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Review

Analysis of Cocoa Yield Forecast in Nigeria: An Autoregressive Integrated Moving Average (ARIMA) Approach (2017 – 2030)

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Cocoa being a food-industrial and one of the most important non-oil export commodities in Nigeria has a very strong potential to play an important role in building a strong economic base for Nigeria. In the light of the importance of this crop to the Nigerian economy, the study employs the ARIMA technique to forecast the yield of cocoa in Nigeria between 2017 and 2030. Data for the study were based on historical cocoa yield time series data sourced from the Food and Agricultural Organization of the United Nations online database (FAOSTAT), The data which covers the period of 1961 -2016 was used to forecast cocoa yield using the Autoregressive Integrated Moving Average (ARIMA). The forecast results which were evaluated using statistically estimated prediction tools to validate it, show that cocoa yield in Nigeria will peak at about 31500Kg/ha in 2030 which is lower that the 4800Kg/ha obtained in 1998. This emphasizes the need for a change of the business as usual policies and investments in order to improve the livelihoods of the cocoa growing farmers in Nigeria as well as build up a nrw revenue base in the face of failing crude oil prices in Nigeria.

Keywords: ARIMA, Forecast, Cocoa Yield, Time Series, Unit root

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INTRODUCTION

In the early 1960s, the Nigeria agricultural sector was the most important in terms of its contributions to local production, employment and foreign exchange earnings. Agricultural products such as palm oil, rubber, cocoa, groundnut and cotton played prominent roles in the growth, development and stability of the nation's economy before the discovery of crude oil in commercial quantities. During this period, Nigeria was once the second leading producer of cocoa in West Africa and the largest producer of palm oil globally. Cocoa as an crop was Nigeria's foreign exchange earning non-oil produce.

After the discovery, exploration and production of crude oil in commercial quantity, the situation changes. Largely, Nigeria began to neglect the agricultural sector which was the largest employer of labour for the crude oil sector. According to Oluyole (2010), agricultural production was the mainstay of the Nigerian economy, providing 65% of Gross Domestic Product (GDP) in the 1960s. Before independence, agriculture was the most important sector of the Nigeria economy, and accounted for more than 50% of GDP and 75% of export earnings. The contribution of the agricultural sector however has dropped in recent times to about 26% of crop (Oduwole, 2000). Of a particular interest was the finding by Awe (2012) who emphatically attributed the reduction in cocoa production on oil boom among other things.

Nigeria's dependence on oil was not without a consequence. According to Akinwumi, (2013), it was described as a disaster to the country's economic growth due to the negligence of non-oil products such as cocoa, cassava, palm oil, among others, that made Nigeria great in the first Republic. The International Cocoa Organization (2010) also reported that, of the global production, Africa contribution to the production of cocoa beans has declined from 71.8% in 2007/ 2008 to 68% in 2009/2010 while Americas, Asia and Oceania have increased from 12.5% and 15.8% to 14.4% and 17.5% respectively. As stated by Akinwale (2006) and Ibiremo *et al*., (2011), in Nigeria, cocoa is a major export crop with revenue of at least 34 billion derived annually from the export of cocoa beans alone, besides revenue from cocoa by-products like butter, cake, liquor and powder. The oil boom period meanwhile did not help the sector at all as it remained stagnant during the 1970s. Up to this moment, the relative neglect of the agricultural sector by successive governments in Nigeria largely accounts for the declining share of its contributions to.

According to Cadoni (2013), Nigeria is the fourth leading exporter of cocoa in the world, after Cote d'Ivoire, Indonesia and Ghana. He stated that Cocoa export is the main agricultural export in Nigeria even if cocoa production accounts for only 0.3% of the agricultural GDP (IFPRI,2010). According to Titilola (1997), Cocoa, as one of the nonoil export commodities accounted for over 90 percent of non-oil exports in 1985. Producers' price tripled between the 1985 and 1986 harvest and the 1986 main harvest after the Cocoa Board had previously set prices close to world prices at the official exchange rate.

Following the investments in the oil sector, the 1970s and 1980s saw a constant economic down turn and decline in cocoa production in the country. Subsequent to the launch of the Structural Adjustment Programme (SAP) in 1986 and overall economic liberalization policy, cocoa production is still primarily managed by small-holders with a low use of both inputs and product enhancing agricultural techniques (Idowu, 2007).

