy action for agricultural growth depends on the measurement of instability, identification of its broad sources and means to stabilize the growth process. It is in view of the foregoing that this research was conceptualized to chart a roadmap for cowpea production self-sufficiency in Nigeria. The specific objectives of the research were to examine the trend and growth patterns of cowpea production; determine factors influencing changes in cowpea production; determine the magnitude of instability in cowpea production as well its sources; determine the factors affecting farmers' decision on acreage allocation; and, to forecast the future trend of cowpea production in Nigeria.

RESEARCH METHODOLOGY

Nigeria is located in Africa continent with an approximate human population of 160 million and has a vast area of land suitable for various agricultural purposes *viz.* livestock, fisheries, crop production etc. owing to suitable prevailing agro-climatic conditions. The country is located on latitudes 4′ to14′ N and longitudes 2′ to 15′ E of the Greenwich meridian time (CIA, 2011). The present research made use of the FAO source dated data, covering production, area and yield which span from 1961 to 2017. For proper exposition, the data were divided 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). The collected data were analyzed using both descriptive and inferential statistics. Objective1 was achieved using descriptive statistics and growth model; objective 2 was achieved using instantaneous change model and Hazell's decomposition model; Objective 3 was achieved using instability indexes and Hazell's decomposition model; Objective 4 was achieved using Autoregressive distributed lag model; and, Objective 5 was achieved using ARIMA model.

Empirical model

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

$$\gamma = \alpha\beta^t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

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

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

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 cowpea. Following Sandeep *et al*.(2016) and Boyal *et al*.(2015) the CV is shown below:

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

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. Following Shimla (2014) as adopted by Umar *et al*. (2019), the instability index was classified as low instability (≤20%), moderate instability (21-40%) and high instability (>40%).

Unlike CV, Coppock's instability index gives 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 prices (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 *etal*.(2016); Kumar *et al*.(2017); Umar *et al.* *(*2019) is given below:

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

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

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 COWPEA 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* represent 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	$\Delta V(A)$	$\bar{Y}^2V(A)$
Change in yield variance	$\Delta V(Y)$	$\bar{A}^2V(Y)$
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 is referred to 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;

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

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

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

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

$\alpha = Intercept$

$\beta = Coefficient\ of\ price\ expectation$

$\varepsilon_t = Disturbance\ term$

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

$A_t^* = \beta_0 + \beta_1 CP_{t-1} + \beta_2 SP_{t-1} + \beta_3 CPR_{t-1} + \beta_4 SPR_{t-1} + \beta_5 CY_{t-1} + \beta_6 SY_{t-1} + \beta_7 CYR_{t-1} + \beta_8 SYR_{t-1} + \beta_9 WI_{t-1} + \varepsilon_t$ .... (18)

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

As expected, variables are not observable, therefore, for estimation purpose, a reduced 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:

$A_t^* = \beta_0 + \beta_1 CP_{t-1} + \beta_2 SP_{t-1} + \beta_3 CPR_{t-1} + \beta_4 SPR_{t-1} + \beta_5 CY_{t-1} + \beta_6 SY_{t-1} + \beta_7 CYR_{t-1} + \beta_8 SYR_{t-1} + \beta_9 WI_{t-1} + \beta_{10} A_{t-1} + \varepsilon_t$ .... (20)

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

Where,

$A_t = current\ area\ under\ the\ cowpea\ crop$;

$CP_{t-1} = one\ year\ lagged\ price\ of\ cowpea$;

$SP_{t-1} = one\ year\ lagged\ price\ of\ soyabeans\ (competing\ crop)$

$CPR_{t-1} = one\ year\ lagged\ price\ risk\ of\ cowpea$;

$SPR_{t-1} = one\ year\ lagged\ price\ risk\ of\ soyabeans$;

$CY_{t-1} = one\ year\ lagged\ yield\ of\ cowpea$;

$SY_{t-1} = one\ year\ lagged\ yield\ of\ soyabeans$;

$CYR_{t-1} = one\ year\ lagged\ yield\ risk\ of\ cowpea$;

$SYR_{t-1} = one\ year\ lagged\ yield\ risk\ of\ soyabeans$;

$T_t = time\ trend\ at\ period\ t$;

$WI_t = one\ year\ lagged\ weather\ index\ for\ cowpea$;

$A_{t-1} = one\ year\ lagged\ area\ under\ cowpea$;

$\beta_0 = intercept$;

$\beta_{1-n} = parameter\ estimates$; and,

$\varepsilon_t = Disturbance\ term.$

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 the 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 the acreage response model (Ayalew, 2015).

The extent of adjustment to changes in the price and/or non-price factors is measured in terms of the "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 years.

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)

ARIMA

Box and Jenkins (1976) posited that a non-seasonal ARIMA model is denoted by ARIMA (p,d,q), which is a combination of Auto-regressive (AR) and Moving Average (MA) with an order of integration or differencing (d). The p and q are the order of autocorrelation and the moving average respectively (Gujarati *et al*., 2012).

