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## **Future Trends in Cassava Production: Indicators and its Implications for Food Supply in Nigeria**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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### **ABSTRACT**

The growing demand for cassava and its products has continued to stretch the supply of cassava globally. Nigeria is a leading producer of cassava in the world yet, there are concerns that if appropriate policy strategies are not adopted to increase production, the current fragile situation of food insecurity in Nigeria may be worsened. Besides the increasing number of gigantic cassava-based industries spring up in Nigeria, the rapidly growing population of consumers is another factor that may further disrupt the relatively stable cassava market in Nigeria in the future. Therefore, "ceteris paribus", the study determined the appropriate quantitative models to forecast the trends in cassava production indicators in Nigeria. Using the historical series (1961 – 2018), 12-year period (2019 -2030) forecasts were made for each of the production indicators as follows: 106 million tonnes (production output), 7.7 tonnes/ha (yield) and 9.6 million hectares (cropped area) in 2030. The study extrapolated the expected food supply from the expected production output in the forecast period using the 2014 FAO estimates of food supply per caput. Thus, in 2030, cassava food supply per caput was found to decline from 267 Kcal/capita/day in 2014 to 239 Kcal/capita/day. The study concludes that despite keeping the future demand of the growing cassava-based industries constant, cassava production is expected to continually increase but future food supply per caput would decline. However, the growing cassava-based industries globally is expected to hugely influence the future cassava market dynamics.

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## 1. INTRODUCTION

The competition for cassava between fervent cassava consuming households and the industry is increasingly becoming a real economic issue in view of the recent discoveries about the industrial use of cassava. This has hyped the importance of cassava beyond a mere common food for rural households to an essential raw material for cassava-based industries. Cassava is ranked behind maize as the second most important source of calories in Africa [1,2,3]. The choice of more than 500 million Africans to be ardent consumers of cassava products is hinged on its negligible expenditure elasticities and a steady supply of carbohydrates [4]. On the other hand, the popularity of cassava among its producers has been fueled by its high adaptability to the local farming environment [5,6] and high tolerance to erratic weather condition [7] including a wide range of rainfall [8]. In addition to these, its harvest time flexibility looks convenient for farmers who consider cassava as a food crop that can easily be converted to income. Above all, there is hardly any part of cassava that is not economically useful [9]. There is evidence in the literature that cassava has grown into one of the highly sought industrial raw materials from the farm [10,11] and Otekunrin and Sawicka [2] also asserted that the cassava products are increasingly becoming popular in urban households' food baskets. In view of the prospect for increased demand for cassava as food and raw materials, [12] made an ambitious projection of 107 million tonnes demand for cassava in Nigeria by 2007. The excess demand above domestic production of cassava in Nigeria is the reason for has not sufficiently met the domestic demand. As part of strategies to enhance productivity, scientists have developed cassava varieties with improved nutrient content and disease resistance [13,14,15]. In the last two decades, many gigantic cassava-based industries have sprung up in Asia, Latin America, and Europe thereby fueling an increase in demand of cassava [11,10]. The fast-changing demand dynamics have influenced the global cassava market to undergo a lot of transformation in the last decade.

Currently, the global market grows at about 3.2% with the cassava market in Asia-Pacific in good stead to dominate the global cassava market in the next decade (Market Research Future [MRF],

[16]. This growth in the cassava market is largely driven by the demand for cassava flour as food and feed [17]. There is no doubt that the market dynamics will change as more gigantic starch dependent factories and cassava gel dependent bio-energy factories are springing up in Asia and South America [10] as well as the rising number of feed factories in Latin America [10]. Now that the size of African markets for food and agricultural products has been projected to hit \$1 trillion in 2030 [18], cassava will play a significant role in defining the shape of the market because of its importance as a major staple food in the continent and its rising profile for industrial use. The World Cassava Market is currently worth over \$4.5 billion and the future market looks more inviting to investors [16]. The industrial potentials of the cassava sub-sector in sub-Saharan Africa are becoming attractive to both domestic and foreign investors [2,19]. Kuiper et al. [20] has hinted that far more than the current volume of the world cassava would be traded in the future as demand from the industrial sector increases. Evidence has shown that more of the demand pressure would come from the non-food industry as more cassava, over the years, have been sold at the international market in various forms like fresh cassava root; dry cassava chips and pellets; and starch and flour [21]. Cassava has been adjudged as an important source of carbohydrate and thus, a major food in most households' food baskets in Africa [21,10,22].