Average cocoa beans production in Nigeria between 2000 and 2010 is 389,272 tonnes per year. There was an overall increase in the production trend between 2000 and 2006, followed by a decline in 2007 and a slightly ascending trend ever since. While the trends in production and area harvested were correlated up to 2006, the negative downturn in production for the year 2007 was associated to an increase in the area harvested during the same period, followed by a relative stable trend in area harvested between 2007 and 2010. As for the yields, while ascending between 2000 and 2006 (average 0.38 tonnes/ha), they saw a decline in the following year, with an average of 0.28 tonnes/ha (Cadoni, 2013).

According to Cadoni (2013), Nwachukwu et al. (2010), identified low yields, inconsistent production patterns, disease incidence, pest attack and little agricultural mechanization as key factors leading to decreasing cocoa production in Nigeria. Additionally, the ageing of cocoa producing trees also plays a role in the decrease of productivity. Particularly, 60 percent of cocoa farms are over 40 years old, thus hampering productivity. Overall, farms in Southern/southern Eastern Nigeria tend to be younger and generally more productive (Nwachukwu *et al.* 2010). When compared to other cocoa producing countries, Nigeria presents yields among the lowest, together with Ghana and Cameroon, while Cote d'Ivoire is the best performing country in West Africa in terms of yields, and Indonesia is the best performer in terms of yield at the global level

In order to reverse the fall in the yield of cocoa in Nigeria, the National Cocoa Rehabilitation Programme was set up by the Federal Government in 1999. The major responsibility of the agency is to evolve and implement policies and programmes which will revive and boost the production of cocoa in Nigeria (Akande, 2012). In like manner, Governemnt also launched the cocoa re-birth programme in 2005. The policy thrust of the programme was to promote the production of cocoa amongst other things (FGN, 2006).The approach, though contributed to increase in agricultural production, also allowed for better connected farmers and relatively well-off farmers to benefit and advance in agricultural productivity. But the approach depends on continued government support, while it is also prone to inefficiency arising from high administrative cost, government monopolies and political manipulation (Banful and Branoah, 2010).

In the light of the failing prices of crude oil globally, it is becoming obvious that Nigeria risks dwindling revenue generating power as well as a low foreign reserve if nothing is done to revive the non-oil sector of the economy especially the agricultural export crops of which cocoa is a factor. Therefore, there is the need to forecast the yield of cocoa in Nigeria into the future. This will assist policy makers in the economy to come up with necessary policy decisions that will preserve the cocoa export sector as well as help prevent a near total loss of the nation's income generating capacity from the non-oil sector. The goal of paper therefore is forecasting the yield of Cocoa in Nigeria using Auto-Regressive Integrated Moving Average also called Box-Jenkins Methodology of forecasting.

Methodology

Data and Data Source

This study is based secondary data of cocoa yield for analyzing cocoa yield forecast in Nigeria. The annual cocoa yield data for Nigeria for the period of 1961 to 2016 was obtained from the Food and Agriculture Organization of the United Nations statistical database (FAOSTAT).

Analytical Techniques

Both inferential and descriptive statistics were used to analyse this study. While the descriptive statistics involved the use of graph to examine the trend in cocoa yield in Nigeria, as well as some ARIMA properties of the data, the ARIMA model was used to forecast the yield of cocoa in Nigeria.

ARIMA modelling

This study applied ARIMA modelling also known as Box-Jenkins Methodology of forecasting to analyze cocoa yield forecast in Nigeria. ARIMA is the method first introduced by Box and Jenkins (1976) and until now has become the most popular models for forecasting univariate time series data (Harris *et al*, 2012). The basic principle of methodology involves forecasting the future values of a particular variable using the past or lagged values of the same variable. The ideology is termed "let the data speak for themselves" (Gujarati, 2004). The various steps and procedure involved in ARIMA modeling is explained below.

The Box-Jenkins ARIMA model has evolved from the combination of AR (Autoregressive) and MA (Moving Average), the ARMA models.

