Sri Lanka Journal of Food and Agriculture (SLJFA)

ISSN: 2424-6913
Journal homepage: www.slcarp.lk

Research Paper

Sesame as a potential cash crop: an alternative source of foreign exchange earnings for Nigeria

M.S. Sadiq^{1*}, I.P. Singh², and M.M. Ahmad³

¹ Department of Agricultural Economics and Extension, Federal University Dutse, Nigeria

² Department of Agricultural Economics, Swamy Keshwanand Rajasta Agricultural University, Bikaner, India

³ Department of Agricultural Economics, Bayero University, Kano, Nigeria

* Corresponding Author: sadiqsanusi30@gmail.com <https://orcid.org/0000-0003-4336-5723>

Article History:

Received: 30 November 2019

Revised form received: 28 May 2020

Accepted: 10 June 2020

Abstract: Despite the high demand for sesame for both local and industrial consumption both at home and abroad, this potential money-spinning cash crop commodity is almost an orphan crop in a country (Nigeria) that is facing economic crises owing to dwindling price of the mono-economy which it solely depends on for economic survival. The

yearning of the present government for an alternative source of foreign earnings *viz.* cash crops motivated this research with the aim of advising policymakers to take the advantage of this money-spinning cash crop and unearth its' potential in order to bridge its' wide-gap foreign exchange earning deficit. Dated data sourced from FAO database for a spanned period of 56 years (1961-2017) covering production, area, yield and producer prices were used. The collected data were analyzed using both descriptive and inferential statistics with the aim of coming-up with valid inferences. The inferential statistics used were Growth model, Instability index, Instantaneous decomposition model, Hazell's decomposition model, Koyck's distributed lag model and ARIMA model. The empirical evidence showed that the performance of the sesame economy has not been impressive throughout the policy regime periods witnessed by the economy which owed to poor institutional supports by the policymakers which invariably affected the viability of this cash crop sub-sector, thus causing the country colossal revenue loss from foreign exchange earnings which run into millions of dollars as their exist potential readily available market for sesame products. Furthermore, the performance of the country's sesame production even in the next decade ahead will not be impressive if the internal sesame supply chain will be largely determined by the market forces as the current sesame market is been strangled by market imperfection owing to sharp market practices perpetuated by the middlemen in the supply chain. Therefore, the study recommends the need for provision of adequate institutional incentive supports by the major stakeholders in order to make the sesame sub-sector a potential foreign exchange earning which will serve as one of the viable potential alternatives to fossil fuel earning which is dwindle due to gradual paradigm shift from fossil fuel energy to green energy and the use of black gold (crude oil) as an instrument for political tango among the superpower blocks in the world.

Keywords: Sesame, Growth trend, Forecast, Nigeria

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

Historically, the top producers and traders of sesame seeds were reported from China and India. The global production of sesame as of 2017 stood at 4.6 million mt and it is expected to hit a CAGR of 1.3% during the 2018-2023 forecasted periods (Anonymous, 2018). Sesame is an important export crop in Nigeria as it plays a substantial role in the

global sesame trade market, having an annual export value of approximately US\$ 20 million (Chemonics, 2002). Nigeria is the primary supplier of sesame seed to the world's largest importer Japan, thus leading to a 40% increase in its production (Anonymous, 2018).

There exist enhanced prospects for Nigeria's sesame production owing to the escalating global demand for sesame seed for confectionery, toppings on sushi, hummus and health foods. The surging popular healthy eating trend of its products has stimulated a stable demand for sesame in the world. Besides, the increasing popularity of Asian and African sesame seed-based seasonings, sauces, and marinades in Europe and North America is expected to further drive the demand for sesame seeds in the future (Anonymous, 2018).

The crop is an important component of the Nigerian agricultural exports as it ranks second to cocoa in terms of export volume. It is fast becoming a prominent crop cultivated among the non-oil exports as it is one of the few cash crops that can earn the country's remunerative foreign exchange. The position of sesame either in Nigeria or in the global trade cycle is not well understood, thus a clear

picture of Nigeria's competitive position and opportunities is very essential. These features are poorly recognized and it is very important to develop an action plan that will facilitate continued expansion of this sector. Hence, the need for Nigerian policymakers to take a cursory look at its production, as it has the potential to shift the country from its current status of a mono-economy to a mixed economy. Therefore, this research was conceptualized with the specific objectives to (1) determine the trend and growth pattern of sesame production in Nigeria, (2) determine the sources of change in the average annual production vis-à-vis regime shifts, (3) determine the degree of instability and sources of fluctuation in the sesame production, (4) to determine institutional and non-institutional factors influencing farmers acreage allocation decision, and (5) forecast the production trend of sesame production in the studied area.

Methodology

Nigeria is located 4' to 14' N and longitudes 2' to 15' E of the Greenwich meridian time (CIA, 2011). The country is blessed with vast suitable arable land for agricultural purposes *viz.* livestock, fisheries, crop production. Time series data spanning for a period of 56 years (1961 to 2017) covering production, area, yield and producer price sourced from FAO database were used. The collected data were analyzed using descriptive and inferential statistics were applicable. Descriptive statistics and growth model were used to achieve objective (1), Instantaneous decomposition model and Hazell's

average decomposition model were used to achieve objective (2); Instability index and Hazell's variance decomposition model was used to achieve objective (3); Koyck's distributed lag model was used to achieve objective (4); while the ARIMA model was used to achieve objective (5).

