



## ECONOMETRIC TRENDS ANALYSIS OF COWPEA AREA AND PRODUCTIVITY IN NIGERIA FROM 2006 - 2018

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### ABSTRACT

The study examined the trends over the years of cowpea cropped area, output and yield per hectare. Time series data of cowpea area and production in Nigeria (2006 – 2018) obtained from the Central Bank of Nigeria annual bulletins were used for the study. Data were analyzed using three trend models; linear, quadratic and exponential growth models which were fitted and the exponential growth models were selected on econometric basis in the analysis. The result of the exponential model showed positive compound growth trends in area (0.031) and output (0.039), but with negative growth trend of -0.008 for the yield/ha analysis. The doubling times for the growth rates were estimated at 17 and 14 years to double the growth rates in cowpea cropped area and output. Result of the growth pattern disclosed that there was deceleration in the growth of cowpea cropped area, output and yield/ha for the period under consideration. It was concluded that that the marginal compound growth rates in cowpea area, output and yield/ha resulted in actual retardation in cowpea production. The study recommended that the trend results can be reversed by land improvement mechanisms that will increase the yield/ha, and the incorporation best practices like Purdue Improved Cowpea Storage (PICS) to achieve the dual objectives of increased production and market successes.

**Keywords:** Area, Cowpea, Productivity, Time trend models, Trend analysis.

### INTRODUCTION

Cowpea is the most consumed legume crop in Nigeria. However, cowpea production in Nigeria is heralded with great potentials and challenges (Onimawo, 2010; FAO, 2014; and Manda *et al.* 2020). Cowpea, *Vigna unguiculata* (L) Walp), otherwise known as beans is the most economically important indigenous African legume crop (Langyintuo *et al.*, 2003). It is the most important grain legume, and the 4<sup>th</sup> most consumed crop after cassava, yam and rice in Nigeria (Ajeigbe *et al.*, 2010; and IITA, 2019). In recent times, an enormous demand for cowpea has been created by a dense population and is expected to increase because, cowpea form a major diet for the average households who cannot afford the relatively more expensive animal proteins. This increased demand is fueled by a key driving factor of the high-quality protein that cowpea offers for both human and animal consumption (Daryanto *et al.*, 2015). Cowpea plays important roles in providing food, fodder, soil nitrogen to cereal crops when grown in rotation, especially in areas where poor soil fertility is a problem. It contains about 23–25% protein by weight and the dried cowpea foliage when cut and store for sale, can increase farmers' income by 25% at the peak of the dry season in Nigeria (Dugje *et al.*, 2009). In fact, Abbey (2006) recommended cowpea as a veritable solution to bridging the gap in protein need.

Nigeria is blessed with tremendous agro-ecological potentials for cowpea production. Ranking highest as world's producer of cowpea, Nigeria accounts for about 61% of the global production, and 1/3 of the 12 million hectares devoted for cowpea production in sub-Saharan



Africa (Food and Agriculture Organization [FAO], 2016; and Cumulative Group for International Agricultural Research [CGIAR], 2017). Paradoxically, Nigeria is also known as the largest consumer of cowpea and with negligible export quota in the world (Manda *et al.*, 2019). In Nigeria, cowpea is produced under rain fed conditions and it performs well in agroecological zones where the rainfall range is between 500 and 1200 mm/year (Dugje *et al.*, 2009). According to Olomola and Nwafor (2018), cowpea production in Nigeria shows wide annual fluctuations in growth pattern during the 2010 – 2015 periods with 2015 production level being lower than that of 2010. Similarly, output growth averaged 50.6% in the 2011/2013 period but reduced to -23% in the 2014/2015 period with output level of beans been higher in 2010 than in 2015, an indication of high volatility in beans output level.

According to the new policy thrust of Nigeria, the Agricultural Promotion Policy (APP), Nigeria is faced with two key gaps: an inability to meet domestic food requirements, and an inability to export at quality levels required for market success (Federal Ministry of Agriculture [FMARD], 2016). These challenges have their root in the inefficient input system and farming models (productivity challenge), as well as the inefficient system for setting enforcing food quality standards (market challenge. The problem of low productivity in the sector is attributed to several factors including insufficient and inefficient extension services, low level of adoption of improved seeds, poor quality inputs and inefficient input distribution system, ineffective and inadequate mechanization and irrigation facilities, poor access to credit, poorly managed soil fertility profile and aging farm population. The inability of the agricultural sector to meet the target production has spurred the Malabo's declaration for the targeted yield/productivity growth for 2015 – 2025 of 7% per annum and doubling the productivity during the period is considered a much less ambitious target.

