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ARIMA Forecasts of Cassava Production Indicators and its Implication for Future Food Supply in Nigeria

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Abstract

The increasing trend in the cases of armed conflicts and insecurity in Nigeria could have had some devastating effects on the production of cassava and food supply in Nigeria. Therefore, in this perspective, the historical series (1961-2018) was modeled and forecasts of a 7-year period (2019-2025) of some selected cassava production indicators in Nigeria were made. The ARMA/ARIMA forecasts were made from the selected series. ARIMA (5,1,0). ARMA (1,1) and ARIMA (1,1,3) were selected to fit production series, yield series, and harvested area series in that order. Findings showed that output and yield indicators would increase in a slothful manner during the forecast period with an average of 60 million tonnes and 10 tonnes/ha respectively. The trajectory of the area of land that would be cultivated in this period shows farmers would still be adopting more extensive production patterns by expanding the area cultivated instead of cultivating more performing cassava cultivars. The implication of this on food availability was explored under two scenarios: only 84% of total cassava output would be available for consumption; and that 29% of the 84% would be lost during post-harvest activities. In view of the importance of cassava, this study recommends that farmers should plant improved cultivars.

Keywords: *Cassava, ARIMA, Insecurity, Production indicators, Food supply*

Nijerya'da Kasava Üretim Göstergelerinin ARIMA Modeli ile Tahmini ve Gelecek Gıda Arzına Etkisi

Öz

Nijerya'daki silahlı çatışmalar ve güvensizlik vakalarındaki artan eğilim, Nijerya'daki kasava üretimi ve gıda tedariki üzerinde bazı yıkıcı etkilere sahip olabilirdi. Bu nedenle, bu perspektifte, tarihsel seri (1961-2018) modellenmiş ve Nijerya'da seçilmiş bazı kasava üretim göstergelerinin yedi yıllık bir döneme (2019-2025) ilişkin tahminleri yapılmıştır. ARMA/ARIMA tahminleri seçilen serilerden yapılmıştır. ARIMA (5,1,0). ARMA (1,1) ve ARIMA (1,1,3) bu sırayla üretim serilerine, verim serilerine ve hasat edilen alan serilerine uyacak şekilde seçilmiştir. Bulgular, tahmin döneminde üretim ve verim göstergelerinin sırasıyla ortalama 60 milyon ton ve 10 ton/ha artacağını göstermiştir. Bu dönemde ekilecek arazinin yörüngesi, çiftçilerin daha performanslı kasava çeşitleri yetiştirmek yerine ekili alanı genişleterek daha kapsamlı üretim modellerini benimseyeceklerini göstermektedir. Bunun gıda mevcudiyeti üzerindeki etkisi iki senaryo altında incelenmiştir. Bunlar; "Toplam kasava üretiminin yalnızca % 84'ü tüketim için kullanılabilir olacağı ve "%84'ün %29'unun hasat sonrası faaliyetler sırasında kaybedileceğidir. Kasavanın önemi göz önüne alındığında, bu çalışma, çiftçilerin iyileştirilmiş çeşitler ekmesini önermektedir.

Anahtar kelimeler: *Kasava, ARIMA, Güvensizlik, Üretim göstergeleri, Gıda arzı*

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INTRODUCTION

The World Cassava Market is expected to take a new shape with the growing demand dynamics. Globally, despite the expansion of cassava processing factories in Asia, South America, and Europe, recent estimates have shown that only 47% of the total cassava produced is available for the industrial sector (FAO, 2015). Similarly, the increasing trajectory in the demand for cassava in sub-Saharan Africa (SSA) due to rising prices of close substitutes (such as rice), population growth, and growth in the number of cassava-dependent industries gives many concerns. This increasing demand may unsettle households of fervent cassava consumers, particularly in SSA. Although the impact of the demand by the industries has just begun to gain momentum however, demand for cassava is increasingly rising. Recent estimates showed that about 80% share of cassava is available for consumption while the remaining 20% is used up in the industrial sector in Nigeria (Kormawa and Akoroda, 2003; Otekunrin and Sawicka, 2019). There is evidence that the demand for cassava for industrial use is fast gaining traction (Otekunrin and Sawicka, 2019; Phillips, Taylor, Sani and Akoroda, 2004). Recent findings have even shown that cassava peels could substitute the expensive maize as animal feeds and reduce environmental hazards due to cassava wastes (Adedeji, 2019). As new markets and industries are being identified, it raises reasons for a more efficient production system with a view to reducing costs, increasing productivity, and making cassava more competitive (Sanni et al., 2009; Phillips et al., 2004). However, the current outlook of cassava production in Nigeria shows some sticky movement for production indicators especially, output and yield. Thus, it gives many concerns as to how to achieve stability of cassava products in household food baskets in view of its increasing demand as a raw material for industrial use. According to FAO estimates, the average cassava yield per hectare in Nigeria (1961-2018) is 10.2 tonnes/ha while the yield performance in the last decade is given as 9.8 tonnes/ha and as of 2018, the yield was 8.7 tonnes/ha. Yet, the current global average yield of cassava is about 13 tonnes per hectare whereas, the yield performance in Indonesia, Thailand, India, and Ghana are currently producing 23, 22, 21, and 20 tonnes per hectare respectively (FAOSTAT, 2019). This is evidence that increases cassava production output has been achieved mainly as a result of expanded cassava cropped area rather than an increase in land & labour productivity and adoption of improved innovations (FAO, 2015; Ikuemonisan et al., 2020). This approach is not sustainable (Dethier, 2011; Terdoo et al., 2016; Moyo, 2016).