The methodology of Padhan Purna Chandra (2012) as contained in Gathondu (2012) is specifically applied in this study. According to Gathondu (2012), let Y_t be a discrete time series variable which takes different variable over a period of time. the corresponding AR (p) model of Yt series, which is the generalizations of the autoregressive model, is expressed as;

$$AR(p); Y_t = \theta_0 + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + ... + \theta_p Y_{t-p} + \varepsilon_t \quad ... \quad (1)$$

Where Y_t is the response variable at time t, Y_{t-1}, $Y_{t-2,}$ Y_{t-p}, *are* the respective variables at different time lags; $\theta_{0,}$ θ_1, ... θ_p are the coefficients and ε_t is the error factor.

Similarly, the MA(q) model which is the generalization of the moving average model is specified as;

$$MA(q); Y_t = \mu_t + \varepsilon_t + \sigma_1 \varepsilon_{t-1} + ...\sigma_q \varepsilon_{t-q} \qquad \varepsilon_t \sim WN(0, \sigma^2_t) \quad (2)$$

Where, μ_t is the constant mean of the, series, σ_1, σ_2, ... σ_q, *are* the coefficients of the estimated term and ε_t is the error term.

When (Y_t) in the data is replaced with ($\Delta Y_t = Y_t – Y_{t-1}$), then the ARMA models become the **ARIMA (*p,d,q*)** models, where ***p*** is order of autocorrelation (indicates weighted moving average over past observations), ***d*** is order of integration (differencing) and ***q*** is order of moving averaging. By combining the models in (1) and (2), this resulting model is referred to as ARIMA model, which have the general form of;

$$Y_t = \theta_0 + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + ...\theta_p Y_{t-p} + \varepsilon_t + \sigma_1 \varepsilon_{t-1} + ... + \sigma_q \varepsilon_{t-q} \quad (3)$$

If Y_t is stationary at level or I(0) or at first difference I(1) then this determines the order of integration. To identify the order of p and q the ACF and PCF is applied.

Test of Stationarity of Time Series Data

ARIMA model is generally applied for stationary time series data. A time series is said to be stationary if both the mean and the variance are constant over time. A time plot of the data can suggests whether the time series needs any differencing before performing formal tests. Also, the stationarity and non-stationarity properties are checked by applying

ADF. The ADF statistic is a negative number and the more negative it is, the stronger the rejection of the hypothesis that there *is* a unit root at some level of confidence i.e., the time series is non-stationary. If the time series is non-stationary, we do the first differencing or a higher order differencing till the time series becomes stationary. The times of differencing the series is indicated by the parameter *d* in the ARIMA(*p,d,q*) model.

ARIMA model Selection

The Box-Jenkins methodology employed a three stage method for selection of appropriate ARIMA model for the purpose of estimating and forecasting univariate time series. These include; i) Identification, ii) Model estimation, and iii) Diagnostic Checking. After these stages, the selected models can now be used for forecasting.

Model Identification

The first step of applying the model is to identify appropriate order of ARIMA (*p,d,q*) model. Identification of ARIMA model involves selection of order of AR(*p*), MA(*q*) and I(*d*). The order of *d* is estimated through I(I) or I(0) process.

The model specification and selection of order *p* and *q* involves plotting of ACF and partial PACF or correlogram of variable at different lag length after stationarity. The plotted ACF and PACF of the variable were observed to determine which correlations were statistically significant at 95% confidence interval. The principle of parsimony was adhered to, in which a model is expected to have as small parameters as possible yet still be capable of explaining the series, that is if two or three explanatory variables can explain the behavior of a model we do not need to add more variables.

Model estimation

Once the order of p, d and q are identified, the next step is to specify appropriate regression model and estimate. With the help of R software various orders of ARIMA model were estimated to arrive at the optimal model. For instance, by ARIMA (2, 1, 1), it means the series is stationary at first difference and follows AR (2) and MA (I) process. The estimated models are compared using AIC and BIC, the one with smallest AIC and BIC values is then selected.

Diagnostic Checking

After selecting an ARIMA model and having estimated its parameters, diagnostic check was done to assess whether the chosen model fits the data reasonably well.This was done by checking on the residual term obtained from ARIMA model by applying ACF and PACF functions, to know if residuals are not auto correlated and follow normal distribution. The Q statistic of Ljung-Box (1978) was used to test for auto-correlation.

Forecasting

After the Box-Jenkins three stage methodology of forecasting was carried out, then the selected model was used in forecasting the future values of the variable.