These are sufficient signals that the future demand for cassava will grow beyond the demand for its flour as food and feed. As these large and integrated cassava dependent factories are being established in Asia and America, FAO [23] has raised concerns about the sustainable supply of cassava roots for food and even industrial use. Nigeria is also not left out on the list of countries experiencing growth in cassava-based industries. This can further restructure both the production and consumption decisions of cassava farming households especially as the cassava market develops [24]. The implication this can have on people whose major source of dietary energy is cassava is better to imagine. This thought is further pricked by the fact that African farmers do not look economically prepared for this competitive global cassava market as suggested by the outlook of the present cassava production system. Therefore, as demand pressure for cassava at

the international cassava market increases, it is most likely that cassava producing countries in sub-Saharan Africa (SSA) may continue to struggle to meet domestic consumption with little or no prospect for the rural households to access imported cassava products at a competitive price for consumption. This opinion has been accentuated by the increasing bi-polarization in the world economy [25].

### **1.1 Challenges and the Prospect for Future Cassava Production in Nigeria**

There is a general concern that there has been declining food production per person in Nigeria and most countries in the SSA because the population growth rate has not been consciously put into most of the agricultural policy reforms in the sub-region [26,27,28]. The problem may be worsened with the expectation of a high population growth rate in the future in the sub-region. Therefore, the novel approach in this study is that it attempts to bring the population factor into the estimation of the future projection of the food supply. The motive is to explore the possibility of sustainably increasing supply of per capita food calorie from cassava in order to ensure sufficient food calorie is available for the growing population in the future. A country that is not sufficiently producing to meet her food needs is not only predisposed to hunger and civil unrest but it has also opened up her market to frequent shocks from exporting countries [29]. This can become worse with a huge population that is not planned for. According to the future projection of the Nigeria population, growing the rate of 2.51% annually is expected to be populated by about 263 million people in 2030 (World Bank data). In view of the growing population in Nigeria, there is a compelling need to aggressively invest more in agriculture, particularly the major staple food in Nigeria in order to be food secured. Moreso, experts have argued that investment in the agricultural (rural) sector has the potentials to foster rural development [30,21].

Despite available evidence of improved farming methods including improved agricultural production system through the development of improved cultivars, cutting edge farm management practices, and agronomic practices geared towards increasing food supply, farmers in Nigeria and other countries in SSA have not adequately embraced these modern innovations in practice. Although there has been a steady increase in agricultural output, this is still largely achieved by expanding the cropped area. The

results are very explicit in the trend of cassava production indicators for Nigeria (FAOSTAT). The harvested area has contributed, more positively than the yield, to cassava production in Nigeria [31]. However, an increasing number of scholars have argued that such agricultural production system is not sustainable for many reasons including environmental implications [32] and food insecurity implication [33]. Similarly, [34] also argued that the widespread infrastructural development that is anticipated in many high food-producing countries in SSA might constrain food production that is dependent on the continual expansion of the land area. The consensus among development economists is that there is a strong connection among land tenure situation, economic well-being, and governance [35,36].

However, the myriads of issues associated with land are increasingly creating bottlenecks against agricultural business development across countries in SSA including Nigeria. The challenges from land are multi-dimensional and are more complex in Nigeria with the intensity of rapid urbanization, increased demand for natural resources food, water, and energy insecurity; natural disasters; and violent conflicts. According to Palmer, Fricska and Wehrmann [37], these problems are becoming escalated due to unequal access to land; insecurity of tenure; unsustainable land use; weak institutions for dispute and conflict resolution, etc. Scholars have argued that the present conventional approach defined by the administrative procedure cannot sufficiently address these complex challenges anymore. In Nigeria and many other African countries, the majority of people do not have legally recognized and documented rights to land. Some of these limitations have gender, geographical and tribal dimensions [37] which may continue to affect the growth of agricultural production especially as more people are interested. Therefore, farmers should inevitably cultivate the most efficient use of land resources in order to get the best output.