The Auto-regressive of order p denoted as AR(p) is given below:

$Z_t = \alpha + \delta_1 Z_{t-1} + \delta_2 Z_{t-1} + \cdots .. + \delta_p Z_{t-p} + \varepsilon_t$ …………………………………….. (24)

Where α is the constant; δ_p is the p-th autoregressive parameter and ε_t is the error term at time 't'.

The general Moving Average of (MA) of order q or MA(q) can be written as follow:

$Z_t = \alpha + \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-1} - \cdots .. - \varphi_q \varepsilon_{t-q}$ ………………………… (25)

Where α is the constant; φ_q is the q-th moving average parameter and ε_{t-k} is the error term at time 't-k'.

ARIMA in general form is as follows:

$\Delta^d Z_t = \alpha + (\delta_1 \Delta^d Z_{t-1} + \cdots .. + \delta_p \Delta^d Z_{t-p}) - (\varphi_1 \varepsilon_{t-1} + \cdots .. + \varphi_q \varepsilon_{t-q}) + \varepsilon_t$ ………….. (26)

Where,

Δ *denotes difference operator like*:

$\Delta Z_t = Z_t - Z_{t-1}$ …………………….. (27)

$\Delta^2 Z_{t-1} = \Delta Z_t - \Delta Z_{t-1}$ ………………. (28)

Here, $Z_{t-1} \ldots \ldots \ldots, Z_{t-p}$ are values of past series with lag 1,………., p respectively.

Modeling using ARMA methodology consists of four steps viz. model identification, model estimation, diagnostic checking and forecasting.

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:

$MAPE = 1/T \sum_{i=1}^{5} (A_{t-1} - F_{t-1})$ .... (29)

$RMPSE = 1/T \sum_{i=1}^{5} (A_{t-1} - F_{t-1})^2 / A_{t-1}$...................... (30)

$RMAPE = 1/T \sum_{i=1}^{5} (A_{t-1} - F_{t-1}) / A_{t-1} \times 100$.. (31)

$$U = \sqrt{\frac{\sum_{t=1}^{n-1} \frac{(\hat{Y}_{t+1} - Y_{t+1})^2}{Y_t}}{\sum_{t=1}^{n-1} \frac{(Y_{t+1} - Y_t)^2}{Y_t}}} \quad \text{............................. (32)}$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (A_{ti} - F_{ti})}{\sum_{i=1}^{n} (A_{ti})} \quad \text{.......................... (33)}$$

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

RESULTS AND DISCUSSION

Trend and Growth Pattern of Cowpea Production

The production trend of cowpea exhibited upward and downward swings during the pre-SAP period with incremental change in the area and yield been pronounced during the mid to late sixties and seventies respectively (Figure 2). During the SAP period, the production trend of cowpea was on the increase with an increasing-decreasing change in yield been pronounced till the year 1995, and thereafter it plummeted. Afterwards, incremental change in the production trend was due to the surge in the area till the late 90s when the area trend plummeted and the yield trend started reviving (Figure 3). For the post-SAP period, the production of cowpea exhibited a gentle rise until the year 2006 when it slightly plummeted and thereafter exhibited an explosive cyclical trend till the end of the studied period. Evidence showed an incremental gentle rise in the area to be the major factor that drives the slight rise in the production trend till the year 2008 and thereafter yield was the major driving force for the explosive cyclical production trend (Figure 4). Therefore, it can be suggested that the production trend of cowpea was driven by area during the pre-SAP and post-SAP area, while yield was the major contributor to the incremental production change during the SAP period. This outcome is expected as the liberalized economic policy focused on technology advancement aimed at increasing supply for exportation. Furthermore, the average annual production from pre-SAP to SAP regimes increased by two-fold and thereafter reverts to an arithmetic increase. The average annual yield exhibited a similar incremental change while the annual average area exhibited an arithmetic increase.

A cursory review of the results showed a negative annual production growth during the pre-SAP period with a negative annual growth rate in the area been the causal factor, as the annual yield growth was positive (Table 3). For the SAP period, the annual cowpea production observed a positive growth rate with area been the driving force as the yield growth rate troughed. Besides, a similar growth pattern was noticed during the post-SAP period except that the area growth rate troughed while an annual increase in the yield growth rate was the major driving force for the positive annual production growth rate. Though the influence of the trough in both periods was not significant, thus the reason for the positive annual production growth rate. However, a review of the annual production growth rate for the overall period revealed an increase in the growth rate of cowpea production with the annual incremental growth rate in yield taking the lead when compared with the annual growth rate observed for area.