The Possible Effects of Social Crises and Insecurity in Future Production of Cassava

The boko haram conundrum in the Northeast, the frequent incursion of the bandits in the Northwest and Northcentral, the persistent strife between farmers and cattle herders in the South, and frequent kidnapping across the countries have had some devastating effects on food production in Nigeria. According to FAO et al., (2017), countries in the sub-region that found it difficult to meet the United Nation's Millennium Development Goals (MDGs) initiatives to reduce hunger and food insecurity by half in 2015 are those ravaged by conflicts, violent social strife, and political fragility. Arrays of evidence abound that these affected countries are contributing to the expanding list of those who are affected by food and nutrition-related crises (Fanzo, 2012). Some of these include: (1) close to 75% of children who are under the age of five but with pronounced stunted growth and 6 out of 10 hungry people in the world live in this conflict-afflicted areas (FAO et al., 2017; and Fanzo, 2012). Holleman et al. (2017) concluded that countries in sub-Saharan Africa ravaged by conflict are more economically distressed than their counterparts in the same category in other regions. Several studies have established empirical evidence between armed conflicts/violent social crises and food insecurity in sub-Saharan Africa (eg. Adelaja and George, 2019; Bellemare, 2015).

The outcomes of these series of conflicts are evident in increasing food expenditure (Verwimp and Muñoz-Mora, 2018), compromised and highly inconsistent household consumption patterns (Serneels and Verpoorten, 2015), increasing the consumption of cheaper and high-calorie food (D'Souza and Jolliffe, 2013), and distortion of investment decisions of farmers (Arias, Ibáñez and Zambrano, 2018), and adoption of low-risk investment portfolios (Rockmore, 2012).

Until the advent of terrorism in Nigeria and other countries in the sub-region, frequent economic shocks of farming households include were usually triggered by political instabilities and income uncertainties (Townsend, 1994; Maccini and Yang, 2009) in addition to crop pest infestation and diseases. However, the spread of armed conflicts to most farming communities in Nigeria has significantly affected the way farmers do their farming activities. Thousands of Nigerian farmers have been killed by boko haram and armed bandits in the last decade (Osuji, Duru, and Okechukwu, 2019; Hardy, 2019). In the same period, hundreds of thousands have been displaced from their homes and farms (World Report, 2019). The shocks arising from these have been linked to both inadequate food production and a low proportion of total output sold (Adelaja and George, 2019). Consequently, both the quantity and quality of food consumed by people are largely compromised (FAO et al., 2017). All these have a direct effect on the productivity of farmers (Ajibefun, 2015).

Cassava farmers, who mainly reside in Southern Nigeria, are consistently troubled by the herders and their herds of cattle reared in the rainforest regions. In the northern part of the country, the activities of the bandits have sent farmers out of their farms, and with the attendant shortage in the food supply, the number of victims of hunger is increasing (FEWS NET, 2017; FAO, 2017). International Crisis Group (2020) hinged the activities of Bandits in Northwest Nigeria on the competitive struggle for land and water resources between cattle herders and farmers in one hand and territorial struggle among explorers of the lucrative gold in some parts of the north. The literature also linked the lingering crisis to the lack of policies to regulate the mining sector, livestock sector, and crop farming activities. Therefore, there are concerns that more crises are likely to ensue as agricultural land shrinks and/or when farmers feel unsafe to work on the farm. Thus, hunger and poverty may take a frightening dimension if these crises are left unchecked.

Another problem that might also depress cassava production in 2020 and are an unforeseen pandemic and/or epidemic. Take for example, COVID-19 was not expected when it came yet its capacity to compromise the health of health condition of people including farmers is undoubted (This could be worse in Nigeria and other countries in the sub-region due to poverty and lack of functional health facilities in the rural areas). Studies have revealed that a significant proportion (about 50%) of them has, at least, one form of an underlying disease like chronic respiratory problems including cough, diabetes, hepatitis, malaria among others (Desalu, Busari and Adeoti, 2014; Okereke and Okereke, 2015; Kughur, Daudu and Yaikyur, 2015; Amodu, Bimba, Bolori, 2017) which can make the effect of COVID-19 devastating. Evidence abounds that COVID-19 related deaths are high among people with co-morbidity. In view of this, the health situation of the rural farmers is of concern because of the ages of neglect of the rural health infrastructure and health education. Many of the farmers are even ignorant of their health status: its effect on the overall wellbeing of others and the implications it has for food security (Desalu, Busari, and Adeoti, 2014).

The nexus between farmers' diseases and their efficiency is well established in the literature. The efficiency of farmers with underlying diseases reduces by 21% (Egbetokun et al., 2012) while Hawkes and Rue (2006) listed other effects as low income, inefficiency, and low productivity. The proportion of household expenditure that also goes into health management has been found to be significantly high (Cole, 2006). The long-run impact of this for an already economically depressed farming household is of serious socio-economic concern. The temporary measures taken so far include physical distancing and lockdown. This made it practically impossible for farmers to effectively sell their previous produce and even begin the new farming season as and when due. When farmers are locked-down, and they are unable to plant during the new planting season against the future or harvest the mature crops, they will go hungry and may eventually die of hunger if the lockdown is prolonged without adequate measures to meet their food needs. Once people continue to disregard the COVID-19 protocols to do their work, they may contract the virulent virus (COVID-19) and die in view of the fact that the survival rate of those who had underlying diseases before contracting the virus is near zero. All these can further lead to shocks to food production and disrupt domestic food supply chains (World Bank, 2020).

Although cassava crop is a highly tolerant crop that can stay on the farm for more than one cropping season, however, inability to intensify production may harm future cassava production output with a significant effect on food supply. On the other hand, farmers who are victims of acute hunger may prioritize buying food over planting cassava for the future period. This may further threaten the food supply in the future.