Cassava, a major staple food in sub-Saharan Africa yet, is increasingly being demanded by the industry globally. In 2003, [17] estimated that about 84% (or 29 million tonnes) was available for consumption while the remaining 16% went for industrial use in Nigeria with a caveat that more proportion could go into the industrial sector in future. The recent estimates by FAO [10] have shown that only 53% of cassava is available for consumption globally while the

remaining 47% is used up by the industrial sector. Yet, the industrial demand for cassava is just gaining momentum. Should the industrial demand continue to increase without a corresponding increase in total production to sustain the proportion that is needed for consumption, it will consequently escalate the problem of hunger, especially among dominant cassava consumers. This fear is further accentuated by the assertion of [38,39] that the share of cassava post-harvest losses in Africa is about 29%. This could mean that less quantity of cassava and products will be available for consumption. Therefore, as cassava gains industrial attention globally, there is a deliberate need for consuming countries to step up efficient production strategies to promote sustainable production. All these are indicators that cassava production must take a significant leap to meet this growing demand. However, failure to achieve this will cause market instability as well as unpredictable movement in prices of cassava and its products. Consequentially, it can unsettle the household economy and throw up more social and economic instability as opined by Bellemare et al. [40], Sekhar et al. [41]. The new development in the global cassava market seems to have overwhelmed the efforts of government in the past. According to Knowledge for Development (2007), the intention of the government efforts to emplace strong competitiveness for cassava products in Nigeria and within the global context is yet to be achieved. Many indicators point to this direction; the export value from cassava, low investments on cassava, import value of cassava products still greater than export value, and many more are contained in FAOSTAT.

The above observations, which bother on food security and sustainability of cassava production in Nigeria, are the motivation for this study. Given the potential food security implication of inadequate supply of cassava products due to low yield for the generality of ardent cassava consumers, this study attempts to explore the analysis of the future trend in cassava indicators vis a vis the expected food balances with a view to providing information that can guide informed decisions and recommending appropriate policies that can also help address food supply gap. Therefore, this study will be guided by the following objectives: to determine the trend of production, harvested area and yield of cassava in Nigeria; to develop an appropriate trend model that best fit each of production, harvested area and yield of cassava respectively; to make an

annual forecast of 12-year periods of the production, harvested area and yield of cassava; and determine the future Compound Annual Growth Rate (CAGR) for each of the selected variables for cassava production in Nigeria.

## 2. DATA DESCRIPTION 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 [42]. The data were modeled and forecast made using trend models.

### 2.1 Trend Analysis

Under the assumption that there is no visible seasonal component, a trend model can be fitted for a time series [43]. This trend model can be linear, logarithmic, quadratic, power, or exponential model. The idea is to select which of the model that best describes the trend component of the series. The best trend model is selected using R-square and other measures of accuracy like Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE), and Mean Standard Error (MSE). The model with the minimum measure of accuracy is what best describes the series.

#### 2.1.1 Trend models

i. Linear Trend Model; The approach to estimating this is by using the Ordinary Least Square (OLS) model. This model is explicitly stated as:

$$Y_t = \beta_0 + \beta_1 t + \varepsilon_t \quad (1)$$

ii. Quadratic Trend Model; which accounts for a simple curve is of the form

$$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t \quad (2)$$

iii. Exponential Trend Model; accounts for exponential growth or decay. Mathematically, it is expressed as follows:

$$Y_t = \beta_0 + \beta_1^t + \varepsilon_t \quad (3)$$

Where  $Y_t$  is the predicted value of the Y variable for a selected value of period t,  $\beta_0$  stands for the

constant intercept;  $\beta_1$  is the slope of the unit periodic change in relation to Y.

### 2.1.2 The projection of balance from cassava in Nigeria

According to FAOSTAT [42], 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 [44,45]. 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 this age group (18 – 29.9 years) with a mean height of 1.70 m and a lifestyle with a mean PAL (physical activity level) of 1.75, is about 11.7 MJ (2 800 kcal)/day or 195 kJ (47 kcal)/kg/day while those within the age group (30 – 59.9 years) with a mean height of 1.70 m and a lifestyle with a mean PAL of 1.75, require about 11.4 MJ (2 750 kcal)/day or 190 kJ (46 kcal)/kg/day and for those within the age group (60 years and above) with a mean height of 1.70 m and a lifestyle with a mean PAL of 1.75, require 9.4 MJ (2 250 kcal)/day or 155 kJ (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 age group (18 -29.9 years) with a mean height of 1.70 m and a lifestyle with a mean PAL of 1.75 is about 10.1 MJ (2 400 kcal)/day or 170 kJ (40 kcal)/kg/day; for those age group (30 – 59.9 years) with a mean height of 1.70 m and a lifestyle with a mean PAL of 1.75 is about 9.8 MJ (2 350 kcal)/day or 165 kJ (39 kcal)/kg/day while for those within the age group (60 years and above) with a mean height of 1.70 m and a lifestyle with a mean PAL of 1.75 is about 8.8 MJ (2 100 kcal)/day or 145 kJ (35 kcal)/kg/day. Therefore, to obtain the per caput supply of each of cassava food available for human consumption is by dividing the respective quantity by the population. This is expressed in terms of quantity.

$$\text{Food Supply (per caput supply)} = \text{Production output (kg)/population/year}$$

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:

$$319.2 \text{ kg/capita/year} \equiv 121 \text{ Kg/Capita/Year} \equiv 267 \text{ Kcal/Capita/day} [46] \dots \quad (4)$$

Other estimates for the other years were extrapolated from the above equation.