TABLE 3: GROWTH PATTERN OF COWPEA PRODUCTION

Variables	Pre-SAP	SAP	Post-SAP	Overall
Area (ha)	2409250(-3.2)**	2680049 (9.5)***	3660631 (-0.6)^{NS}	2875686 (1.1)***
Yield (hg)	2947.375 (2.9)***	5406 (-0.5)^{NS}	7968.278 (2.4)*	5179.93 (2.8)***
Production (ton)	629250 (-0.2)^{NS}	1397867 (9.0)***	2864373 (1.8)^{NS}	1537346 (3.9)***

Source: Authors' computation, 2019

Note: Figure in parenthesis is CAGR

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

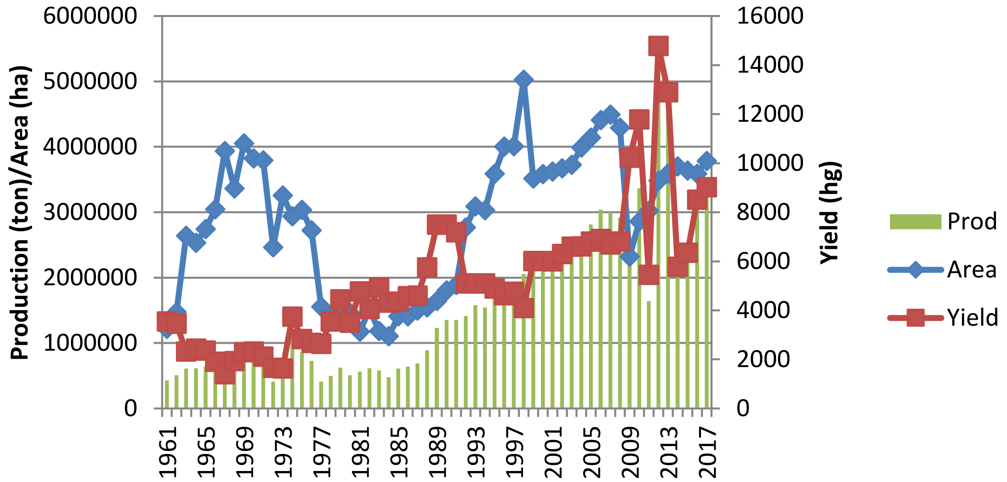

Figure 1: Production trend of cowpea (1961-2017)

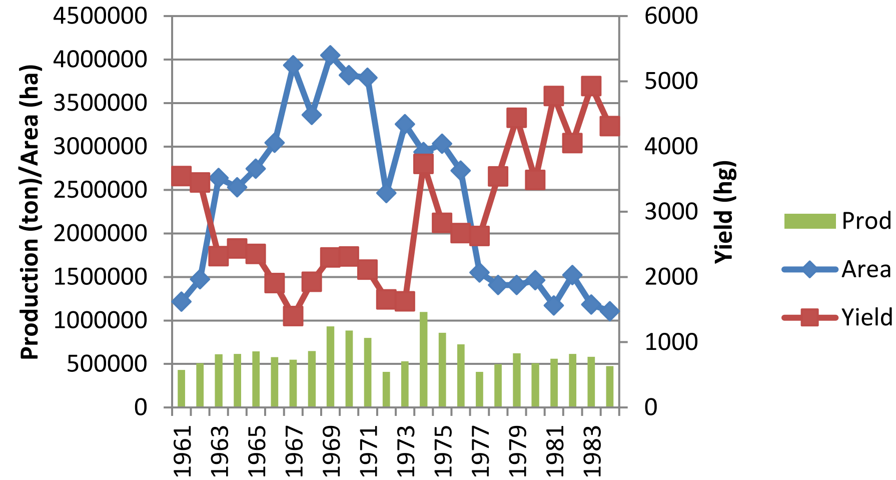

Figure 2: Pre-SAP production trend of cowpea (1961-1984)

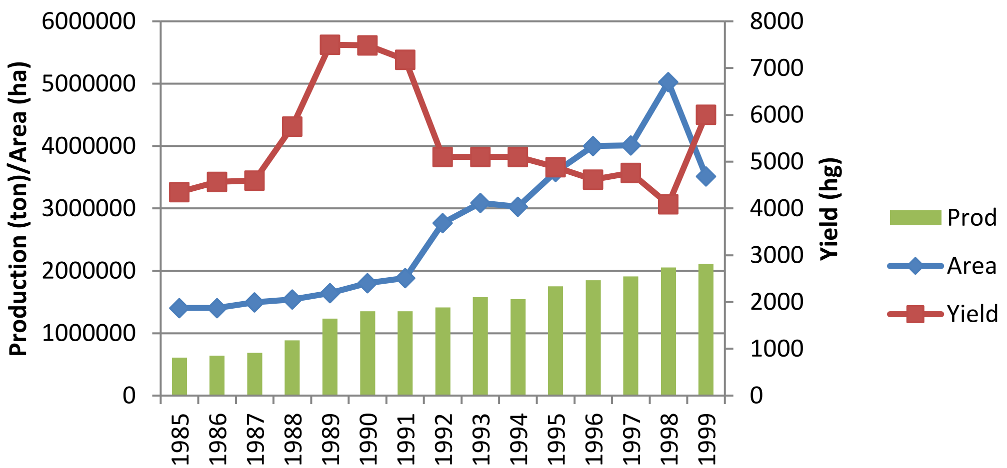

Figure 3: SAP production trend of cowpea (1985-1999)