The resultant consequence of the low agricultural productivity is manifested in the growing phenomenon of poor nutrition mostly in the aspect of protein intake in Nigeria (Adekunmi *et al.*, 2017). Like many other developing countries, Nigeria is faced with a worsening situation of inadequate protein consumption, resulting in widespread malnutrition due to the decline in protein intake occasioned by the scarcity and unaffordable price of animal protein food sources such as milk, egg, meat and fish (Obasi, 2003; and Adekunmi *et al.*, 2017). Efforts to bring the agricultural sector on a path of growth require actions to produce enough fresh, high quality foods, and to serve the export market in a successful and sustainable manner to earn foreign exchange. To this effect, the federal government has prioritized the improvement of cowpea production and other domestically focused crops for home consumption and export markets. In a similar vein, the introduction of genetically modified cowpea in 2019 under the approval of Nigerian Biosafety Management Agency was also seen as efforts to increase cowpea productivity (IITA, 2019). Therefore, an assessment of the trends in cowpea production (area, output and yield/ha) is relevant and timely in order to avert the pitfalls that led to declined productivity or improvement on the production innovations for sustainable growth. Thus, understanding the trend of cowpea production has enormous policy implications. Nonetheless, the trends in cowpea area, production and yield/ha will serve as possible indicators to the actualization of the country's mandate on cowpea production. The objective of the study was to determine the trend of cowpea area, production and yield/ha in Nigeria using the econometric approach.



## MATERIALS AND METHODS

### Sampling Techniques

The study was conducted using time series data of cowpea area and production in Nigeria from 2006 and 2018 (12 years) of cowpea production. The data (secondary) were collected from various issues of Central Bank of Nigeria annual bulletins (CBN, 2006 and 2018).

### Data Analytic Techniques

Data analysis was achieved through the use of time trend models such linear trend model, quadratic trend model and exponential growth model were modeled and analyzed using IBM 23 Statistical Software. Empirically, the models were expressed as follows:

1. Linear Trend Model:

$$Y_t = \alpha + \beta t + \mu_t \quad \dots (1)$$

2. Exponential Growth Model:

$$Y_t = \alpha e^{\beta t} \quad \dots (2)$$

In linearizing the model, the natural logarithm of both sides of the equation was taken to enable it conform to ordinary least square regression as:

$$\ln Y_t = \alpha + \beta t + \mu_t \quad \dots (3)$$

where;

$Y_t$  = Crop variable: production in metric tonnes), area cultivated (ha) and yield (kg/ha),

$\alpha$  = constant term,

$\beta$  = trend coefficient,

t = time trend variable for 10 years, 2008 – 2018 and

$\mu_t$  = error term.

3. Quadratic Trend Model:

To determine whether there is acceleration, deceleration or constant trend in the growth (production) of cowpea, the quadratic trend equation was used and fitted as follows;

$$\ln Y_t = \alpha + \beta t + \gamma t^2 + \mu_t \quad \dots (4)$$

where;

path in the dependent variable ( $Y_t$ ) and

$\gamma$  = Coefficient of the quadratic time variable while other variables are as defined above. The magnitude of  $\gamma$  allows for the possibility of determining the pattern of growth of the crops (cowpea). According to Sawant (1983), Ghosh (2010) and Nmadu *et al.* (2015), the value of  $\gamma$  imply the followings:

1. If  $\gamma > 0$  or positive and it is statistically significant, there is acceleration in growth of the crops;
2. If  $\gamma < 0$  or negative and it is statistically significant, then there is deceleration in the growth; and
3. If  $\gamma$  is positive or negative, but is not statistically significant, then there is stagnation in growth of cowpea.

To determine the compound growth rates for cowpea and groundnut, the coefficient of the linear time variable in equ. (3) was used and the growth rate computed according to Sawant (1983; and Nmadu *et al.*, 2015) as follows:

$$R = (e^{\beta_1} - 1) \times 100 \quad \dots (5)$$

where;

R = compound rate in the growth of cowpea and groundnut, respectively;

e = Euler's exponential constant (2.71828); and

$\beta$  = estimated coefficient of the linear time variable from the exponential model in equ. 2.



The doubling time (the number of years it will take to double the rate of growth of the crops was computed based on Nmadu *et al.* (2015) as follows:

$$D_T = \frac{54.5}{R} \quad \dots (6)$$

where;

$D_T$  = the doubling time (years);

R = Compound growth rate;

54.5 = the average lifespan or expectancy of an average Nigerian as estimated by World Population Review (2019).

### RESULTS AND DISCUSSION

A diagnostic measure was used to select the model with best fit based on econometric criteria. In this regard, the magnitudes of the Sum Square of Regression (SSR) in different regression equations were checked and the one with the minimum Error Sum of Square (ESS) was chosen. Out of the three models: linear trend model, quadratic trend model and exponential growth model used, the exponential growth model was best fitted for trend analysis of cowpea area and productivity in Nigeria based on its smaller value of ESS (Table 1 - 3).