Assumptions:

- i. That cassava products are consumed by all Nigerians (total population).
- 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.

### 2.2 Compound Annual Growth Rate (CAGR)

The compound growth rate (CAGR) was preferred to the linear growth rate (LGR) in analyzing the growth rate in the area, production and yield of cassava because according to [47,48], the LGR is not convenient for comparing two periods. After exploring the four functional forms of linear model to capture the linear trend of the series, the exponential model best fits the trend. Therefore, the compound annual growth function was specified as exponential model according to the specification of [49,50] as follows:

$$\ln Y = a + t \ln b + e \dots \quad (5)$$

Y = area (ha)/production (1000 tonnes) /yield (kg/ha)

a = Intercept

t = Year

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 exponential form of the linear trend model was adopted to estimate the compound growth rate model 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 Compound Annual Growth Rate is usually estimated using the following equation:

$$\text{CAGR} = [\text{antilog } b - 1] * 100-- \quad \text{----- (6)}$$

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 [51].

Since the growth models for the area, production, and yield of cassava do not reveal the relative contributions of area and yield towards the total output change, this paper adapted component/decomposition analysis model to achieve the relative contributions of area and yield towards change in production output. The literature is replete with evidence of how this model has been used to estimate the relative growth performance of individual output in agricultural production [52-54].

### 3. RESULTS AND DISCUSSION

#### 3.1 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 could help understand the pattern of the trend of cassava production indicators in Nigeria. During the periods under review (1961 -2018), the minimum and maximum values for cassava production output were about 7 million and 60 million tonnes in 1961 and 2018 respectively. The minimum and maximum values of yield and harvested area were found to be approximately 7 and 12 tonnes/ha in 2013 and 2010, and close to 780 thousand and 7 million hectares respectively in 1961 and 2018. This suggests a consistent upward moving trend for the values of both production and harvested area because there was no year in the series where the value of the referenced indicators fell below the value obtained in 1961. However, the pattern of yield where the least of the values were obtained in

2013 and highest in 2010 suggests some form of fluctuations. This corroborated the findings of Ikuemonisan et al. [31] on the pronounced unpredictable nature of cassava yield series during the period of reference. The average yield during the period under review was about 10 tonnes/ha. The average values for production 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 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. Scholars have argued that this approach of cultivating more land without recourse to labour and land productivity is not sustainable [34] and [32]. Thus, this has necessitated the promotion of efficient cassava production systems across developing countries [11,10].

#### 3.2 Trend Analysis of Production Indicators

Figs. 1, 2 and 3 show data obtained on cassava production output, yield and harvested area respectively. Despite the upward movement in the data of cassava production output and harvested area over the period under consideration, there were evidences of trend and cycles of fluctuations. However, the fluctuations around the mean yield was the most pronounced. These cycles were influenced by vagaries of weather, government policies, war, market shocks, research breakthrough etc. There was a sharp decline in production from 44 million tonnes in 2008 to 37 million tonnes in 2009. The period coincided with when the farmers were just getting over the shocks on global food prices that occurred mid-2008. The shocks

created an unpredictable phenomenon in the production pattern by dampening the hope for farmers to earn sufficient market incentives to produce more in 2009. Such phenomenon discouraged them from intensifying cassava cultivation either by the use of improved variety or the same or more expanse of land as they had done in 2008. Consequently, this led to a reduction in cassava production in 2009. Also at this period, there was a fall in the cassava cropped area from 4 million hectares to 3 million hectares harvested while the yield remained relatively the same (about 12 million tonnes/ha).

However, despite increased cropped area between the period between 2012 to 2013, cassava output declined from 51 million tonnes to 48 million tonnes accordingly. The yield performance also surged below the mean by declining from 8 to 7 tonnes/ha. Even to date, the yield performance has not risen above the mean yield during the periods under review. Despite the dismal yield performance, the harvested area has continued to increase at a similar trend with which production output has also been increasing. This outlook suggests that the pronounced cassava production output in Nigeria might have been accentuated by increased cropped areas rather than yield performance. In view of the rising challenges associated with land and infrastructural development, the above approach may not be sustainable. It further describes the fragility of the cassava production system, and should there be unfavourable interference from any external force like natural occurrence (weather, flood, disease or pest attack), it may affect the rising profile of Nigeria among high cassava producing countries. Besides, it may escalate hunger and poverty in the country.