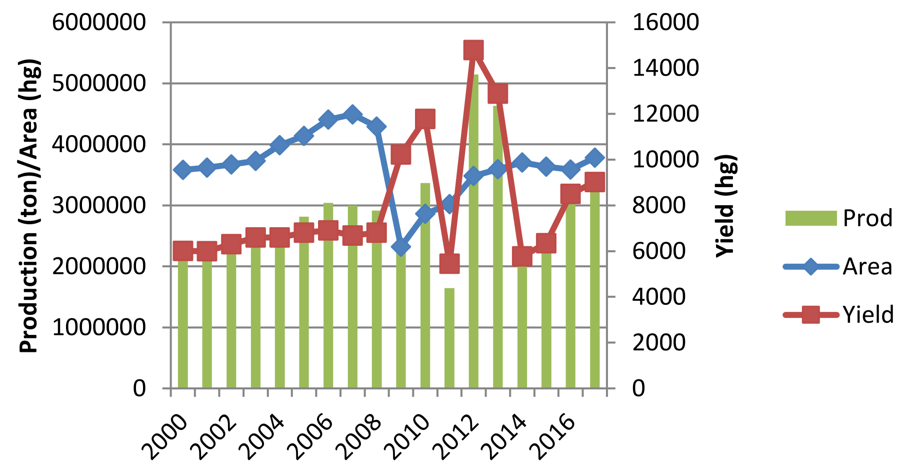

Figure 4: Post-SAP production trend of cowpea (2000-2017)

A cursory review of the results of the source of instantaneous source of production change showed yield effect to be the source of production change during the pre-SAP and post-SAP periods, while area effect was observed to be the source of production change during the SAP and the overall periods (Table 4). Therefore, it can be inferred that change in production was driven by technology during the pre-SAP and post-SAP while area expansion was the major driving force behind production change during the SAP and the overall periods.

TABLE 4: SOURCES OF CHANGE IN COWPEA PRODUCTION (INTRA-WISE %)

Source of change	Pre-SAP	SAP	Post-SAP	Overall
Area effect	139.3654	95.19016	41.39289	73.23342
Yield effect	643.3461	41.09691	87.18221	67.59436
Interaction effect	-682.565	-36.2793	-28.5745	-40.8205
Total change	**100**	**100**	**100**	**100**

Source: Authors' computation, 2019

A further review of the inter-regime production change showed yield effect to be the source of production change between the regime shifts *viz.* pre-SAP to SAP, and SAP to post-SAP as indicated by the Hazell's decomposition model (Table 5). Therefore, the introduction of various improved and hybrid cowpea seed varieties developed by research institutes impacted positively on cowpea output in Nigeria.

TABLE 5: SOURCES OF CHANGE IN COWPEA PRODUCTION (INTER-REGIME WISE %)

Source of change	Pre-SAP to SAP	SAP to Post-SAP
Area effect	10.62	35.77
Yield effect	78.80	46.34
Interaction effect	8.86	16.96
Covariance effect	1.73	0.93
Total change	**100**	**100**

Source: Authors' computation, 2019

INSTABILITY IN COWPEA PRODUCTION AND SOURCE OF PRODUCTION RISK

A perusal of the CV index showed cowpea production to be marked by moderate instability across the three regimes with yield fluctuation whittling down the effect below high instability during the pre-SAP and post-SAP. For the post-SAP period, low area instability was responsible for the marked moderate production instability observed. However, the cowpea production for the overall period was marked by high instability owing to high yield fluctuation (Table 6).

A review of the exact direction of instability showed production instability to be moderate during the pre-SAP, post-SAP and the overall periods, while production during the SAP era was marked by low instability. Evidence showed fluctuation in area to be the major source of fluctuation in production during the pre-SAP and overall periods while yield shock was the source of instability observed during the SAP and post-SAP regimes (Table 6). The low production instability observed during the SAP era is attributed to the need of the nation to achieve self-sufficiency in cowpea production as the major producers in the sub-Saharan region focused on exploring the comparative advantage in the exportation of the crop, thus affecting Nigeria'sexport orientation despite the economy been liberalized.

Further investigation of instability vis-à-vis a price trend showed production during pre-SAP and post-SAP periods to be marked by moderate instability while during the SAP era cowpea production was marked by low instability as evident from their respective CDII indexes (Table 6). Area instability was the major source of instability during the pre-SAP and SAP periods, while instability in yield was observed to be the major driver of instability during the post-SAP regime. For the overall period, the production instability was observed to be moderate with area instability been more pronounced.