The above situations painted the past, present, and likely future conditions in which farmers in Nigeria will have to wriggle through to effectively produce and increase their income. Now, if diseases can reduce productivity by 21%, the nefarious activities of Boko Haram, Bandits and conflicts between farmers and cattle herders can totally displace farmers from their farmers (World Report, 2019). For a country like Nigeria that is predominantly practicing extensive farming with significantly low productivity due to poor agronomic practices and inefficient use of production resources (Ospina, 2015; and Ajibefun, 2015), it is important to know the future output of cassava in Nigeria in the perspective of the rising armed conflict in the country.

The Place of Cassava in the Fight against Hunger in Nigeria

The evidence that there is more than a 20% increase in per capita food available now than it was 30 years ago points to the food distribution challenge the world is confronted with. Despite the huge amount the poor countries spend on food importation, they are yet to close the supply and demand gap. Thus, the hunger outlook remains fragile, and the problem may get worse if the population increases at a faster rate than food supply (Knirsch, 1996; FAO, 2018).

Countries in the sub-region, in response to this and other associated food security challenges, have been taking some measures to transform the food sector. In all the equations to solve the food insecurity puzzle, cassava is on the priority list because of its importance in the Nigerian households' food baskets. Therefore, it is not surprising to see some of the efforts of the government at increasing the production capacity of cassava in the past (Knowledge for Development, 2007). But, despite government strategic interventions to meet the projected cassava demand estimates of 107 million tonnes in 2007, her efforts could only amount to the production of 43 million tonnes. Up to 2019, the target has not been met. It raises the question: how did they arrive at 107 million tonnes in the first place? Drawing from basic economic theory, a wrong forecast can lead to wrong planning and budgeting (Makridakis, 1990; Fildes et al., 2009). The target might just be an unrealistic expectation that was not drawn from known and proved scientific theories. A number of agribusiness investors who premised their investments' decisions on the incorrect forecast could hardly reach the break-even point as a result of the shocks to food and agricultural markets in 2008. This triggered a fall in production from 43 million tonnes in 2007 to 37 million tonnes in 2009 (FAOSTAT). Inconsistent movement or consistent decline in food production output causes unstable food supply and consequently food price inflation (Sekhar et al., 2017).

A persistent inflation rate has been linked to frequent changes in consumption habits and hunger (Lovendal et al., 2007). The consequences of persistent hunger include an increase in the number of victims of undernourishment, malnutrition, nutrition-linked diseases, and deaths (WHO, 2017).

Recent studies have revealed that more than 842 million people have been seriously haunted by hunger in recent times in countries ravaged by food insecurity due to varying degrees of poverty (FAO, IFAD and WFP, 2012; FAO, IFAD, UNICEF, WFP and WHO, 2017). Although facts have shown that undernourishment in sub-Saharan Africa (SSA) reduced from 33% in 1990-92 to 23% in 2014-16 however, the percentage of casualties in developing countries remains the highest (FAO, IFAD, and WFP, 2015). According to FAO (2015), about 10.8% of the 7.3 billion people globally suffered from chronic undernourishment in 2014-2016. The prevalence is higher in developing countries when compared to developed countries. In the absolute figure, undernourished people rose by 44 million in 1992 to hit about 218 million in 2015 and 224 million in 2016 (FAO, 2017). This is connected to the rapid population growth of about 3.0% per annum. and the rising cost of feeding during the reference period (OECD and FAO, 2016). The inconsistency in domestic food production tends to complicate the food insecurity challenge in sub-Saharan Africa (SSA). There is evidence that the population of undernourished in SSA accounts for one in each four of the 842 undernourished people in the world (FAO, IFAD, UNICEF, WFP, and WHO. 2017).

However, the lean literature as regards the prevailing dynamics in the cassava industry poses a serious challenge to policymakers on the timeliness and appropriate strategy to adopt in order to mitigate against future shocks in cassava supply in Nigeria. A conservative demand estimate of cassava in sub-Saharan Africa in 2020 has been put at 168.1 million tonnes (Scott et al., 2000). Despite the conservativeness of this estimate, there are concerns that the current cassava production across the countries in the sub-region, particularly in Nigeria may not be able to meet demand targets for their respective countries in 2020 let alone sustain future demand. The limiting factors, among others, include inefficient use of resources and poor agronomic practices (Asumugha et al., 2010).

The current demand gap may be worsened by the rapid increase in industrial demand for cassava globally and low productivity as well as the threatening pandemic that is not only causing the deaths of farmers but preventing them from optimizing their cassava production potentials. There is a compelling need to forecast the future series of cassava production in Nigeria. Therefore, different approaches to do this have been provided in the literature (Badmus and Ariyo, 2011; Amanni, 2015; and Nedeljković et al., 2019). All these allude to the usefulness of the knowledge of the expected values for production indicators for adequate planning.

The following research questions emanated from the problems identified in this study:

-What is the appropriate ARIMA model that best fit production, harvested area, and yield of cassava in Nigeria?

-What is the 7 years forecast of the production, harvested area, and yield of cassava in Nigeria?

-What is the future Compound Annual Growth Rate (CAGR) for each of the selected variables for cassava production in Nigeria?

The general objective of the study is to the prospect of cassava production in Nigeria using time series analysis. The specific objectives include:

-To develop an appropriate model that best fit production, harvested area, and yield of cassava in Nigeria.

-What is the 7 years forecast of the production, harvested area, and yield of cassava in Nigeria

-Determine the future Compound Annual Growth Rate (CAGR) for each of the selected variables for cassava production in Nigeria.

This paper presents future projections of cassava production indicators up to 2025 with a view to providing quality piece of information that is essential for proper planning and allocation of scarce resources towards enhancing cassava production in Nigeria. Besides the government, cassava producers and consumers will also incorporate the forecast values of the selected variables useful in their production strategy. All these will culminate in stable social and economic stability in one hand, and promote economic growth on the other hand.