Empirical model

Growth rate: The compound annual growth rate calculated using the exponential model is given as Equations 1 to 3;

$$\begin{aligned} \gamma &= \alpha\beta^t \dots\dots\dots \text{(Equation 1)} \\ \ln\gamma &= \ln\alpha + t\ln\beta \dots\dots\dots \text{(Equation 2)} \\ \text{CAGR} &= [\text{Antilog}\beta - 1] \times 100 \dots\dots\dots \text{(Equation 3)} \end{aligned}$$

where, CAGR is compound growth rate; t is time period in year; γ is the area/yield/ production; α is

the 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 sesame. Following Sandeep *et al.* (2016) and Boyal *et al.* (2015) the CV is shown in Equation 4;

$$\text{CV}(\%) = \frac{\sigma}{\bar{x}} * 100 \dots\dots\dots \text{(Equation 4)}$$

where, σ is standard deviation and $\bar{x}$ is the mean value of the area, yield of 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 in Equation 5:

$$CDII = CV \cdot (1 - R^2)^{0.5} \dots\dots\dots \text{(Equation 5)}$$

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 ($\leq 20\%$), moderate instability (21-40%) and high instability ($> 40\%$). 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 as Equations 6 and 7:

$$CII = (\text{Antilog} \sqrt{\log V} - 1) * 100 \dots\dots\dots \text{(Equation 6)}$$

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

where, X_t = area or yield or production in year 't', N = number of years, CII = Coppock's instability index;

m = mean difference between the log of X_{t+1} and X_t and and, $\log V$ – Logarithms of Variance of the series.

Source of change in sesame 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 as Equations 8 to 12:

$$P_0 = A_0 \times Y_0 \dots\dots\dots \text{(Equation 8)}$$

$$P_n = A_n \times Y_n \dots\dots\dots \text{(Equation 9)}$$

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.

$$P_n - P_0 = \Delta P \dots\dots\dots \text{(Equation 10)}$$

$$A_n - A_0 = \Delta A \dots\dots\dots \text{(Equation 11)}$$

$$Y_n - Y_0 = \Delta Y \dots\dots\dots \text{(Equation 12)}$$

From equation (8) and (12) we can derive the Equation 13, and therefore, the Equations 14 and 15.

$$P_0 + \Delta P = (A_0 + \Delta A)(Y_0 + \Delta Y) \dots\dots\dots \text{(Equation 13)}$$

$$P = \frac{Y_0 \Delta A}{\Delta P} \times 100 + \frac{A_0 \Delta Y}{\Delta P} \times 100 + \frac{\Delta A \Delta Y}{\Delta P} \times 100 \dots\dots\dots \text{(Equation 14)}$$

$$\text{Production} = \text{Area effect} + \text{Yield effect} + \text{Interaction effect} \dots\dots \text{(Equation 15)}$$

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, which 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; 2019) was used. 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 in Equations 16 and 17 and components of change in the average production is shown in Table 1.

(ii) *Change in variance decomposition:* The source of instability is caused by ten factors and the model is shown as Equation 18 and the components of variance decomposition is shown in Table 2.

$$E(P) = \bar{A}\bar{Y} + \text{COV}(A, Y) \dots \dots \dots \text{(Equation 16)}$$

$$\Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1 \Delta \bar{Y} + \bar{Y}_1 \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y} + \Delta \text{COV}(A, Y) \dots \dots \dots \text{(Equation 17)}$$

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	$\Delta \text{COV}(A, Y)$	$\Delta \text{COV}(A, Y)$

$$V(P) = \bar{A}^2 \cdot V(Y) + \bar{Y}^2 \cdot V(A) + 2\bar{A}\bar{Y} \text{COV}(A, Y) - \text{COV}(A, Y)^2 + R \dots \dots \dots \text{(Equation 18)}$$

Table 2: Components of change in variance production

Sources of change	Symbols	Components of change
Change in mean area	$\Delta \bar{A}$	$2\bar{Y}\Delta \bar{A} \text{COV}(A, Y) + \{2\bar{A}\Delta \bar{A} + (\Delta \bar{A})^2\}V(Y)$
Change in mean yield	$\Delta \bar{Y}$	$2\bar{A}\Delta \bar{Y} \text{COV}(A, Y) + \{2\bar{Y}\Delta \bar{Y} + (\Delta \bar{Y})^2\}V(A)$
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)	$\Delta \bar{A} \Delta \bar{Y}$	$2\Delta \bar{A} \Delta \bar{Y} \text{COV}(A, Y)$
Changes in area-yield covariance	$\Delta \text{COV}(A, Y)$	$\{2\bar{A}\bar{Y} - 2\text{COV}(A, Y)\}\text{COV}(A, Y)\{\Delta \text{COV}(A, Y)\}^2$
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)	$\Delta \bar{A} \Delta \bar{Y} \text{COV}(A, Y)$	$(2\bar{A}\Delta \bar{Y} + 2\bar{Y}\Delta \bar{A} + 2\Delta \bar{A} \Delta \bar{Y})\Delta \text{COV}(A, Y)$
Residual	ΔR	$\Delta V(AY)$

Nerlovian's model: Following Sadiq *et al.* (2017), the basic model which has come to be called as

Nerlovian's price expectation model is shown in Equations 19 and 20:

$$A_t = \alpha + \beta_1 P_t^* + \varepsilon_t \dots \dots \dots \text{(Equation 19)}$$

$$(P_t^* - P_{t-1}^*) = \beta(P_{t-1} - P_{t-1}^*) \quad 0 < \beta < 1 \dots \dots \dots \text{(Equation 20)}$$