### 3.3 Trend Model Selection for the Production Indicators

Table 2 reveals the selected trend models for each of the indicators: production, yield and harvested. On Figs. 1, 2 and 3, the best trend model (line equation) for each of the selected production indicators are indicated on that accordingly. Among the simulated line models, only the best fits as shown on the trend plots above were used for predicting the future trends of the indicators (production output, yield, and harvested area) (Table 3). According to R-squared and other measures of accuracy deployed for selection, the exponential trend

model was selected for cassava production output while the quadratic trend model was selected for yield and harvested area.

### 3.4 Trend Forecast

Table 3 reveals the trend forecast values of the indicators. According to the results presented on the table, there would be a consistent increase in the production output and the harvested area between the periods, 2019 and 2030. Production output is expected to rise from 67 million tonnes in 2019 to 106 million tonnes in 2030 while harvested area would rise from 6 million hectares to 10 million hectares accordingly. It should be noted that the annual trend line is estimated on the assumption that there would not be an effect of any influence that may cause both cyclical or irregular movement. This is rarely possible in agriculture where production is subjected to many influences such as innovations in the area of farm management and agronomic practices, vagaries of weather, flood, diseases and pest infestations, price, and market shocks, etc. Therefore, production is expected to rise rapidly where there are production enhancing factors like favourable policy strategies, an increase in the number of cassava farmers adopting cutting edge innovations, favourable ecophysiological factors, etc. Conversely, production may fall when there are demotivating factors like floods, unfavourable market outcomes, crop diseases, pest infestation etc. Thus, it implies that interpreting the trend line should be done with a lot of caution because it may not truly reveal the true picture of future events. At best, it gives a direction. However, this position does not underrate that Nigeria's production output could be 106 million tonnes or above.

In order to achieve such feat, more efforts have to be intensified to adopt well-integrated production system as suggested by experts and subject matter on cassava production. On the other hand, during this period under review, the yield would decline from 9 tonnes/ha (2019) to about 8 tonnes/ha (2030). This is relatively small when compared to the global average yield of cassava of about 13 tonnes per hectare [42]. Under a functional agricultural system, yield performance (land productivity) should drive production output and thus, should move in the same direction. However, there is an inverse relationship between production output (that will be increasing) and land yield (that will be declining) within the period of reference. The revelation from these findings is that increase in

cassava production in the future would depend largely on the cropped area and not necessarily through efficient utilization of factors of production (particularly land). The expected decline in yield performance in the future suggests that production outcomes may be fragile or unpredictable. These findings agree with the findings from previous studies [55,8,31]. A little shock may unsettle the cassava market and the upstream segment (farming) of the production chain. Therefore, government and other critical stakeholders should be pricked by this, and do everything to ensure farmers have access to high yield producing cassava varieties.

### 3.5 Food Supply from Cassava

Table 4 shows the trend estimates of future food supply from cassava. Based on the mapped out historical time trend of production output, forecast values for future food supply from cassava were obtained. Intuitively, this trend forecast (Table 4) could be seen to be ambitious however, the future values of food supply (Kg/Capita/Year and Kcal/Capita/day) were extrapolated using the estimates from FAO food balance sheet in Nigeria [46]. These results were explained under two scenarios of assumptions.

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

	Production	Yield	Harvestedarea
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

*Author's Computation, 2020*

**Table 2. Trend models selection for the production indicators**

Type of Trend	Equation	R-squared	MAPE	RMSE	MAE
<b>Cassava Production Output in Nigeria (Tonnes)</b>					
Linear	$y = 948476x - 3E+06$	$R^2 = 0.9028$	29.8	5170770.04	4137718.58
Quadratic	$y = 16978x^2 - 53207x + 7E+06$	$R^2 = 0.9676$	35.29	6068066.82	5391800.11
Exponential	$y = 6E+06e^{0.041x}$	$R^2 = 0.9498$	12.93	3342293.18	2560099.70
<b>Cassava Yield in Nigeria (Tonnes/ha)</b>					
Linear	$y = 0.0063x + 9.9721$	$R^2 = 0.0098$	8.25	1.04	0.82
Quadratic	$y = -0.0019x^2 + 0.1169x + 8.8656$	$R^2 = 0.2082$	6.97	0.94	0.70
Exponential	$y = 9.9754e^{0.0004x}$	$R^2 = 0.0044$	8.27	1.04	0.83
<b>Harvested Area of Cassava in Nigeria (Ha)</b>					
Linear	$y = 98617x - 379195$	$R^2 = 0.8235$	35.57	744382.22	591659.18
Quadratic	$y = 2410x^2 - 43572x + 1E+06$	$R^2 = 0.9337$	13.23	473048.37	317046.16
Exponential	$y = 596811e^{0.0405x}$	$R^2 = 0.9324$	15.45	502855.25	351523.55