TABLE 6: MAGNITUDE OF INSTABILITY IN COWPEA PRODUCTION

Regimes	Variables	CV	CDII	CII
Pre-SAP	Area	0.4183	36.37046	57.78081
	Yield	0.3544	29.18156	52.82304
	Production	0.2771	27.6684	47.66971
SAP	Area	0.4374	12.97538	57.46922
	Yield	0.2105	20.89153	44.81046
	Production	0.36096	11.18394	56.14472
Post-SAP	Area	0.1466	14.40117	43.15227
	Yield	0.3406	30.76732	49.51564
	Production	0.3059	28.64701	48.64333
Overall	Area	0.3728	33.90226	56.8426
	Yield	0.5342	27.34353	62.86162
	Production	0.7225	32.79227	75.51846

Source: Authors' computation, 2019

For the source of risk, the results showed interaction effect between changes in mean yield and area variance to be the major source of output risk across the two transitional periods *viz.* pre-SAP to SAP, and SAP to post-SAP transitions (Table 7). However, for the overall period, change in residual was observed to be the major source of output risk across the three policy regimes *viz.* policy shifts. Therefore, it can be inferred that risk was the major source of production risk vis-à-vis two inter-regime shifts: pre-SAP to SAP, and SAP to post-SAP; while across the three regimes, production risk was caused by uncertainty.

TABLE 7: SOURCES OF INSTABILITY IN COWPEA PRODUCTION

Source of variance	Pre-SAP to SAP	SAP to Post-SAP	Overall
Change in mean yield	1.30	-123.57	16.52
Change in mean area	0.41	5.22	-1.49
Change in yield variance	-8.14	0.59	9.25
Change in area variance	27.80	117.53	41.66
Interaction between changes in mean yield and mean area	-1.37	2.71	1.15
Change in area yield covariance	7.27	-15.73	-22.70
Interaction between changes in mean area and yield variance	-1.93	0.51	-7.72
Interaction between changes in mean yield and area variance	65.72	137.82	-10.17
Interaction between changes in mean area and yield and change in area-yield covariance	7.36	-15.86	14.54
Change in residual	1.59	-9.22	58.96
Total change in variance of production	**100**	**100**	**100**

Source: Authors' computation, 2019

FARMERS' ACREAGE RESPONSE

The result of the ordinary least square (OLS) estimation revealed the linear regression functional form to be the best fit for the specified equation as it satisfied the economic, statistical and econometric criteria, thus chosen as the lead equation (Table 8). The diagnostic test results exonerated the residual from the problem of abnormal skewness, heteroscedasticity, serial correlation and Arch effect as indicated by their respective test statistics which were not different from zero at 10% degree of freedom. In addition, it was evident that the model specification is adequate and the parameters did not change (Figure 5) as shown by their respective t-statistics which were not different from zero at 10% probability level. Furthermore, the diagnostic test result showed the population to be one i.e. no structural break in the sample when sub-divided as indicated by the Chow test Chi^2 test statistic which exceeded the 10% error gap probability level. Evidence of spurious/nonsense regression and correlation were absent as indicated by the coefficient of multiple determination (R^2) (0.804) which is lower than the Durbin Watson (D-W) statistic (2.15); and the reasonable value of the R^2, respectively.

The estimated R^2 value of 0.804 implies that 80.4% of the change in the current cowpea acreage was explained by the predictor variables included in the model while the left-over percentage account for the contribution of variables not included in the model. The results showed lagged area, lagged cowpea yield risk, lagged cowpea price, lagged price of the competing crop (soyabeans) and weather to be the factors that significantly impacted on the current acreage as indicated by their respective least squares which were different from zero at 10% degree of freedom.

The negative significant of the lagged cowpea price showed how the effect of the convergent cobweb cycle owing to past experience makes the farmers reduce their current acreage to avoid a situation of a supply glut which tends to dampen the price in the current production season. In addition, the price relationship that turned out to be negative showed the farming system associated with cowpea in the studied area to be subsistence, thus resulting in the production of a certain quantity irrespective of the prevailing market price. Thus, the marginal, the short-run elasticity (SRE) and the long-run elasticity (LRE) implications of a unit change in the lagged cowpea price will lead to a decrease in current acreage by 20.20 hectares, 0.18 and 0.93% respectively. It is worth to note that negative acreage response of a crop to own price is not uncommon as literature showed similar researches which found similar results, for example, Sadiq *et al. (*2017); Sadiq *et al*. (2019); and, Jain *et al. (*2005). The LRE shows the acreage responsiveness of cowpea crop to price change given sufficient time for adjustment. Thus, from the foregoing, it can be inferred that the impact of the price policy on cowpea production in the studied area is low owing to low LRE. Furthermore, evidence showed that the required time adjustment for price effect to materialize is small (1.79 years), thus implying that the farmers faced less institutional and technological constraints and the price policy instrument in bringing a desired change in the studied area will be effective.