Where; A_t = actual acreage under the crop in year 't'; P_t^* = expected price for 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'; α = intercept; β = coefficient of price expectation; and ε_t = disturbance term. The Nerlovian's model depicting farmer's behaviour in its simplest form is shown Equations

21 and 22. As expected, the variables were not observable and hence, for estimation purposes, a reduced form containing only observable variables may be written after substituting the value of A_t^* from equation (Equation 22) into equation 21, and shown as Equation 23;

$$A_t^* = \beta_0 + \beta_1 P_{t-1} + \beta_2 PR_{t-1} + \beta_3 Y_{t-1} + \beta_4 CYR_{t-1} + \beta_5 T_t + \beta_6 WI_t + \varepsilon_t \dots \dots \dots \text{(Equation 21)}$$

$$A_t - A_{t-1} = \beta(A_t^* - A_{t-1}^*) \text{ (Nerlovian adjustment equation)} \dots \dots \dots \text{(Equation 22)}$$

$$A_t^* = \beta_0 + \beta_1 P_{t-1} + \beta_2 PR_{t-1} + \beta_3 Y_{t-1} + \beta_4 YR_{t-1} + \beta_5 T_t + \beta_6 WI_t + \beta_7 A_{t-1} + \varepsilon_t \dots \dots \dots \text{(Equation 23)}$$

The first equation is a behavioural equation, stating that desired acreage (A_t^*) depends upon the following independent variables, where, A_t = current area under the studies crop; P_{t-1} = one year lagged price of the studied crop; PR_{t-1} = one year lagged price risk of the studied crop; Y_{t-1} = one year lagged

yield of the studied crop; YR_{t-1} = one year lagged yield risk of the studied crop; T_t = time trend at the period 't'; WI_t = one year lagged weather index; A_{t-1} = one ear lagged area under the studied crop; β_0 = intercept; $\beta_{1=n}$ = 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 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 as Equation 24 (Sadiq *et al.*, 2017).

$$(1 - r)^n = 0.05 \dots\dots\dots \text{(Equation 24)}$$

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 shown in Equations 25 and 26;

$$\text{SRE} = \text{Price coefficient} * \frac{\text{Mean of price}}{\text{Mean of area}} \dots\dots\dots \text{(Equation 25)}$$

$$\text{LRE} = \frac{\text{SRE}}{\text{Coefficient of adjustment}} \dots\dots\dots \text{(Equation 26)}$$

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 as Equation 27.

$$Z_t = \alpha + \delta_1 Z_{t-1} + \delta_2 Z_{t-1} + \dots\dots + \delta_p Z_{t-p} + \varepsilon_t \dots\dots\dots \text{(Equation 27)}$$

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 Equation 28:

$$Z_t = \alpha + \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-1} - \dots\dots - \varphi_q \varepsilon_{t-q} \dots\dots\dots \text{(Equation 28)}$$

where α is the constant; φ_q is the q -th moving average parameter and ε_{t-k} is the error term at time

‘ $t-k$ ’. The ARIMA in general form is shown as Equations 29 to 31:

$$\Delta^d Z_t = \alpha + (\delta_1 \Delta^d Z_{t-1} + \dots\dots + \delta_p \Delta^d Z_{t-p}) - (\varphi_1 \varepsilon_{t-1} + \dots\dots + \varphi_q \varepsilon_{t-q}) + \varepsilon_t \dots\dots\dots \text{(Equation 29)}$$

$$\Delta Z_t = Z_t - Z_{t-1} \dots\dots\dots \text{(Equation 30)}$$

$$\Delta^2 Z_{t-1} = \Delta Z_t - \Delta Z_{t-1} \dots\dots\dots \text{(Equation 31)}$$

where, Δ denotes the difference operation like $Z_{t-1} \dots\dots\dots, Z_{t-p}$, which are the 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 Equations 32 to 36;

$$\text{MAPE} = 1/T \sum_{i=1}^5 (A_{t-1} - F_{t-1}) \dots\dots\dots \text{(Equation 32)}$$

$$\text{RMPSE} = 1/T \sum_{i=1}^5 (A_{t-1} - F_{t-1})^2 / A_{t-1} \dots\dots\dots \text{(Equations 33)}$$

$$\text{RMAPE} = 1/T \sum_{i=1}^5 (A_{t-1} - F_{t-1}) / A_{t-1} \times 100 \dots\dots\dots \text{(Equation 34)}$$

$$U = \sqrt{\frac{\sum_{t=1}^{n-1} (\hat{Y}_{t+1} - Y_{t+1})^2}{\sum_{t=1}^{n-1} \frac{(\hat{Y}_{t+1} - Y_{t+1})^2}{Y_t}}} \dots\dots\dots \text{(Equation 35)}$$

$$R^2 = 1 - \frac{\sum_{i=1}^n (A_{ti} - F_{ti})^2}{\sum_{i=1}^n (A_{ti})^2} \dots\dots\dots \text{(Equation 36)}$$

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 Sesame

The trend of the sesame production in the country did not exhibit significant rise from the pre-SAP (Structural Adjustment Program) through to a decade during the post-SAP period, until after a decade during the post-SAP were it suddenly surged very high, then plummeted and thereafter slightly rise at the terminal periods under study.

Evidence showed that the production trend was driven during the early pre-SAP by a slight rise in the area till the mid-pre-SAP period where the area was overtaken by a slight rise in yield. This slight rise in yield trend persists in driven the annual incremental change in production till the mid-SAP period (the year 2007) where the yield trend plummeted and a steep gentle rise in area resurfaced in driving the annual slight rise in the production trend. Afterwards, an explosive surge in the yield forced the production trend to gallop during the year 2011 to 2012, and thereafter the production trend suddenly declines steeply owing to a sharp decline in the yield level through 2013 to 2015 where it ebbed.