**Table 1:** Comparison and Selection Criteria of the Best Fitted Model for Cowpea Area in Nigeria

Model	R <sup>2</sup>	$\bar{R}^2$	ESS	$\beta$	$\Gamma$
Linear	0.976	0.974	2.617	0.988 ***	
Quadratic	0.990	0.988	2.617	1.485***	-0.511***)
Exponential	0.967	0.964	0.182	9.190***	

\*\*\* indicates significant at 1%.

**Table 2:** Comparison and Selection Criteria of the Best Fitted Model for Cowpea Production in Nigeria

Model	R <sup>2</sup>	$\bar{R}^2$	ESS	$\beta$	$\Gamma$
Linear	0.889	0.879	1.243	1.485 ***	
Quadratic	0.968	0.961	1.243	2.130 ***	-1.220 ***
Exponential	0.877	0.886	0.317	0.937***	

\*\*\* indicates significant at 1%.

**Table 3:** Comparison and Selection Criteria of the Best Fitted Model for Cowpea Yield per Hectare in Nigeria

Model	R <sup>2</sup>	$\bar{R}^2$	SSE	$\beta$	$\Gamma$
Linear	0.383	0.327	8441.028	0.619 **	
Quadratic	0.798	0.758	8441.028	3.339 ***	-2.796 ***
Exponential	0.384	0.327	0.030	0.619**	

\*\* and \*\*\* indicate significant at 5 and 1%, respectively.

The use of ESS in the Table 1-3 indicates the differences between the *predicted* value (area in ha, output in kg and yield/ha) and the mean of the dependent variable (time in years) as shown by ESS values of 0.182, 0.317 and 0.030 as measure of goodness of fit reflect how the regression model captures all the observed time variability for area, output and yield/ha, respectively. This implies that time trend variable accurately



explained the variation in the area of cowpea under cultivation, output and yield per hectare, respectively. This result is validated by the findings of Abid *et al.* (2018) and Nmadu *et al.* (2015).

**Exponential Growth Model for the Trend Cowpea Area and Production**

The results of the exponential growth equations of cowpea area and production (output and yield/ha) in Nigeria during 2006 – 2018 were presented in Table 4. The adjusted R<sup>2</sup> values were 0.964, 0.866 and 0.327 for area, output and yield/ha of cowpea, respectively. These statistics indicate that time trend as a variable was critical factor, accounting for 96.4, 86.6 and 32.7% variability in the area, output and yield/ha of cowpea, respectively. The result for yield/ha however, suggests high level of instability in yield/ha as compared to area and output. The results show that the area and output of cowpea exhibited positive trends in the entire period under consideration. The yield/ha analysis however, showed negative trend in growth. During the period under investigation, the coefficient of the trend variable (time) was significantly different from zero at 1% for cowpea acreage and output and also significant at 5% for yield/ha. By implication, the estimated growth rate models will lead to a corresponding increase in area, output and yield/ha by 0.031 and 0.039, respectively to a unit increase in time. This indicates that for each passing year, there could be an increase of 0.031 and 0.039 in area devoted for cowpea production and output of cowpea, respectively. This result is in conformity with the finding of Akibode (2011) who reported similar trends in Sub-Saharan Africa.

**Table 4:** Exponential Coefficients for Area under Cultivation, Output and Yield/ha of Cowpea in Nigeria

Variables	Area		Output		Yield/ha	
	Coeff. (β)	t-value	Coeff. (β)	t-value	Coeff. (β)	t-value
Constant	9.190*** (0.0014)	668.21	8.507*** (0.035)	355.756	7.591*** (0.024)	312.97
Linear time (t)	0.031*** (0.002)	17.95	0.039*** (0.004)	12.438	-0.008** (0.003)	-2.62
R <sup>2</sup>	0.967		0.877		0.384	
$\bar{R}^2$	0.964		0.866		0.327	

\*\*\* and \*\* Indicate the level of significance at 1 and 5%, respectively.

Source: Source: Field survey, 2019

Conversely, an increase in time (a year) leads to a significant decrease in yield/ha of cowpea by a magnitude of 0.008. The estimates of instantaneous growth in cowpea parameters (area, output and yield/ha), show the growth rates of 3.1, 3.9 and -0.8% for area, output and yield/ha per annum, respectively. Thus, it can be inferred that, there were increase in area and output of cowpea by 3.1 and 3.9% per annum, respectively. This result shows that the growth rates were complimentary; as the area under cultivation increased, there was instantaneous increase in output, and not necessarily as a result of improvement in agronomical practices nor technological advancement in cowpea production. This is indicative in the instantaneous growth rate of 0.8% decrease per annum in yield/ha for the period (2006-2018). This result is in consonance with the assertions of Akibode (2011) and FAO (2014) who averred decreasing trend in cowpea yield/ha in SSA. This can be inferred that, the increase in output of cowpea occurred primarily as a result of increased area devoted for cowpea production.