The positive significance of the lagged price of the competing crop (soyabeans) revealed how the impact of the lagged soyabeans price encouraged cowpea farmers to increase the current acreage under cowpea cultivation owing to massive shift to soyabeans cultivation which will result to glut, causing soyabeans price to ebb in the current production while that of the cowpea will surge owing to supply deficit against the demand. Therefore, the marginal, SRE and LRE implications of a unit rise in the price of competing crop will lead to an increase in the current acreage by 25.28 hectares, 0.93 and 1.03% respectively. The negative significant of the lagged cowpea price risk proved how the effect of price fluctuation i.e. upswing and downswing which determine the forces of demand and supply in the short-run, thus, causing convergent cobweb cycle, forced farmers to decrease the current hectare cultivated for cowpea in the studied area. The toll effect of the price risk on the supply response of the farmers is due to the fear of capital loss as the bulk of the producers in the studied area are smallholder resource-poor farmers who have no economic capital but rather social capital. Thus, the marginal, SRE and LRE implications of a unit increase in the lagged cowpea price risk will lead to a decrease in the current acreage by 24.94 hectares, 0.05 and 0.27% respectively. Evidence showed current weather vagaries to have a negative toll on the current acreage under cowpea as indicated by the negative significant of the weather index parameter. Therefore, the marginal, SRE and LRE implications of unfavourable weather will force farmers to decrease the current acreage under cowpea by 748968 hectares, 0.251 and 1.341% respectively. The positive significant of the lagged acreage coefficient indicated that lagged acreage accounted for more than two-thirds of the current acreage under cowpea production. Furthermore, the high value of the adjustment coefficient (0.813), indicated that the farmers adjusted rapidly the area under cowpea production. Unfortunately, production, financial and marketing policies promulgated and implemented across the regime periods had no influence on cowpea food security of the nation as indicated by the non-significant of the time trend coefficient at 10% degree of freedom.

TABLE 8: FARMERS' ACREAGE RESPONSE

Variables	Parameters	t-stat	Mean	SRE	LRE
Intercept	1.051E6 (827292)	1.271^{NS}	-	-	-
CP_{t-1}	-20.1959 (10.9676)	1.841*	24977.16	-0.17469	-0.93391
SP_{t-1}	25.2786 (11.0369)	2.290**	22030.71	0.192859	1.031048
CPR_{t-1}	-24.9407 (9.71088)	2.568**	5814.695	-0.05022	-0.26849
SPR_{t-1}	57.3012 (36.3255)	1.577^{NS}	2626.06	0.052111	0.27859
CY_{t-1}	42.5373 (74.66)	0.5697^{NS}	5133.041	0.075614	0.404243
SY_{t-1}	-32.038 (74.3643)	0.4308^{NS}	5089.367	-0.05647	-0.30187
CYR_{t-1}	-120.08 (130.308)	0.9215^{NS}	768.542	-0.03196	-0.17086
SYR_{t-1}	203.205 (166.882)	1.218^{NS}	487.3991	0.034299	0.183365
T_t	4359.91 (21663.7)	0.2013^{NS}	24.5	0.036991	0.197761
WI_{t-1}	-748968 (413632)	1.811*	0.966827	-0.25077	-1.34063
A_{t-1}	0.812949 (0.131596)	6.178***	2828705	0.796358	4.257439
R^2	0.8039				
F-stat	42.94{5.04E-17}***				
Durbin-Watson	2.152{0.371}^{NS}				
Autocorrelation	1.101{0.301}^{NS}				
Arch effect	0.016{0.897}^{NS}				
Heteroscedasticity	24.57{0.3177}^{NS}				
Normality	3.955{0.138}^{NS}				
CUSUM test	-0.647{0.521}^{NS}				
RESET test	30.50{0.608}^{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.

PRODUCTION FORECAST OF COWPEA

The trend in the production variables of cowpea were removed for accurate and reliable forecast *viz.* ACF unit root test which showed that the production, area and yield variables attained stationarity at first difference. In order words, it implies that the variables had white noise at level but after first differencing their residuals became Guassian white noise (The results were not reported here), thus indicating that the variables were devoid of unit root. Thereafter, for forecasting, ARIMA model at different levels was tried out for each of the variables and the best chosen based on the lowest Akaike information criterion (AIC) value. For the production, area and yield, ARIMA (0,1,1); ARIMA (1,1,0) and ARIMA (1,1,1) were chosen as the best fit as they have the lowest AIC value, thus used for cowpea production prediction (Table 9).

TABLE 9: ARIMA MODEL

ARIMA	Production (AIC)	Area (AIC)	Yield (AIC)
ARIMA (1,1,1)	26.663	26.650	15.054
ARIMA (1,1,0)	26.869	26.581	15.287
ARIMA (0,1,1)	26.575	26.587	15.057

Source: Authors'computation, 2019

VALIDATION (*EX-POST* PREDICTION POWER)

One-step-ahead forecast of the variables along with their corresponding standard errors using naïve approach for the period 2013 to 2017 (a total of 5 data points) for each of the best fit ARIMA models against each variable was computed to determine the predictive power of the estimated equation (Table 10). The estimated models were validated through the sample periods to determine how closely they could track the path of the actual observation.