At the point where it ebbed (i.e. year 2015), a recovery trend in yield cycle was observed which triggered a slight steep rise in the annual production till the end of the studied period (Figure 1). Furthermore, the decomposition analysis showed that the production trend was driven by an incremental rise in area and yield in the early pre-SAP and late pre-SAP period respectively, with the production trend been marked by a mild rise during the former and thereafter plummeted during the later period (Figure 2).

A review of the SAP period showed a gently incremental change in the production till the end of the studied period which was marked by a gentle increase in the annual yield till 1990 where the yield break-even with area, and thereafter a gentle rise in area that steep above the yield trend, thus responsible for the annual production increase till

the end of the studied period (Figure 3). For the post-SAP regime, the marked gentle rise in the annual production from the beginning of the period till year the 2006 was driven by a slight rise in the annual yield which afterward plummeted and a slight rise in area became the driving force of the gentle production rise and thereafter, an explosive-yield which exhibit a cyclical trend appeared as the driven force of the upward and downward swings in the production trend (Figure 4). Therefore, it can be inferred that the production trend of sesame in the country was driven by yield, though the latter did not wax significant influence in bringing about the desired change in sesame production in Nigeria.

The results of the annual average production of sesame across the regime shifts showed the yield to be on the increase by almost two-fold across the three policy periods i.e. increased by geometric rate while the annual average in area between pre-SAP and SAP plummeted and thereafter, was marked by geometric increase between the SAP and post-SAP regimes, thus forcing the annual average production across the policy regimes to increase arithmetically (Table 3).

Furthermore, the empirical evidence showed the annual production growth rate of sesame to be on the trough (-2.5% i.e. negative growth rate) during the pre-SAP era which is solely due to annual negative growth rate in area (-2.8%) as the yield was marked by an instantaneous marginal positive growth (0.3%). During the SAP era, annual sesame production was marked by a positive growth rate (5.7%) owing to positive growth in both the area (3.1%) and yield (2.6%), though the influence of the former is more pronounced than the latter. For the post-SAP era, evidence showed that sesame production recorded high instantaneous growth annually owing to positive growth rates in both area and yield, with the growth rate recorded by area waxing more influence than the growth rate recorded by yield during the studied period.

A further examination of the production pattern for the overall period showed sesame production to be marked by a positive growth annually which owed to positive growth in both area and yield (Table 3). Therefore, with the exception of the pre-SAP era in which the performance of sesame production in the country was dismal as the production ebbed as a result of trough in area growth and almost insignificant growth in yield; the country had it good in sesame production *viz.* the remaining policy

regimes and the overall period but the performance is not a healthy one that stimulates growth and development in the economy given that growth in area was the major driving force of the annual production growth. This showed that sesame production is been practiced on marginal to small-scale levels in the country with little policy support to this money-spinning cash crop sub-sector in Nigeria.

Table 3: Growth pattern of sesame production

Variables	Pre-SAP	SAP	Post-SAP	Overall
Area (ha)	151512.5(-2.8)***	119920 (3.1)***	292362.3 (7.2)***	187677.6 (1.4)***
Yield (hg)	2915.5 (0.3)***	4134.467 (2.6)***	6904.278 (5.2)**	4495.895 (2.0)***
Production (ton)	44083.33 (-2.5)***	50133.33 (5.7)***	235179.9 (12.4)***	106021.7 (3.4)***

Source: Authors' computation, 2019; Note: Figure in parenthesis is CAGR *** ** * & NS denotes statistical significance at $p=0.001$, 0.05, 0.01, and Non-significant, respectively. SAP = Structural Adjustment Program

Source of Change in Production

The results of the instantaneous source of change in the average annual production level across the three policy regimes showed area effect and yield effect to be major source of incremental change in the average annual production level during the pre-SAP and post-SAP eras respectively, while area effect and interaction effect simultaneously were responsible for the incremental change in the average annual production level during the post-SAP period. However, a cross-examination of the overall period

showed interaction effect and area effect which are almost at par to be the factors that account for incremental change in the annual production level of sesame in the studied area (Table 4). Therefore from the instantaneous point of view, it can be inferred that area effect predominates in determining the average annual production level of sesame in the studied area. This result further justifies the findings observed in the trend and growth pattern of sesame production.

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

Source of change	Pre-SAP	SAP	Post-SAP	Overall
Area effect	114.52	41.60	63.53	60.07
Yield effect	-9.13	63.14	-26.87	-21.29
Interaction effect	-5.39	-4.73	63.34	61.23
Total change	100	100	100	100

Source: Authors' computation, 2019

Furthermore, detailed examination of the source of annual average change in sesame production between regime shifts *viz.* inter-regime shifts, showed that between the pre-SAP and SAP eras, "change in average yield level" was the major factor that has made the production level of the SAP period to be higher than that of the pre-SAP period. Between the SAP and post-SAP inter-regime shift, 'change in the average annual area' was the identified driving factor that has made the average annual sesame production level during the post-SAP to be higher than the output level of the immediate preceding period *i.e.* SAP era (Table 5). Therefore, it can be inferred that liberalization policy during the

SAP period played a key role in expanding sesame output for the internal and external market while deregulation of the economy during the post-SAP era forced sesame producers in the country to relegate back to land for output expansion owing to almost total withdrawal of government incentive supports. The producers which are mostly marginally to smallholder farmers, who account for the bulk supply of sesame, with it been cultivated on tiny and uneconomic holdings, had to resort to area increase for expansion as they lacked the economic power to purchase improved technologies for high sesame productivity during this period.