MATERIAL AND METHODOLOGY

The set of data used in this study include cassava production indicators (harvested area in hectares[ha], yield in tonnes/hectare [ton/ha], production tonnes [tons]). These time-series data contained 58 data points for each of the variables (indicators) which spanned from 1961 through 2018 and were obtained from FAOSTAT (2019). The data were modeled and forecasts made using the ARIMA stochastic model developed by Box-Jenkins (1976).

Statistical Technique

According to Box & Jenkins (1976), the forecasting using the ARIMA model follows four distinct stages: Identification, Estimation, Diagnostic checking, and Forecasting.

Upon achieving stationarity, the first task was to determine or identify which of the models best captured the informational structures in the series. At the identification stage, the data were carefully observed to ascertain the type of operational model is required for further investigation. This was achieved by exploring the autocorrelation and partial autocorrelation coefficients calculated for the data. The motive was to obtain the values *p, d,* and *q* needed in the general linear ARIMA model with a view to obtaining the initial estimates for the parameters. This helped to detect the suitable sub-group of equations from the general ARIMA family that functionally characterized the selected time series. The choice of the model arrived at was a function of the number of autoregressive-AR (p) and moving average-MA (q) parameters were appropriate to give the most efficient and parsimonious model. This was motivated by the fact that the parsimonious model does not encourage overfitting. It advocates fewer parameters with much more degree of freedom (df) among other competitive models that fit the concerned data (Enders, 2018). While avoiding over-fitting, the study ensured the final selection of the model is guided by the rules and post-diagnostic conditions as contained in the literature (Brooks, 2019). To achieve that, the study compared the sample autocorrelation plot and the sample partial autocorrelation plot to the theoretical behaviour of the plots.

The second stage, estimation, came up after the equations had been identified. This created that ample opportunity to ascertain which of the parameter estimates minimize the MSE. For each of the variables selected, there were more than one or two ARIMA models identified. However, the best fit model for each of the variables under consideration was selected using the model with least, volatility, highest R-square, the highest number of significant coefficients, and the least statistics values for the following information criteria: Akaike information criterion [AIC] (Akaike, 1974), the Bayesian information criterion [BIC] (Schwarz, 1978), and the Hannan and Quin information criterion [H&Q] (Hannan and Quinn, 1979). The expectation is that the parameter estimates of the selected ARIMA (p, d, q) should converge at an optimal value for the parameters with a small number of iterations. In view of its complicated nature, most studies often adopt a sophisticated software package for analysis.

The third stage of Box Jenkins' method of forecasting is diagnosis checking. At this stage, residuals from the fitted equations were explored to be sure the model sufficiently captured the structure of the time series. Therefore, time plots of the residuals allowed the standardized residual plotted against time to be observed for outliers, trends, or any fixed pattern. Similarly, the Q-Plots allowed the residuals to be observed for normality.

The normal Q-Q plots compared the distribution of a sample to a theoretical distribution thus, only when most of the points are in line and closer to the normal line that the model is considered a good fit (Enders, 2008). The Autocorrelation Function (ACF) is another diagnostic test that allowed the study to assess the fitness of the model (Enders, 2008). The rule is that when most of the sample autocorrelation coefficients of the residuals fall within the 95% confidence interval (CI) limits in a random pattern, then the model is a good fit. The Ljung-Box Q Statistics was used to check the overall model adequacy (Enders, 2008; Brooks, 2019).

Forecasting came last of the Box-Jenkins procedure. At this stage, the satisfactory model that was selected for each of the series was used for forecasting. What justifies the importance of a model is its sufficiency to predict and forecast future outcomes (Gujarati, 2003; Brooks, 2019), with a view to incorporating such into development plans (Badmus and Ariyo, 2011; Yakubu and Awaab, 2018). After the appropriateness of the model assured, the study relied strongly on the model to forecast future values for the selected variables. After making a forecast for $Y_{t+1,}$ it is added to the series and used to forecast for Y_{t+2}. The process continued until the desired future (2025) for which a forecast was desired. The numbers of the forecasts made were minimal because as the forecast period becomes farther ahead, the chance of forecast error becomes larger (Gujarati and Porter, 2009; Yakubu and Awaab, 2018; Brooks, 2019).

The Projection of Balance from Cassava in Nigeria

According to FAO, the food balance sheet offers an opportunity to observe the food supply over a specified period. This study focuses on the food supply from cassava. Cassava products are a principal food component in many Nigerian food households. The holistic approach to its calculation has been provided by the Food and Agriculture Organization (Jacobs and Sumner, 2002; FAO, 2004). According to the literature, to maintain an optimum population median BMI (basal metabolic index) of 21.0, the recommended mean energy intake for a male population of the following age group: 18-29.9 years; 30-59.9 years; and 60 years and above is given as 47 kcal/kg/day; (46 kcal)/kg/day and (38 kcal)/kg/day. For the female, the recommended mean energy intake to maintain an optimum population median BMI of 21.0 for those within the following age group: 18-29.9 years; 30-59.9 years; and 60 years and above is given as 40 kcal/kg/day; 39 kcal/kg/day; and35 kcal)/kg/day. Therefore, to obtain the per caput supply of each cassava food available for human consumption is by dividing the respective quantity by the population. This is expressed in terms of quantity.