*Source: Author's Computation, 2020*

### Trend Analysis of Production Indicators (Production Output, Yield and Harvested Area)

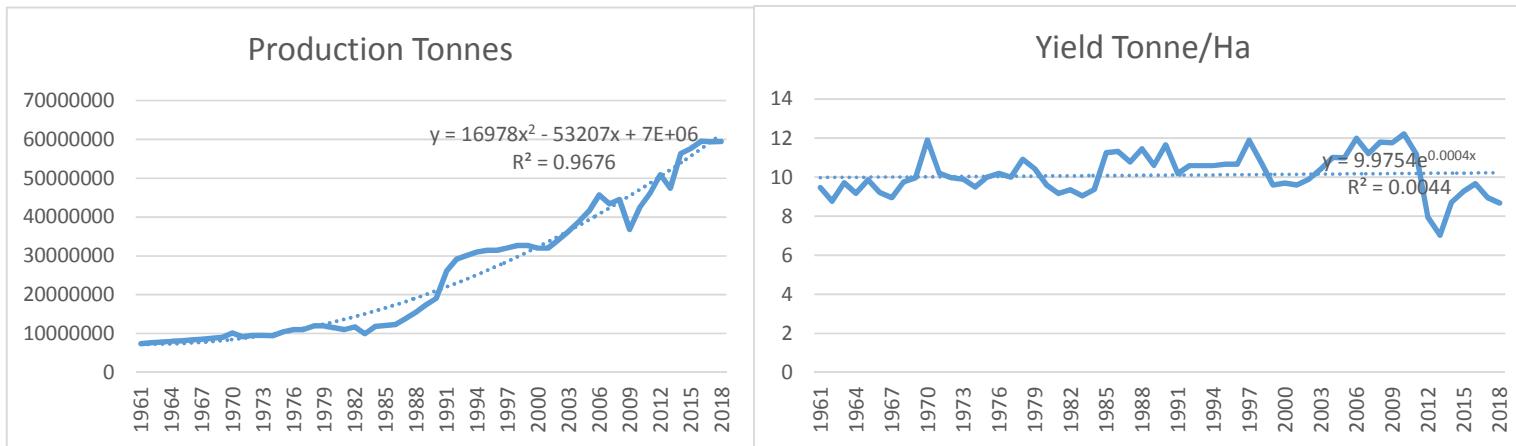


Fig. 1. Cassava production output in tonnes in Nigeria

Fig. 2. Cassava yield in tonnes/ha in Nigeria

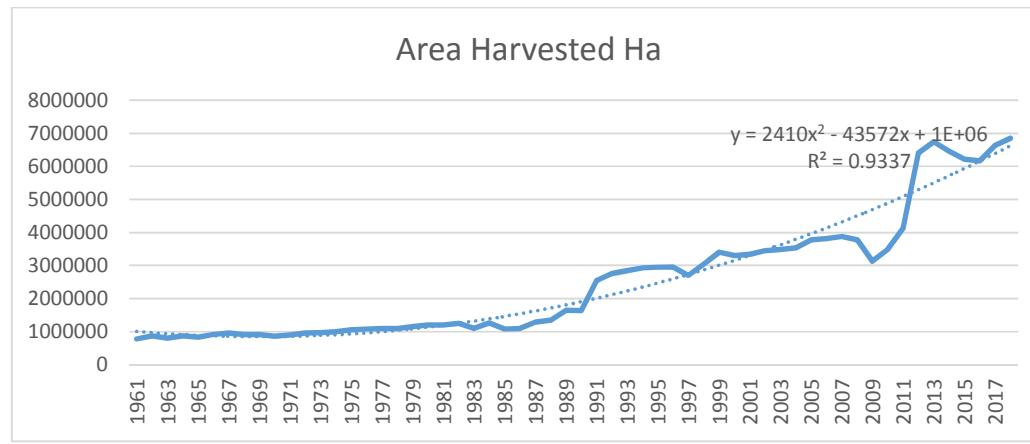


Fig. 3. Harvested area of Cassava in Nigeria

One, on the assumption that only 84% of the total cassava output supplies energy requirements, column 2 and 3 show that food supply will consistently increase from about 121Kg/capita/year and 267Kcal/capita/day (2014) to close to 152 Kg/capita/year and 336 Kcal/capita/day (2030).