Table 5: Sources of change in sesame production (Inter-regime wise %)

Source of change	Pre-SAP to SAP	SAP to Post-SAP
Change in Mean yield	298.77	21.9
Change in Mean Area	-149.0	47.01
Interaction between Changes in mean area and mean yield	-62.3	31.49
Change in yield and area covariance	12.53	-0.41
Total change	100	100

Source: Authors' computation, 2019

Degree of Instability and Sources of Instability

The results of the CV index showed sesame production viz., pre-SAP and SAP to marked by moderate fluctuation which is been caused by moderate instability in the average annual area as the average annual yield status recorded low instability. However, for the post-SAP and the overall period, the average annual production level was marked by explosive fluctuation (i.e. the CV index been greater than 100%) with high instability in both area and yield fluctuations been the causal factors (Table 6). Furthermore, determining the exact direction of instability using the CDII index, similar scenario of the magnitude of instability

which unfolds across the three regimes plus the overall period was observed, except during the post-SAP era, as area fluctuation was observed to be moderate when compared to high area instability observed for CV during the same period (Table 6).

These outcomes did not come as a surprise. The bulk of this cash crop is produced on small-scale basis by resource-poor farmers who lack economic power, and solely rely on social capital which has little or no effect on commercialization of sesame in the country. Thus, the reason for area instability is the major factor responsible for production instability in the studied area.

Table 6: Extent of instability in sesame production

Regimes	Variables	CV	CDII	CII
Pre-SAP	Production	0.255	18.101	47.344
	Area	0.263	16.982	47.640
	Yield	0.025	1.5399	37.725
SAP	Production	0.254	4.1677	47.667
	Area	0.158	8.4137	43.429
	Yield	0.121	5.3242	41.826
Post-SAP	Production	1.064	62.326	83.113
	Area	0.451	22.763	57.367
	Yield	0.612	49.844	59.309
Overall	Production	1.549	107.841	80.288
	Area	0.567	48.983	57.723
	Yield	0.647	38.864	55.784

Source: Authors' computation, 2019; CV = coefficient of variation; CDII = Cuddy-Della instability index; CII = Coppock's instability index

In measuring the extent of the production instability in relation to the price trend, the empirical evidence showed the annual average production to be marked by high instability across the three policy regime periods plus the overall period as indicated by their respective CII index values which were $\geq 40\%$. The degree of the instability been high was due to high fluctuation which marred both the annual average area and yield in the studied period (Table 6). Therefore, it can be inferred that the high production instability during the pre-SAP and SAP periods was due to cost-push inflation while that of the post-SAP was due to both cost-push and demand-pull inflations. The spread effect of both the cost-push and demand-pull inflation was responsible for the very high fluctuation in sesame

production for the overall period. The examination of the source of instability between regimes as they shift and across the three regimes shifts, showed 'change in area-yield covariance', 'change in average yield' and 'change in yield variance (fluctuation)'; in descending order to be the major factors which forced the instability status of SAP period to be higher than that of pre-SAP regime. Between the SAP and post-SAP periods, the causal factors which make the instability status of the latter period to surge above the former period owed to shock largely generated by 'interaction effect between change in average yield and area variance (fluctuation)'. While for the overall period, the upward-staircase-wise of a surge in the average annual production instability across the three-regime shifts owed largely to the

shock caused by uncertainty *viz.* weather vagaries which are the nemesis of climate change caused by excessive human exploitation of the natural environmental resources (Table 7). Therefore, it can

be concluded that risk was the major source of instability in sesame production between regime shifts while across the regime shifts, the stretched effect of uncertainty was more pronounced

Table 7: Sources of instability in sesame production

Source of variance	Pre-SAP to SAP	SAP to Post-SAP	Overall
Change in mean yield	86.82	2.73	-0.44
Change in mean area	3.70	4.46	-0.04
Change in yield variance	57.98	-0.54	-0.89
Change in area variance	-76.93	36.00	16.57
Interaction between changes in mean yield and mean area	1.70	1.20	0.00
Change in area yield covariance	95.21	-1.24	-0.84
Interaction between changes in mean area and yield variance	-21.66	-2.66	-0.26
Interaction between changes in mean yield and area variance	-77.77	64.39	-1.62
Interaction between changes in mean area and yield and change in area-yield covariance	11.71	-3.83	-0.07
Change in residual	19.23	-0.51	87.57
Total change in variance of production	100	100	100

Source: Authors' computation, 2019; SAP = Structural Adjustment program

Farmers' Acreage Response

The result of the Koyck's distributed lag model which was applied to eliminate the tendency of the serial correlation showed the linear functional form to be the best fit as its statistical properties satisfied the economic, statistical and econometric criteria, thus was chosen as the best fit equation for the specified Koyck's adjustment lag model (Table 8). The diagnostic test results showed the residual to be a Gaussian white noise (no-autocorrelation), the successive values of the stochastic term had the same variance (homoscedastic) and the variance of

successive values of the disturbance term did not correlate (no-Arch effect) as indicated by the Durbin-Watson (DW) and Lagrange Multiplier (LM) test statistics respectively, which were not different from zero at 10% degree of freedom. Also, the parameter estimates (least squares) were stable *i.e.* do not change and there is no evidence of structural break despite that the economy passed through different reform as indicated by the CUSUM (Figure 5) and Chow test statistics, respectively, which were not different from zero at 10% error gap.