RESULTS AND DISCUSSION

Trends in Cocoa Production in Nigeria

This section briefly examines the trends in cocoa yield in Nigeria. The result show that the maximum production of cocoa yield in Nigeria was 4980 Kg/ha in 1998 while the lowest yield was 2000 Kg/ha in 1983. On the average the Cocoa yield in Nigeria from 1961 – 2016 was 3180 Kg/ha. There is an irregular movement in the time plot as shown in Figure 1, which depicts a non-seasonal movement of the Cocoa yield. The Cocoa yield dropped after 1970 till it reached minimum in 1983 where it picked up again and it increased sharply after 1987 – 1994 and it continued in an irregular manner until 2007 when it began to decline steadily thereafter.

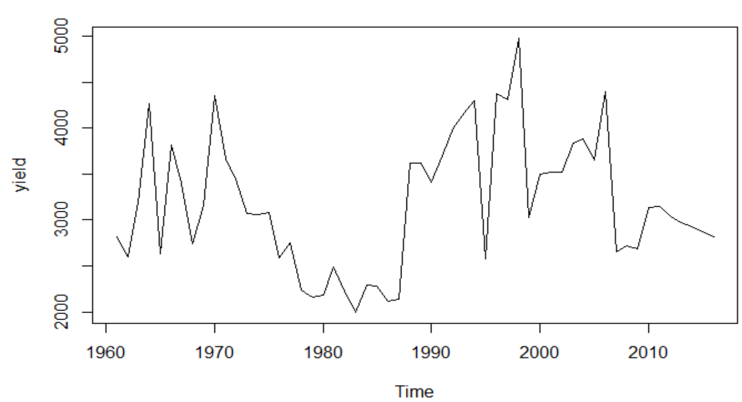

Figure 1. Time plot of the cocoa yield data

Unit Root Test for Cocoa Yield in Nigeria

The time series analysis of the cocoa yield data was conducted using R statistical software. The Augmented Dickey-Fuller unit root test was done to examine the time series property of cocoa yield in Nigeria. The result (in Table 1) shows that the data was stationary at levels since its p-value is less than 0.05 at 5% level of significance. Therefore we reject the null hypothesis that the data is not stationary at levels. Hence the cocoa yield data is integrated of order zero, $d = 0$.

Table 1: Augmented Dickey-Fuller Test of the Cocoa Yield data

Dickey-Fuller	Lag Order	P-Value
-3.8135	10	0.02411

Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) Plots for Cocoa Yield in Nigeria

The ACF and PACF plots of the cocoa yield data were estimated and the results obtained are as shown in figure 2. The results implied that the cocoa yield data was stationary at level since there is a sharp decline the ACF plot of the data.

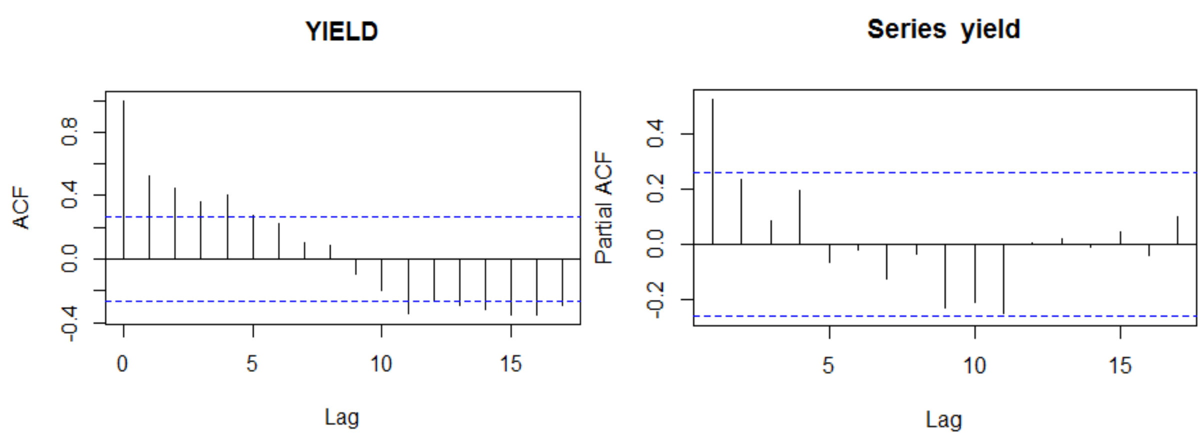

Figure 2. ACF and PACF plots of the cocoa yield

Model estimation

The next step was to identify the ARIMA model with best fit to be used in forecasting cocoa yield. The *auto.arima* function in R statistical software which can identify the ARIMA model with best fit based on the minimum AIC and BIC values was employed in determining the model with best fit. The result showed that ARIMA (2, 0, 0) was the best ARIMA model fit for forecasting cocoa yield in Nigeria given the selected data set.