Two, on the assumption that 29% of the 84% is lost during post-harvest activities, the food supply will increase from 121Kg/capita/year and 267Kcal/capita/day (2014) to close to 99 Kg/capita/year and 219 Kcal/capita/day (2025) and continues in that trend up to 108 Kg/capita/year and 239 Kcal/capita/day (2030). On the account that Nigeria is a low-income country, Scott et al. [55] gave a conservative estimation of the expected household expenditure elasticity of demand for cassava in 2020 to be about 0.2%. Therefore, if this is projected into the forecast period, it will imply that as income increases, household demand for cassava products will also increase.

On the consideration that the range of per caput daily energy requirements is given as 2100 kcal – 2 800 kcal for all population, although it could be more for those with habitual physical activities, the results obtained from this study indicate a tremendous shortfall in both scenarios explored. It further confirms hunger is highly pronounced in Nigeria.

The decline in the future food supply (in terms of energy requirements) from cassava, as observed

in Table 3, occurred because of rapid population growth. The results showed that in spite of the expected increase in cassava production from 2019 to 2030, the production growth rate may not adequately respond to or match, the nutritional needs of the increasing population in Nigeria. The findings from this study have added to the debate on the need to implement sound policy strategies on cassava production.

### 3.6 Cassava Annual Growth Rate (CAGR)

Table 5 presents the compound annual growth rate of the area, yield, and production of cassava in Nigeria between 1961 – 2030. The results showed that the values of the CAGR obtained for all the cassava production indicators were statistically significant at 1% level. Table 4 shows production and harvested area of cassava in Nigeria would continue to grow at about 9.9% and 9.8% annually. However, productivity per hectare will decline at the rate of 0.5% annually under the same farmers' attitude and agronomic practices that farmers had maintained over the years.

The results suggest that in the forecast period, cassava production will be largely dictated by the cropped/harvested areas. Couple with the fact that the present production output cannot meet the food requirements of the Nigerian population, it may be more difficult to meet future food needs if the cassava production system is not rejigged

Table 3. Trend forecast output

Year	Production Output (Tonnes)		Yield (Tonnes/ha)		Harvested Area	
	Trend Model	Exponential	Confidence Limits (95%)	Quadratic	Confidence Limits (95%)	Quadratic
2019	67407714.46	±4519400	9.1488	±1.876	6818462	±1099827.22
2020	70228869.24	±6083255	9.0396	±2.098	7061680	±1230136.46
2021	73168095.29	±7322830	8.9266	±2.300	7309718	±1348356.32
2022	76230334.13	±8383230	8.8098	±2.486	7562576	±1457432.50
2023	79420734.12	±9325780	8.6892	±2.659	7820254	±1559285.83
2024	82744659.07	±10183258	8.5648	±2.823	8082752	±1655250.93
2025	86207697.28	±10975623	8.4366	±2.978	8350070	±1746299.48
2026	89815670.92	±11716095	8.3046	±3.127	8622208	±1833164.88
2027	93574645.86	±12413966	8.1688	±3.269	8899166	±1916416.66
2028	97490941.82	±13076059	8.0292	±3.405	9180944	±1996507.54
2029	101571143.00	±13707561	7.8858	±3.538	9467542	±2073804.35
2030	105822109.20	±14312525	7.7386	±3.665	9758960	±2148609.24
Mean	85306884.53		8.478533		8244528	

Source: Author's Computation, 2020

**Table 4. Trend estimates of future food supply from cassava**

Year	Population Projection	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	
		Kg/Capita/Year	Kcal/Capita/day	Kg/Capita/Year	Kcal/Capita/day
2014	176404999	120.99*	267**	120.99*	267**
2019	200964000	127.09	280.47	90.23642	199.1332
2020	206140000	129.09	284.87	91.65242	202.258
2021	211400000	131.14	289.41	93.11235	205.4798
2022	216750000	133.26	294.08	94.61484	208.7954
2023	222180000	135.44	298.90	96.16554	212.2175
2024	227710000	137.69	303.84	97.75712	215.7298
2025	233340000	139.99	308.92	99.39107	219.3356
2026	239070000	147.92	326.43	105.0226	231.7632
2027	244900000	144.78	319.49	102.7921	226.8411
2028	250830000	147.27	324.99	104.5623	230.7475
2029	256860000	149.83	330.64	106.3811	234.7611
2030	262980000	152.47	336.47	108.2541	238.8944