Table 8: Farmers' acreage response

Variables	Parameters	t-stat	Mean	SRE	LRE
Intercept	-29753.4 (33155.2)	0.8974 ^{NS}	-	-	-
P _{t-1}	0.836665 (1.54886)	0.540 ^{NS}	31667.79	0.142	0.237
PR _{t-1}	-0.10035 (3.15642)	0.0317 ^{NS}	18233.33	-0.009	-0.016
Y _{t-1}	-1.65007 (5.16349)	0.319 ^{NS}	4565.415	-0.040	-0.068
YR _{t-1}	15.6384 (7.43466)	2.103 ^{**}	723.732	0.062	0.101
T _t	819.399 (1068.07)	0.767 ^{NS}	26	0.114	0.191
WI _t	96421.4 (23068.7)	4.180 ^{***}	0.958097	0.495	0.828
A _{t-1}	0.401667 (0.1377)	2.915 ^{***}	182974	0.394	0.659
R ²	0.8474				
F-stat	34.117{1.47e-15} ^{***}				
Autocorrelation	2.278{0.1386} ^{NS}				
DW test	2.1913{0.5228} ^{NS}				
Arch effect	1.4833{0.215} ^{NS}				
Heteroscedasticity	5.0958{0.398} ^{NS}				
Normality	30.346{2.57e-7} ^{***}				
CUSUM test	0.2830{0.778} ^{NS}				
Chow test	0.5596{0.8031} ^{NS}				
RESET test	1.388{0.245} ^{NS}				

Source: Authors' computation, 2019; Note: *** ** and NS refer to statistical significance at p=0.001, 0.05, 0.01% and Non-significant, respectively. Values in (), [] and { } are standard error, t-statistic and probability level, respectively. SRE = short-run elastic; LRE = long-run elasticity; Refer to the text for the abbreviation of variables.

Figure 5: CUSUM test for parameter stability

The coefficient of multiple determination value of 0.847 being less than the DW statistic (2.19) and fair indicates that the regression is not spurious and spurious correlation is absent respectively. Thus, this implies that the chosen functional treated the different economy policy regimes as one population. Furthermore, the R^2 (0.847) implies that 84.7% of the variation in the current acreage is being explained by the explanatory variables included in the model, while the disturbed reality accounts for 15.3%. The variables which impacted on the current acreage are weather index (WI), lagged yield risk and lagged area of sesame as indicated by the significant of their respective estimated least squares which were different from zero at 10% degree of freedom. The positive significance of the WI showed how favourable weather conditions experienced encouraged farmers to increase the current acreage under sesame production in the studied area. It is expected that poor weather condition usually affects agricultural production due to the fact that crop production in the country is mostly rainfed because the bulk producers of sesame and any other crops are mostly resource-poor farmers.

Sesame being a seasonal crop that is virtually cultivated during the rainy season, any failure or poor yield in the crop will discourage farmers to produce it in the subsequent period as the small capital base which they depend upon for both household expenditure and enterprise going concern will be affected. The positive significance of the lagged price risk implied that the farmers had a preference for price risk owing to readily available markets for the crop, as there is a supply deficit of

the crop in the studied area. Thus, the farmers produce irrespective of the yield risk and price factor because it is cultivated on a subsistence basis and there is no potential alternative crop substitute to this crop in the country. Though if all things being equal, the positive and negative signs for lagged yield risk and lagged price risk respectively, imply that the farmers will be risk-averse if there is any yield variability and will be risk-taker if there is any variability in the sesame price.

The non-significant of the estimated lagged yield coefficient indicated that the farmers used local seed varieties, while the negative sign connotes the effect of supply glut on the market price, which in turn discourage farmers from adjusting forward the current area cultivated under sesame. The positive non-significant of the lagged price coefficient is an indication that the farmers didn't possessed bargaining power due to lack of market link with the industrial consumers and the exporters as they depend on the exploitative tendency of middlemen who take advantage of this vacuum.

This attitude of the middlemen is a common phenomenon in cash crop markets in sub-Sahara countries owing to poor market infrastructure and poor economic status of its' farmers. Also, it revealed that there is no government price support measure which will aid in bringing desired higher goal in sesame production. However, the positive sign is an indication that *ceteris paribus*, if the lagged producer price is remunerative, farmers will be motivated to increase output, thus increase in the acreage cultivated under sesame in the studied area.

The short-run and long-run price elasticities reflect the sesame farmers' acreage responsiveness to price changes in the preceding period and if given sufficient time for adjustment respectively. Therefore, given the low value of the LRE coefficient (0.238), thus the impact of any price policy on sesame crop in the long-run will be small. Furthermore, the empirical evidence showed that high constraints owing to technological and institution problems affected sesame production as indicated by the number of years i.e. 5.83 years required for price effect to materialize, thus more time is required for price adjustment to bring desired change in sesame supply in the studied area. According to Sadiq *et al.* (2017), the smaller the required time for price adjustment effect to materialize, the more effective is the policy instruments of price in bring the desired change in the supply of a crop.

The positive non-significant of the time index implied that the impact of the economic policy regimes observed in the country was not felt by the sesame subsector. The non-significant of the managerial efficiency parameter revealed the non-consequential effect of technology on sesame production as the crop is cultivated on uneconomic holdings using primitive or crude implements and local technology. However, *ceteris paribus*, the negative sign implies that the use of local technology

will discourage farmers from going into proper commercialization of sesame production in the studied area. The positive significant of the lagged acreage coefficient implies that the lagged area accounted for almost half of the current area allocated to sesame production. In addition, the farmers did not fully adjust the current area under sesame cultivation as indicated by the adjustment coefficient of 0.60 which is less than unity (1), thus adjustment goes on and give rise to lags which are distributed over time. The adjustment coefficient being 0.60, which is high, indicates rapid adjustments by the farmers of the acreage under sesame crop in the studied area.