TABLE 10: ONE STEP AHEAD FORECAST OF COWPEA PRODUCTION

Period	Production		Area		Yield	
	Actual	Forecast	Actual	Forecast	Actual	Forecast
2013	4630540	3363621	3593300	3451171	12887	10139
2014	2137900	3713181	3701500	3626007	5776	9795
2015	2306200	3392688	3635700	3734945	6343	7940
2016	3050342	3187428	3586579	3700456	8505	8154
2017	3409992	3205992	3782760	3648333	9015	8826

Source: Authors' computation, 2019

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 to measure the forecasting reliability of the chosen ARIMAs (Table 11). The results showed the RMAPE and U coefficients to be less than 5% and 1 respectively, indicating the predictive error associated with the estimated equations in tracking the actual data (*ex-post* prediction) to be very low and insignificant, thus could be used for *ex-ante* projection with high projection validity and consistency.

TABLE 11: VALIDATION OF MODELS

Variable	R^2	RMSE	RMSPE	MAPE	RMAPE (%)	Theil's U
Production	0.832967	862829.6	338190	-518971	-23.8614	0.823252
Area	0.999825	96527.05	2528.323	-640.4	-0.06232	0.901271
Yield	0.880638	1942.251	643.3984	-1015.2	-17.707	0.601691

Source: Authors' computation, 2019

FUTURE TREND OF NIGERIAN'S COWPEA PRODUCTION

The estimated one-step-ahead out of the sample forecasts for production (ton), area (hectare) and yield (hg) of cowpea spanning from 2018 to 2027 are presented in Table 12 and Figure 5-8. Evidence showed that cowpea production will witness a gentle rise in the time ahead with both incremental adjustment in area and technological advancement *viz.* improved varieties being the major driving force. However, in the case of any shock, the forecasted production, area and yield will not exceed the upper limit nor go below the lower limit as the case may be.

Therefore, the study suggested the need by the policymakers to explore more on technology in order to achieve food security in cowpea production in the country due to continuous decrease in the availability of arable land owing to competing demand for land for other purposes.

FIGURE 5: CUSUM TEST FOR STABILITY TEST

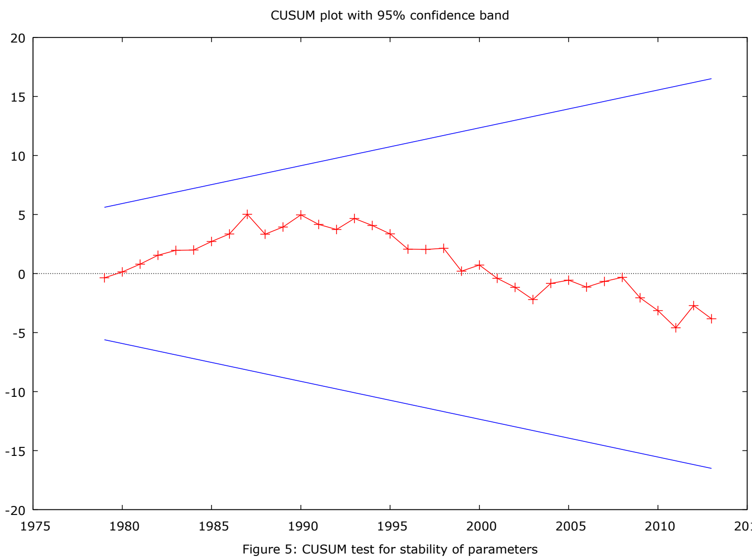

FIGURE 6: PRODUCTION FORECAST OF COWPEA (2018-2029)