Food Supply (per caput supply) = Production output (kg)/population/year

Recall that in 2014, when the total cassava production in Nigeria was 56328480 and the total population was 176404999, the per caput supply is given as:

$$319.2 \text{ kg/capita/year} \equiv 121 \text{ kg/capita/year} \equiv 267 \text{ kcal/capita/day (FAO estimate)} \qquad (1)$$

Other estimates for the other years were extrapolated from the above equation. Assumptions: (i) That all the Nigerian population is involved in the consumption of cassava products, (ii) That 84% of total cassava output is converted to food, (iii) That 29% of the 84% is lost during postharvest activities before getting to the food table.

Compound Annual Growth Rate (CAGR)

The Compound Annual Growth Rate (CAGR) was preferred to the Linear Annual Growth Rate (LGR) in analyzing the growth rate in the area, production, and yield of cassava. Despite the criticism against LGR and CAGR because of inherent unrealistic biological interpretation (Chandran, 2005), the acceptability of CAGR for empirical consideration has endeared it to be used in several studies (Dandekar, 1980; Ammani, 2015). Therefore, the compound growth function for the estimation is specified as follows:

$$lnY = a + bt + e \qquad (2)$$

Y = area (ha)/production (1000 tonnes) /yield (kg/ha)
a = Intercept
t = Year (1961 – 2023)
b = 1 + r (the slope coefficient 'b' measures the instantaneous relative change in Y for a given absolute change in the value of explanatory variable 't') – instantaneous growth rate.
r = Growth rate

The semi-log growth rate model is preferred to other models because it has the highest value for R-square (94%). Besides, this model enabled the study to observe both absolute and relative changes. The parameter of utmost interest in Eqn (2) is the slope coefficient (b) which measures the constant proportional or relative change in Y for a given absolute change in the value of the regressor t. However, when the relative change in Y is multiplied by 100, the percentage change or growth rate in Y for an absolute change in variable 't' is obtained while the slope coefficient 'b' measures the instantaneous rate of growth. Therefore, the CAGR is usually estimated using the following equation:

$$CAGR = [\text{antilog } b - 1] * 100 \quad (3)$$

Equation (1) was estimated using Ordinary Least Square (OLS) method hence the t- test was applied to test the significance of 'b'. The underlining assumption in this estimation is that a change in cassava output in a given year would depend upon the output in the succeeding year (Deosthali and Chandrehekhar, 2004).

Since the growth model is not programmed to reveal the relative contributions of the area and yield towards the total output change, this paper adapted a component/decomposition analysis model to determine the relative contributions of yield, harvested area, and the interaction of both to production output. The literature is replete with evidence of how this model has been used to estimate the relative growth performance of production output in agriculture (Ahmadi and Mohammad, 2008; Rehman, Saeed and Salam, 2011; Devi, Arivelarasan and Kapngaihlian, 2017).

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 shows the descriptive statistics of production output, yield, and harvested area of cassava production in Nigeria. The table reveals some striking statistics that provide a deeper understanding of the pattern of trends in cassava production indicators in Nigeria. The average yield during the period under review was about 10 tonnes/ha. The average values for production output and harvested area were 25 million tonnes and 3 million hectares respectively. The values for the coefficient of variation for the selected production indicators were found to be 67% (production); 10% (yield) and 73% (harvested area). These values indicated high variability in each of the indicators except the yield during the period under review. The skewness of the distribution of cassava production output and the harvested area was to the right.

These results can be interpreted in two scenarios: one, more often, cassava farmers have harvested cassava from less than the average 3 million hectares than they have harvested more than the average. The second leg of the interpretation is that the number of years within the reference period that farmers produced less quantity of cassava than the total average (25 million tonnes) is more than the years for producing more than the average. When these are matched, it is apparent both followed the same trend and such clearly suggests that increasing production still largely depends on the expansion of the cultivation area.

Moyo (2016) has argued that this approach of deploying more land without recourse to less-land/labour saving strategy is not sustainable. However, quite a number of experts have been promoting efficient cassava production systems across developing countries (Phillips et al., 2004; Naziri et al., 2013; and FAO, 2015). On the other hand, yield skewed negatively which implies more distribution of the series above the mean.

Table 1. Descriptive statistics of production output, yield and harvested area of cassava production in Nigeria

	Production	Yield	Harvested area
Mean	25274698	10.15660	2529997.
Median	18223504	10.00000	1636954.
Maximum	59565916	12.21550	6852857.
Minimum	7384000.	7.032300	780000.0
Std. Dev.	16857148	1.064220	1835087.
Coefficient of Variation (%)	66.69574	10.47811	72.53317
Skewness	0.594269	-0.195213	1.031784
Kurtosis	2.037923	3.052408	3.059764
Jarque-Bera	5.650688	0.375015	10.29955
Probability	0.059288	0.829023	0.005801
Sum	1.47E+09	589.0830	1.47E+08
Sum Sq. Dev.	1.62E+16	64.55621	1.92E+14
Observations	58	58	58

Source: Author’s computation, 2020

A Conservative Approach to Analysing Times Series of Cassava Production Indicators

Since the trend forecast is considered ambitious in view of the fact that it does not sufficiently consider the inter-year factors that could bring about cyclical and irregular movement in production indicators, a more conservative approach is courted to forecast production indicators in this study. This thought aligns with those of IFPRI and FAO who suggested a more conservative forecast for cassava production output (Phillips et al., 2004). In view of this, ARMA/ARIMA model is popular for its ability to account for the detailed structures of time series which the trend model often overlooks. In order to proceed with the estimation of ARMA/ARIMA model, the stationarity (unit root) of the series is examined. The major characteristics of stationary series include mean and variance which values do not change over time, and the evolution process does not have a trend. This study employed both Augmented Dickey-Fuller (ADF) and Phillip-Peron (PP) tests to find evidence of stationarity in the selected series. For the above tests, the hypothesis was tested in this order;

H_0: the series is not stationary (series has unit root)

H_1: the series is stationary (does not have unit root)

Decision threshold: At a 95% significant level, a P-value less than 0.05 indicates a rejection of H_0. Thus, it implies a series is stationary. On the other hand, if P-value is higher than 0.05, it is an indication that the series is not stationary. Where the null hypothesis could not be rejected, the series is differenced at a higher integration order until the null could be rejected eventually.