Production Forecast of Sesame Crop

For efficient and reliable forecast, the trend element in the sesame production *viz.* production, area and yield were eliminated through the application of the ADF-GLS unit test which revealed that the production variables were not stationary at level but after first differencing they became stationary as indicated by their respective absolute tau-statistics which were lower and higher than the t-critical values at 5% probability level, respectively. Furthermore, the variables were subjected to various ARIMA stages, and ARIMA (1,1,1); ARIMA (0,1,1) and ARIMA (0,1,1) were chosen as the best fit for the production, area and yield as their respective residuals satisfied the least square criteria (Table 9).

Table 9: ARIMA model

ARIMA		Production (AIC)	Area (AIC)	Yield (AIC)
ARIMA (1,1,1)		1478.65	1392.789	1015.1
ARIMA (1,1,0)		1487.86	1399.386	1019.501
ARIMA (0,1,1)		1482.522	1391.473	1014.172
Autocorrelation		14.183(0.361) ^{NS}	20.961(0.2814) ^{NS}	12.517(0.1296) ^{NS}
Arch effect		0.0083(0.927) ^{NS}	29.102 (0.259) ^{NS}	5.896(0.2069) ^{NS}
Normality		269.02(3.822e-59) ^{***}	22.664(1.198e-5) ^{***}	90.871(1.85e-20) ^{***}
ADF	Level	-2.627{-3.03}	-0.644{-3.03}	-2.334{-3.03}
	1 st Diff.	-7.781{-3.03}	-9.216{-3.03}	-6.024{-3.03}

Source: Authors' computation, 2019; Note: *** and NS refer to statistical significance at p=0.001 and Non-significant, respectively. Values in () and { } are standard error and t-critical value at p=0.05, respectively. AIC = Akaike information criterion.

In determining the predictive power of the chosen ARIMAs, one-step-ahead forecast of the variables together with their respective corresponding standard errors using naïve approach for the period 2013 to 2015 were computed (Table 10). The validation of the estimated models was done through the sample periods in order to determine how closely the path of the actual observation could be track. Furthermore, the empirical evidence

showed the forecasting ability of the chosen ARIMAs to be reliable as indicated by the RMAPE and the Theil (U) coefficient values which were less than 5 and 1%, respectively (Table 11). Therefore, the chosen models could be used for *ex-ante* projection with high validity and consistency in the projection as the predictive error associated with the estimated equations in tracking the actual data (*ex-post* prediction) is low and insignificant.

Table 10: One-step ahead forecast of sesame production

Period	Production (hg)		Area (ha)		Yield (t)	
	Actual	Forecast	Actual	Forecast	Actual	Forecast
2013	584,980	625,588.8	526,900	375,267.8	11,102	22,229.34
2014	166,962	462,382	291,402	448,679.2	5,730	6,018.7
2015	171,900	256,642.2	329,460	382,064.5	5,218	5,740.74
2016	450,000	249,540.1	480,000	362,897	9,375	5,118.75
2017	550,000	393,735.6	500,000	420,656.6	11,000	11,521.82

Source: Authors' computation, 2019

Table 11: Validation of models

Variable	R ²	RMSE	RMSPE	MAPE	RMAPE (%)	Theil's U
Production (hg)	0.987817	178357.5	139636.5	-4687.58	-30.6555	0.789224
Area (ha)	0.993686	97480.07	26889.11	-2687.06	-5.93486	0.786258
Yield (t)	0.931102	1936.211	404.8011	584.598	5.119955	0.754987

Source: Authors' computation, 2019

The results of the estimated one-step-ahead out of the sample forecast of sesame production for the period 2018 to 2029 showed that the production will plummet after year 2018 and will persist till the year 2022, which will owe to almost stagnant changes in annual yield. Thereafter, a revival in the production in the year 2023 which will take a recovery trend direction will set in and it will be

driven by a gentle rise in both area and yield till the end of the forecasted period. In case of any unforeseen condition owing to institutional and non-institutional factors, the forecasted trends viz. production, area and yield will not go below or above the lower and upper boundary points (Table 12 and Figure 6-8).

Table 12: Out of sample forecast of the variables

Year	Production (hg)			Area (ha)		
	Forecast	LCL	UCL	Forecast	LCL	UCL
2018	461,156	223,330	698,981	461,300	349,874	572,725
2019	430,291	159,202	701,380	465,977	343,639	588,316
2020	422,200	137,248	707,152	470,655	338,300	603,010
2021	423,055	129,348	716,762	475,333	333,668	616,998
2022	427,423	126,684	728,162	480,011	329,611	630,410
2023	433,171	126,091	740,252	484,688	326,034	643,342
2024	439,462	126,366	752,558	489,366	322,866	655,866
2025	445,965	127,043	764,888	494,044	320,052	668,036
2026	452,552	127,937	777,168	498,722	317,547	679,897
2027	459,172	128,973	789,372	503,399	315,316	691,483
2028	465,805	130,119	801,491	508,077	313,330	702,825
2029	472,443	131,360	813,525	512,755	311,564	713,946