Table 2. ARIMA (2,0,0) Model for Cocoa Yield.

Parameter	**Coefficient Estimate**	**Standard Error**
Mean	3150.2613	205.4612
AR1	0.3982	0.1278
AR2	0.2356	0.1283
Log likelihood= -436.45 AIC=880.91 AICc=881.69 BIC=889.01		

Source: *Authors' Analysis, 2017*

Diagnostic Checking

Diagnostic checking was done by plotting the ACF and PACF of the residuals of the ARIMA (2,0,0) model which is the best fit, to test for autocorrelation in the residuals. The Ljung-Box test was also carried out to check for independence of the residuals. The ACF and PACF plots of the residuals (Figure. 3) showed that there was no autocorrelation in the residual of the model selected.

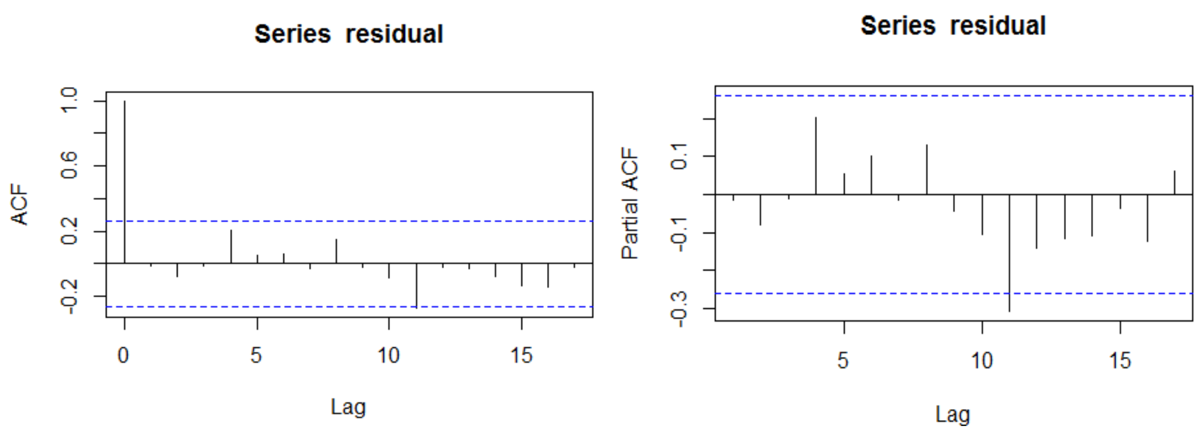

Figure 3. ACF and PACF plot for the Residual of ARIMA (2,0,0)

Table 3. Model forecast Accuracy criteria

	ME	RMSE	MAE	MPE	MAPE	MASE
Training set	8.062079	584.6695	584.6695	-3.071687	14.50794	1.016764

Table 4, provided the Ljung-Box for the final noise of the series. There was not enough evidence to reject the model and we conclude that the model is statistically significant and adequate. Hence ARIMA (2,0,0) was the most appropriate model for forecasting cocoa yield in Nigeria.

Table 4. Box-Pierce (Ljung-Box) Chi-Square statistic

Chi-squared	Lag	p-value
14.553	20	0.8014

Cocoa Yield Forecast Model

With the given dataset, the ARIMA (2,0,0) model was estimated at the following forecast equation was obtained:

$$AR(2); Y_t = 3150.2613 + 0.3982 Y_{t-1} + 0.2356 Y_{t-2} + \varepsilon_t$$

Finally, the ARIMA model was used to forecast cocoa yield in Nigeria by 2030. Figure 4 below shows the graphical description of cocoa yield forecast in Nigeria from year 2017 till 2030. The quantitative yearly yield forecast till year 2030 is also given in the table 5 below.