The results of the stationarity tests are presented in Table 2. Both ADF and PP tests showed that the two of the series selected were non-stationary at their levels except the yield. In reality, the yield series does not have a time trend because it simply revolves around a mean. This implies that the historical time series of both production and harvested area indicators have a unit root since the absolute values of their test statistics were observed to be less than their critical values at both 1% and 5% levels of significance. However, stationarity was reached after the first difference. The results of the test on the yield (both ADF and PP) were different as the null hypothesis for each was rejected at a level without trend (Table 2). After careful checks on the structure of ACF and PACF, the study observed that, at a 95% confidence interval, the three series (differenced production series, yield series, and differenced harvested area series) became apparently stable and stationary. In the observed structure of the production series, the ACF has a significant spike at lag 5 and none in the PACF. This structure suggested ARIMA

(5,1,0); ARIMA (0,1,5). In the structure of the yield series, the ACF has significant spikes at lag 1 and lag 2 while the PACF has a significant spike at lag 1. Therefore, the following ARMA models were identified: ARMA (1,1); ARMA (1,2); ARMA (2,1). You would recall that the yield series became stationary at level without any need for differencing hence the suggested ARMA instead of the integrated structure of ARIMA.

In the observed structure of the differenced series of harvested area, both ACF and PACF have significant spikes at lag 1 and lag 3 accordingly. Therefore, the identified models include: ARIMA (1,1,1); ARIMA (3,1,3); ARIMA (3,1,1); ARIMA (1,1,3). The integrated structure of ARMA (ARIMA) model was considered for both differenced series of production and harvested area of casaba because these series did not become stationary until they were differenced at the order of I(1).

Table 2. Test for stationarity

Test	Level of integration	Test statistic			P value		
		Production output	Yield	Harvested area	Production output	Yield	Harvested area
ADF	I(0) (trend & intercept)	-1.8706	-3.2931(NT) -3.2086(WT)	-2.2001	0.6566	0.0193 0.0930	0.4802
	I(1) (trend & intercept)	-8.7409	-8.0157	-6.2650	0.0000	0.0000	0.0000
	I(1) (intercept)	-0.8343	-8.0067	-5.6719	0.0000	0.0000	0.0000
PP	I(0) (trend & intercept)	-1.8388	-3.3415(NT) -3.2507(WT)	-1.2353	0.6727	0.0175 0.0845	0.8933
	I(1) (trend & intercept)	-8.7248	-11.3071	-8.1567	0.0000	0.0000	0.0000
	I(1) (intercept)	-8.3316	-9.8206	-5.4529	0.0000	0.0000	0.0000

Source: Author’s computation, 2020 (NT: no trend; and WT: with trend)

Tables 3, 4 and 5 describe the output of the identified ARIMA (5,1,0); ARIMA (0,1,5) for production series; ARMA (1,1); ARMA (1,2); ARIMA (2,1) for yield series; and ARIMA (1,1,1); ARIMA (3,1,3); ARIMA (3,1,1); ARIMA (1,1,3) for harvested area as suggested by their respective ACF and PACF structure.

Given the selection criteria set in the methodology, it could be observed that ARIMA (5,1,0), ARMA (1,1), and ARIMA (1,1,3) were preferred to others in each of the respective categories because of the favourable selection criteria as set out in the methodology. The output values of the selection procedure are Table 3 (production), Table 4 (yield), and Table 5 (harvested area) series accordingly. These models were also ranked highest among their peers because of the least value of AIC, BIC, and HQ as well as relatively lowest volatility. Therefore, ARIMA (5,1,0) was preferred for production series while ARMA (1,1), and ARIMA (1,1,3) yield and harvested area series accordingly.

Table 3. Output of ARIMA (5,1,0); ARIMA (0,1,5)

	ARIMA (5,1,0)	ARIMA (0,1,5)
R Squared	10.10%	9.93%
Sign Coef.	3	3
AIC	32.1757	32.1773
BIC	32.2832	32.2848
HQ	32.2175	32.2191
Volatility	4.91E+12	4.92E+12

Source: Author’s computation, 2020

Table 4. Output of ARMA (1,1); ARMA (1,2); ARIMA (2,1)

	ARMA (1,1)	ARMA (1,2)	ARMA (2,1)
R Squared	42.69%	42.07%	42.46%
Sign Coef.	3	3	4
AIC	2.5360	2.5463	2.5402
BIC	2.6781	2.6884	2.6822
HQ	2.5914	2.6017	2.5955
Volatility	0.638	0.644	0.640

Source: Author’s computation, 2020

Table 5. Output of ARIMA (1,1,1); ARIMA (3,1,3); ARIMA (3,1,1); ARIMA (1,1,3)

	ARMA (1,1,1)	ARMA (3,1,3)	ARMA (3,1,1)	ARIMA (1,1,3)
R Squared	0.07	23.51%	17.06%	24.22%
Sign Coef.	1	1	2	3
AIC	28.5277	28.4309	28.4146	27.3718
BIC	28.6681	28.5743	28.5580	28.5152
HQ	28.5805	28.4867	28.4731	28.4275
Volatility	1.24E+11	1.02e+11	1.11E+11	1.01E+11

Source: Author’s computation, 2020

In order to be sure that the selected model has adequately captured all the inherent structure of differenced production series, yield, and differenced harvested area, the following diagnostics procedures were carried out.