Year	Yield (t)		
	Forecast	LCL	UCL
2018	10,901	7,060	14,741
2019	11,047	4,220	17,875
2020	11,194	2,334	20,053
2021	11,340	835	21,845
2022	11,486	-438	23,412
2023	11,633	-1,560	24,827
2024	11,779	-2,571	26,130
2025	11,926	3,495	27,347
2026	12,072	4,349	28,494
2027	12,219	5,146	29,584
2028	12,365	5,894	30,625
2029	12,511	6,600	31,624

Source: Authors' computation, 2019; LCL = lower confidence level; UCL = upper confidence level

Figure 6: Production forecast of sesame

Figure 7: Area forecast of sesame

Figure 8: Yield forecast of sesame

The results revealed that the performance of sesame crop as an important cash crop will not be impressive if the sesame economy will be largely govern by the market forces. Therefore, policymakers need to put in place effective and

operational institutional instruments that will create an enabling and viable environment for the various stakeholders involved in the sesame supply chain and the sesame economy itself to operate and function efficiently

Conclusion and Recommendations

The sesame subsector in Nigeria has not been viable throughout the period studied owing to little or no institutional incentive supports from government and non-governmental organization *viz.* production technologies, marketing infrastructures, ineffective agricultural reform policies, etc. The insensitive of the farmers to the producer price vividly showed the subsistence status of sesame production despite high industrial demand for sesame both for local and

international consumption. Risks and uncertainties have been identified in the average annual production between regime shifts and across the regime shifts, to be the source of this instability. Poor institutional incentive support is the main factor affecting the viability of sesame sub-sector in the country. Unfortunately, based on the production forecast, the country will be a loser in the sesame export market owing to poor yield as output. This

will largely depend on area expansion and not productivity. Thus, it is likely to cost the country a loss of millions of dollars as foreign exchange, given the money-spinning potential of sesame in the global international markets. Therefore, the study recommends the need for providing an adequate institutional incentive support mechanism by both the government and non-governmental agencies to enable a viable sesame subsector for potential foreign exchange earnings. This will also be a

potential alternative to fossil fuel earnings, which is dwindling owing to gradual global paradigm shift from fossil fuel energy to green energy and the use of black gold (crude oil) as an instrument for political tango among the super power blocks in the world. It is imperative for Nigeria to change its economic gear by focusing on potential cash crops to bridge its' upward revenue widening gap, which is seriously deepening and bleeding its economy.

References

- Ahmed, S.I. and Joshi, M.B. (2013). Analysis of instability and growth rate of cotton in three district of Marathwada. *International Journal of Statistika and Matematika*, 6(3): 121-124.
- Anonymous (2018). Global Sesame Seeds Market - Segmented by Geography - Growth, Trends, and Forecast (2018 - 2023). researchandmarkets.com.
- Ayalew, B. (2015). Supply response of maize in Ethiopia: Cointegration and Vector Error Correction Approach. *Trends in Agricultural Economics*, 8 (1): 13-20.
- Boyal, V.K., Pant, D.C. and Mehra, J. (2015). Growth, instability and acreage response function in production of cumin in Rajasthan. *The Bioscan*, 10(1): 359-362.
- Central Intelligence Agency (CIA) (2011). *The World Factbook*. Central Intelligence Agency.
- Chemonics International Inc. (2002). Overview of Sesame Industry. The United State Agency for International Development (USAID)/Nigeria RAISE IQC contract No PCE-1-00-99-00003-00.
- Coppock, J.D. (1962). *International Economic Instability*. pp 523-525. McGraw-Hill, New York.
- Cuddy, J.D.A. and Valle, P.A.D. (1978). Measuring the instability of time series data. *Oxford Bulletin and Economic Statistics*, 40: 53-78.
- Gujarati, D., Porter, D. and Gunasekar, S. (2012). *Basic Econometrics*. McGraw Hill, New Delhi.
- Hazell, P.B.R. (1982). Instability in Indian food grain production. *Research Report* 30, Washington, D.C., USA: International Food Policy Research Institute.
- Kumar, N.S, Joseph, B. and Muhammed, J.P.K. (2017). Growth and Instability in Area, Production, and Productivity of Cassava (*Manihot esculenta*) in Kerala. *International Journal of Advance Research, Ideas and Innovations in Technology*, 4(1): 446-448.
- Paul, R.K. (2014). Forecasting wholesale price of pigeon pea using long memory time-series models. *Agricultural Economics Research Review*, 27(2): 167-176.
- Sadiq, M.S., Singh, I.P. and Karunakaran, N. (2017). Supply response of cereal crop farmers to price and non-price factors in Rajasthan state of Nigeria. *Journal of Agricultural Economics and Rural Development*, 3(2): 203-210.
- Sandeep, M.V., Thakare, S.S. and Ulemale, D.H. (2016). Decomposition analysis and acreage response of pigeon-pea in western Vidarbha. *Indian Journal of Agricultural Research*, 50(5): 461-465.
- Sihmar, R. (2014). Growth and instability in agricultural production in Haryana: A District level analysis. *International Journal of Scientific and Research Publications*, 4: 1-12.
- Stalling, J.L. (1960). Weather indexes. *Journal of Farm Economics*, 42: 180-186.
- Umar, S.M., Suhasini, K., Jainuddin, S.M. and Makama, S.A. (2019). Sources of growth and instability in cassava production in Nigeria: An evidence from Hazell's Decomposition Model. *SKUAST Journal of Research*, 21(1): 86-95.
- Umar, S.M., Suhasini, K., Sadiq, M.S. and Aminu, A. (2017). Growth and Instability in Yam Production in Nigeria: An Inter Zone and State Level Analysis. *Dutse Journal of Agriculture and Food Security*, 4(1): 10-24