Source: Author's Computation, 2020. (\* and \*\* FAO forecast of Kg/Capita/Year and Kcal/Capita/day respectively)

**Table 5. Compound annual growth rate of area, yield & production of cassava in Nigeria (1961 – 2030)**

	Area (Ha)	Yield (Tonne/Ha)	Production (Tonne)
CAGR	9.787841	-0.45065	9.922166
R-Squared	0.960235	0.226823	0.971012
P-Value	2.37E-49	3.08E-05	5.08E-54

Source: Author's Computation, 2020

Therefore, it is important for government and other stakeholders in cassava production and market system to work together with a view to increasing cassava production far beyond these forecast values.

#### 4. SUMMARY, CONCLUSION AND RECOMMENDATION

This study examined among others the historical trend in and forecast 12-year periods of cassava production indicators in Nigeria. Relying on the selection criteria and measures of accuracy suitable for selecting trend models, the quadratic trend model was selected to fit harvested area and yield of cassava series for the analyzed period while the exponential equation was deployed for production series. The average of the trend forecasts for 12-year periods for production (about 85 million tonnes) was found to be 69% higher than the previous 12-year period of the analyzed period (50 million tonnes). For yield, the average of the trend forecast (8.5 tonnes/ha) was found to be -15% lower than the equivalence in the analyzed period (9.9 tonnes/ha). Similarly, the harvested area (8 million ha) was found to be 54% higher than its

equivalence in the analyzed period (5 million ha). On the assumption that 29% of the 84% is lost during post-harvest activities, the food supply will decrease from 121Kg/capita/year and 267Kcal/capita/day (2014) to close to 99 Kg/capita/year and 219 Kcal/capita/day (2025) and continues in that downward trend up to 108 Kg/capita/year and 239 Kcal/capita/day (2030). 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 (9.8%) and production series (9.9%) but conversely, the yield series would experience a declining growth rate (-0.5%) in between 1961 and 2030.

In conclusion, there is tough time ahead for consumers of cassava products. the study found that cassava production output would increase from 67 million tonnes in 2019 to 106 million tonnes in 2030. In the same period, yield would decline from 9.1 tonnes to 7.7 tonnes/ha (yield) and cropped area would increase from 6.8 hectares to 9.6 million hectares. O the contrary, in the same period, the food supply per caput from the expected production output would decline from 267 Kcal/capita/day (2019) to 239

Kcal/capita/day (2030). Although in arriving at the conclusion, the study assumed the future demand of the growing cassava-based industries would be constant but it is certain that the industrial demand for cassava would rise in the future. Experts have argued that the growing cassava-based industries globally is expected to hugely influence the future cassava market dynamics with more pressure on the exports of cassava to Asia. The study also found that the future increase in cassava production output will largely depend on increase in the cropped area. In line with the concerns of experts, such approach of increasing cassava production output by solely increasing cropped area is not sustainable.

Therefore, one, the study recommends that there should be a thorough investigation on the future total demand for cassava, particularly, the demand by the growing domestic cassava-based industries and the share of exports from Nigeria in addition to household consumption. This will help in determining the total demand for cassava in Nigeria ahead of 2030 with a view to arresting any disruption to future cassava market that can compromise sustainable supply of cassava products and food security.

Two, the study recommends that an increase in the national awareness on the increasing market value of cassava and its products and a robustly developed off-taking strategy to avoid market glut can attract young graduates into either the farm production (up-stream segment) or post farm production (mid-stream segment). This will give a double edge outcome: it will create employment for the youths who are willing to embrace cultivation of cassava and also increase the foreign earning on agricultural exports for Nigeria.

In addition, an intensified campaign on cassava education using well trained specialized farm extension workers distributed across cassava planting regions in Nigeria. The training of this category of extension workers should focus more on acquiring knowledge of modern cassava production systems geared towards yield performance based on best agronomic practices required for efficient cassava production and effective farm management including cultivation of improved varieties. Disseminating such information to farmers and making high yield producing cassava cultivars available to them; and teaching cassava processors how to reduce post-harvest losses are ways to improve yield

performance. Above all, some measurable and trackable indicators need to be developed for all stakeholders (farm extension workers, financing agent, cassava farmers, cassava cooperative society, Ministry of Agriculture, etc) in the cassava subsector.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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