Residual Plot: The residuals are not only random but are also independent of each other. The structures of each of the residual plots show no defined pattern as it randomly hovers around the zero. This is an indication that each of the models adequately fits their respective series.

Normal Q-Q Plot: In each of the procedures, the distribution of each of the series when compared to a theoretical distribution shows that both the theoretical (red) and the actual distribution of the series (blue) lines are very close each other. This is an indication of the normal distribution of the residuals. Since these fitted series show normality, the study concludes that each of the models properly fits the respective series.

Q-Statistics: The Q-statistics for each of the series show that the spikes remain with the 95% confidence interval for both ACF and PACF. This also confirms that all the structure within the were adequately accounted for by the selected model.

Forecast: The distributions of the historical series of the selected production indicators showed that ARIMA (5,1,0), ARMA (1,1), and ARIMA (1,1,3) have proved to be a good fit, each of these models was deployed to forecast the next 7 observations (2019-2025) for each of production, yield, and harvested area series respectively. The red line shows the past historical series while the blue line shows the forecast series.

Table 6 shows the forecast output of cassava production series, cassava yield series, and cassava harvested area of series in Nigeria (2019-2025). Since ARIMA (5,1,0), ARMA (1,1), and ARIMA (1,1,3) have proved to be a good fit to model (1961 – 2018), the models were deployed to forecast the selected series from 2019 to 2025 at a 95% confidence interval. According to the results, the forecast cassava production showed a decline from 2018 output of about 59 million tonnes to close to 58 million tonnes in 2019. However, in the forecast results, there was an observed consistent increase in production from 58 million tonnes in 2019 to about 60 million tonnes in 2022. Interestingly, the forecast showed that the upward movement in production will continue up to 64 million tonnes in 2025 (Table 6). Similarly, the forecast results showed a clumsy growth in the yield (per hectare) of cassava beginning from 9.0 tonnes per hectare in 2019 through 9.9 tonnes per hectare in 2022 up to about 10.1 tonnes per hectare in 2025. In the same vein, the forecast output for the harvested area for cassava showed that there would be a slight decline from about 7.06 million hectares in 2019 to near 7.00 million hectares in 2021 and would later experience a clumsy rise to close to 7.35 million hectares in 2025.

Table 7 presents the estimates of food supply from cassava based on the forecast values obtained from Table 6. Forecast values of cassava indicators obtained from their historical data using ARMA/ARIMA are considered to be more conservative than the ambitious trend forecast. Therefore, based on FAO estimates on food supply from cassava and products, this study attempted to extrapolate the future values of food supply.

Columns 3 and 4 (Table 7) reveal the estimates of food supply based on the assumption that only 84% of the cassava produced will be used for consumption, indicated a consistent decline from 121 kg/capita/year and 267 kcal/capita/day (2014) to about 104 kg/capita/year and 230 kcal/capita/day (2025). When this is compared to daily energy requirements of 3100 kcal/capita/day (FAO, 2004), it is abysmally low for those who their dominant source of dietary energy is cassava. Columns 5 and 6 (Table 7) show the estimates of food supply based on 29% post-harvest losses. This is based on the assertion of Bloom (2015) and Naziri et al. (2014) that the share of cassava post-harvest losses in Africa is about 29%. On this basis, the expected food supply will decline from 121 kg/capita/year and 267 kcal/capita/day (2014) to about 74 kg/capita/year and 163 kcal/capita/day (2025).

The decline in the future food supply (in terms of energy requirements) from cassava, as observed in Table 7, occurred because of rapid population growth and perhaps due to low productivity. The results showed that in spite of the expected increase in cassava production from 2019 to 2025, the production growth rate may not adequately respond to, or match, the nutritional needs of the increasing population in Nigeria as opined by Pingali and Sunder (2017).

This study is cautious to report the possible low cassava output that may be recorded in the forecast period beginning from 2020 as a result of the effect of COVID-19 on the cassava farmers because the magnitude of effect could not be determined in this study. However, from literature, the effect of chronic health challenges of Nigerian farmers may reduce their efficiency by 21% (Egbetokun et al., 2012).

Table 6. ARIMA forecast output

Year	Production Output(Tonnes)			Yield (Tonnes/ha)			Harvested Area (ha)		
	ARIMA (5,1,0)	Confidence Limits (95%)		ARMA (1,1)	Confidence Limits (95%)		ARIMA (1,1,3)	Confidence Limits (95%)	
		Lower Limit	Upper Limit		Lower Limit	Upper Limit		Lower Limit	Upper Limit
2019	57756459	5.29E+7	6.26E+7	9.201141	7.5	10.9	7058452	6.36E+06	7.76E+06
2020	58516250	5.17E+7	6.53E+7	9.587598	7.4	11.8	7058333	5.90E+06	8.22E+06
2021	59077986	5.07E+7	6.74E+7	9.809138	7.6	12.1	6996895	5-44E+06	8.55E+06
2022	60336235	5.07E+7	6.99E+7	9.936138	7.6	12.3	7054899	5.35E+06	8.76E+06
2023	61483912	5.07E+7	7.22E+7	10.00894	7.7	12.3	7147086	5.33E+E3	8.96E+06
2024	63232107	5.21E+7	7.44E+7	10.05068	7.7	12.4	7249055	5.33E+06	9.17E+06
2025	64172731	5.25E+7	7.59E+7	10.0746	7.8	12.4	7353823	5.34E+06	9.37E+06
Mean	60653669			9.8097479			7131220.4		