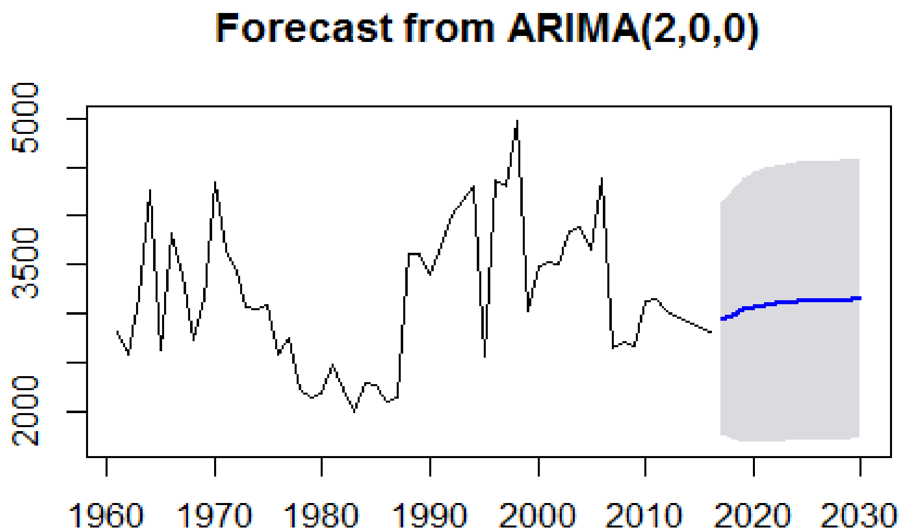

Figure 4. Actual and Forecasted cocoa yield in Nigeria

It was found that cocoa yield will continue to increase from 2954.22 Kg/ha in 2017 to 3147.139 Kg/ha in 2030 all things being equal. In the plot (Figure 4) the blue line indicates the forecasted period while the shaded portion is the 95% confidence interval. Cocoa yield will increase slowly but steadily when compared with the actual yield in 2016. The results suggests that cocoa yield in Nigeria will peak around 3.15 tonnes/ha in 2030. This result obtained is very similar to the result obtained by Kozicka et al (2018). This is not a good news for the Nigerian cocoa sector as it portends a reduced foreign exchange earnings through the agricultural export sector in the future.

Table 5: Cocoa Yield Forecast in Nigeria from 2017 -2030

	Years	Point Forecast	Lo 95	Hi 95
##	2017	2954.222	1776.305	4132.138
##	2018	2994.864	1726.977	4262.750
##	2019	3042.196	1691.974	4392.418
##	2020	3070.619	1688.462	4452.777
##	2021	3093.088	1692.412	4493.764
##	2022	3108.732	1698.948	4518.515
##	2023	3120.255	1705.609	4534.901
##	2024	3128.529	1711.370	4545.687
##	2025	3134.538	1716.058	4553.018
##	2026	3138.880	1719.711	4558.050
##	2027	3142.025	1722.494	4561.556
##	2028	3144.300	1724.580	4564.021
##	2029	3145.947	1726.128	4565.767
##	2030	3147.139	1727.268	4567.010

Source: Authors' Calculation, 2018.

CONCLUSION AND POLICY RECOMMENDATION

Having forecasted the yield of cocoa in Nigeria using ARIMA (2,0,0), this study reveals that the yield of cocoa in Nigeria will peak at about 3150Kg/ha in 2030. This is far below the 4,800Kg/ha obtained in 1998. This study concludes that all things being equal and except certain economic and agronomic policy decisions are taken on the Nigerian cocoa sector, the yield of cocoa is not going to improve in the future.

Based on the findings and conclusions made from this study, the following recommendations are made;

- In order to drastically boost the yield of cocoa in Nigeria, problems like ageing trees, which calls for replacement with new plantings, through a programme that seeks to encourage cocoa afforestation in regions where they are grown should be aggressively pursued.
- Factors such as degrading soils, pest and disease outbreaks and negative climate change effects, lack of access to quality inputs and low farm-gate prices must be tacked by the government and other stakeholders in the Nigerian cocoa sector.
- The cocoa rebirth programme initiated by the government should be resurcitated and intensified.
- Among other things, government in partnership with research institutions should develop new high yielding and disease resistant cocoa varieties.

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