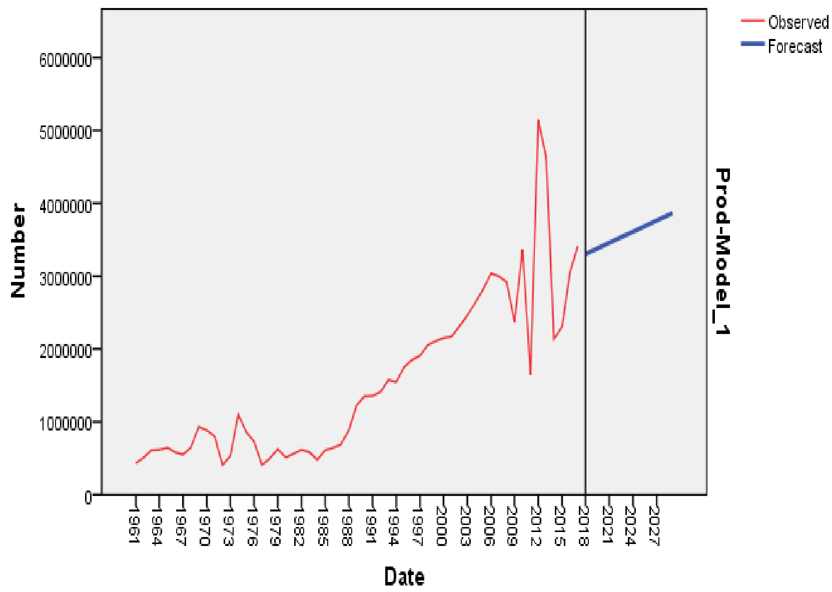

FIGURE 7: AREA FORECAST OF COWPEA (2018-2029

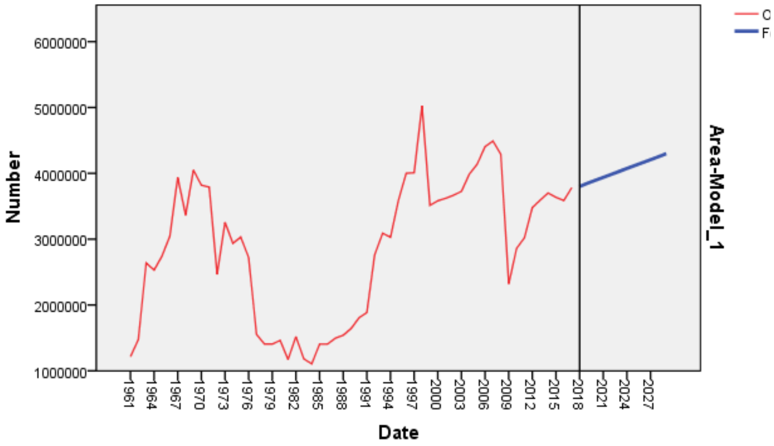

FIGURE 8: YIELD FORECAST OF COWPEA (2018-2029)

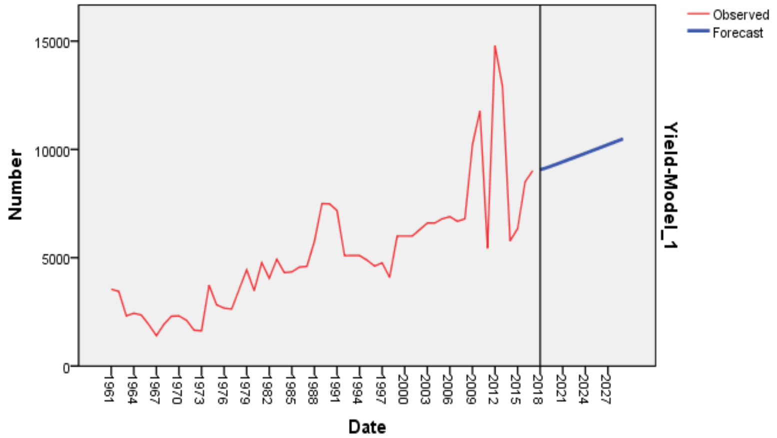

TABLE 12: OUT OF SAMPLE FORECAST OF THE VARIABLES

Year	Production			Area		
	Forecast	LCL	UCL	Forecast	LCL	UCL
2018	3304967	2204664	4405269	3800373	2696766	4903980
2019	3355848	2225382	4486314	3850119	2422883	5277354
2020	3406730	2246885	4566575	3894082	2184692	5603473
2021	3457612	2269113	4646110	3939086	1991018	5887155
2022	3508493	2292017	4724970	3983903	1822864	6144942
2023	3559375	2315549	4803201	4028753	1674009	6383498
2024	3610257	2339670	4880843	4073598	1539901	6607295
2025	3661138	2364343	4957934	4118443	1417627	6819260
2026	3712020	2389536	5034505	4163289	1305108	7021470
2027	3762902	2415218	5110586	4208134	1200811	7215457
2028	3813783	2441362	5186205	4252979	1103570	7402389
2029	3864665	2467945	5261385	4297825	1012468	7583181

Year	Yield		
	Forecast	LCL	UCL
2018	9062	5740	12384
2019	9171	5720	12623
2020	9298	5833	12762
2021	9428	5961	12895
2022	9560	6092	13028
2023	9692	6224	13160
2024	9824	6355	13293
2025	9956	6487	13425
2026	10088	6619	13557
2027	10220	6751	13690
2028	10353	6883	13822
2029	10485	7015	13954

Source: Authors' computation, 2019

CONCLUSION AND RECOMMENDATION

It can be inferred that the production trend of cowpea was driven by area and yield during the pre-SAP and post-SAP periods; and, SAP period respectively. The cowpea production growth rate turn-out to be more impressive during the post-SAP era owing to technological improvement. Furthermore, the incremental changes in the production across the regimes were influenced by yield effect. The impact of the price policy on cowpea production in the studied area is low and the time adjustment period required for the price effect to materialize is small, an indication that the farmers faced less institutional and technological constraints. Thus, the price policy instrument in bringing the desired change in the studied area will be effective. Also, uncertainty is the major factor affecting production stability of the crop in the country. However, the future trend of cowpea will be marked by a gentle rise which is not impressive as it will not augur well for cowpea food security of the nation. Therefore, the study recommends the need for policymakers to invest more in technology so that the country will be self-sufficient in cowpea production.

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