Source: Author’s Computation, 2020

Table 7. ARIMA estimates of future food supply from cassava

Year	Population Projection (1000)	On the assumption that only 84% of the total cassava output supplies food requirements		On the assumption that 29% of the 84% is lost during post-harvest activities		Available cassava output for industrial use (tonnes/year)
		kg/capita/year	kcal/capita/day	kg/capita/year	kcal/capita/day	
2014	176405	120.99*	267**	120.99*	267**	16% of Total Output
2019	200964	108.8966	240.3124	77.31661	170.6218	9241033
2020	206140	107.5589	237.3603	76.36683	168.5258	9362600
2021	211400	105.8895	233.6763	75.18154	165.9102	9452478
2022	216750	105.4754	232.7625	74.88755	165.2614	9653798
2023	222180	104.8549	231.3931	74.44697	164.2891	9837426
2024	227710000	105.2174	232.1932	74.70438	164.8572	10117137
2025	233340000	104.2062	229.9616	73.98639	163.2727	10267637

Source: Author’s Computation, 2020. (* and ** FAO forecast of kg/capita/year and kcal/capital/day respectively)

Compound Annual Growth Rate

The study evaluated the compound annual growth rate (CAGR) of production, yield and harvested area of cassava during the year under review (1961-2025) and (2019-2025) the results are presented on Table 8 and 9 respectively. The results showed that the values of the CAGR obtained were statistically significant at a 1% level except yield which is significant at a 5% level. Table 8 shows production and harvested area of cassava in Nigeria would continue to grow at about 9.4% and 9.7% annually. However, productivity per hectare would decline at the rate of 0.2% annually under the same farming attitude or agronomic practices that farmers had maintained over the years. The study also simulated annual growth rate of the forecast period and the values obtained for all the production indicators were statistically significant.

The procedure considered 2019 as the beginning of the series which spanned up to 2025. The results are presented on Table 9. The results showed that the value of future annual growth rate of production which was found to be 4.29% was statistically significant at 1% level while the annual growth of harvested area (1.64%) was statistically significant at 5%. From the table, annual growth rate of yield would decline at the 3.06% (at 1% statistical significance).

Table 8. CAGR of area, yield and production of cassava in Nigeria between 1961-2025

	Harvested area (ha)	Yield (tonne/ha)	Production (tonnes)
CAGR	9.699101	-0.20755	9.392263
P value	1.61E-42	0.032252	6.12E-44

Source: Authors' computation, 2020

Table 9. Expected growth rate of area, yield and production of cassava in Nigeria between 2019-2025

	Harvested area (ha)	Yield (tonne/ha)	Production (tonnes)
CAGR	1.63779287	-3.06062	4.291436
R-Squared	0.73110217	0.998449	0.981655
P-Value	0.01418893	3.22E-08	1.56E-05

Source: Authors' computation, 2020

CONCLUSION

Besides the uninspiring expectations of the future yield of cassava, the COVID-19 pandemic could have devastating effects on the future production of food including cassava in Nigeria. This study examined among others the historical trend in and forecast 7-year periods of cassava production indicators in Nigeria. Realizing some of the deficiencies of trend forecast, a robust approach was considered to forecast these production indicators. Using appropriate measures of accuracy, ARIMA (5,1,0). ARMA (1,1) and ARIMA (1,1,3) were selected to fit production series, yield series, and harvested area series. Having considered the appropriateness of the models using apposite diagnostic tests, the models were respectively deployed to forecast the series for a period of 7 years (7 data points). The values of the average of production (61 million tonnes), yield (9.81 tonnes/ha) and harvested (7 million ha) area series in the forecast period were found to be higher than its periodic equivalence in the analyzed period by 9%, 13% and 10% accordingly. The study also analyzed the compound annual growth rate of the forecast of the production indicators and found increasing growth rate in harvested area series (9.7%) and production series (9.4%) but conversely, the yield series would experience a declining growth rate (-3.1%) in between 1961 and 2025. According to the CAGR estimates of the forecast period alone, the annual growth rate of harvested area and production series will be 1.6% and 4.3%

In conclusion, the findings from this study showed that cassava production indicators (production output, yield, and harvested area) are expected to increase in the future especially in the forecast period. The expected growth is hinged on the status quo where cassava farmers would continue in their previous state of health and continue with their farming operations. However, the impact of COVID-19 may be devastating for many reasons including a reduction in farmers' efficiency and reduction of farmers due to deaths due to COVID-19. This is because farming in Nigeria is dependent on increasing farm labour and expansion of the cropped area. When the majority of farmers are sick, they can hardly be available for farm operation or expand their farmland for the cultivation of cassava. In view of the importance of cassava food in the household food equation and the fact that the majority of the poor rural dwellers and low-income households do not have adequate food in the household food basket could increase the number of victims of hunger in Nigeria. This ugly situation is cable of unsettling the fragile socio-economic stability in the southern part of Nigeria where cassava food is critical to daily food consumption.

Therefore, this study recommends substantial investment in the mechanization of cassava production which can guarantee more production of cassava with minimal labour. Similarly, since the planting of a high yield can guarantee more cassava output with the minimal cropped area, this study recommends that a compelling policy strategy to produce more of high yield cassava stems and distribution of the same to farmers should be deployed. A deliberate effort should be made by the government to encourage farmers in the remote rural and high cassava producing communities to adopt high yield producing cassava stems with a view to increasing cassava production output in Nigeria. Encouraging a more efficient post-harvest processing system will make more food available for cassava food consumers. In view of the above, the government needs to develop a more robust and holistic policy strategy that can help leapfrog cassava production to increasing demand for food consumption, industrial use, and foreign earnings through exports. However, for a temporary measure, the government should intensify testing of rural dwellers particularly farmers against COVID-19, those infected should be isolated for treatment. They should also strengthen health extension workers to go into the rural farming communities to intensify the farmers' education on what they can do to boost their immunity and keep physical distancing, especially where it is obvious lockdown will cause more pains.

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