### **Compound Growth Rates of Cowpea production**

The result in Table 5 shows that the compound growth rate for area of cowpea cultivated as derived from the exponential time trend coefficient ( $\beta_1$ ) and equation 5 were 3.148% for area cultivated, which is translated literally to 3.9770% growth rate in the total output for the period under consideration. This implies that there has been relatively slow process of increase in both the area cultivated and the total output of cowpea between 2006 and 2018. This result conforms to the assertion of Olomola and Nwafor (2018) that cowpea production exhibited wide fluctuation in growth pattern especially; between the year 2010 and 2015. This marginal increase could be attributed to the natural inclinations that the core producing states have for cowpea production and the mere expansion of cultivatable areas to keep the producing states afloat in cowpea production. Since the increase in total output is directly attributed to the marginal increase in the area under cultivation, it then portends that process of growth could be enhanced through devotion of more land to cowpea production and inclusion of more states with ecological characteristics that support cowpea production.

The growth rate for the yield/ha however showed negative growth rate (-1.7867%). This result indicates that there has been a decline in the yield of cowpea on hectare basis since 2006. This result also shows that the increase in total output that was earlier recorded was mainly as a result of increase in area under cultivation without any correlation with yield/ha. This is could be as a result of the use of outdated farming technologies and poor management practices that are kin with the Nigeria's agricultural sector, the position that has been maintained by Agwu (2004) and FAO (2014). However, this decline could be reverted through investment in improved farming practices especially in seed technologies, soil fertility management and capacity building of cowpea farmers.

The results in Table 5 further show the time it will take to double the growth rate of area devoted for cowpea production, total output and the yield/ha. The results showed a doubling time of 17.309 and 13.704 years to double the growth rate of area devoted for cowpea cultivation and total output of cowpea. This implies that it will take approximately 17 and 14 years each, that is by the year 2032 and 2036, respectively, to double the growth rate of cowpea output and area cultivated going by the present production trends. This result is at variance with the Malabo's declaration of doubling the growth in agricultural productivity by the year 2025 (African Union Commission, 2014). These rates thus, need to be improved drastically in order to reduce the long doubling times. This could be done through increasing and enriching the soil fertility of the area devoted for cowpea production as well as improvement in the total yield of cowpea through the incorporation of improved agricultural practices. The result also revealed that it will take about 68 years to double the rate of decrease in the yield of cowpea per hectare based on the current production trend. This suggests that the decline in yield/ha was marginal but indicative of the poor agronomic practices and management. To address this decline, high yielding cowpea cultivars such as Sample 11 and 12 that have 80% advantage over local varieties (Buhari, 2017) should be introduced to replace the existing varieties and other agronomic practices such as appropriate site selection and pest management should be enhanced. This could be achieved through capacity building and sensitization of local farmers in the producing areas on the best practices of cowpea production such as integrated pest management to mitigate losses.



**Table 5:** Compound Growth Rate and Doubling Time in Cowpea Production

Variable	Area	Output	Yield/ha
Growth Rate (%)	3.1485	3.9770	- 0.7967
Doubling time(years)	17.309	13.7038	- 68.416

Source: Field survey, 2019

**Pattern of Growth in Cowpea Production in Nigeria**

The results in Table 6 show the pattern of growth using the coefficients of the quadratic time variable  $t^2$  in equation (4). This was used to investigate the existence of acceleration, deceleration or stagnation in the growth of area under cultivation, output and yield/ha of cowpea production for the period under consideration. The Result showed that the coefficients ( $\gamma$ ) of the quadratic time variable ( $t^2$ ) were negative (-0.002, -0.004 and -0.003), and statistically significant ( $p < 0.01$ ) for area, output and yield/ha, respectively. This implies that there was deceleration in the pattern of annual growth of cowpea cropped area, output and yield/ha for the period under investigation. These results connote that cowpea production (in cropped area, output and yield/ha) actually showed retarded growth over the period in spite of the marginal increase in area and output earlier observed. This result is in agreement with the findings of Ajeigbe *et al.* (2010) who averred that cowpea production in Nigeria is heralded with myriad problems of insect and *striga* infestation, drought and low soil fertility and poor infrastructural development that thwart the growth of it production. The retarded growth in cowpea production variables could be attributed to intense pressure on available farmland due to population increase and competition for non-agricultural purposes that constrained land expansion.

**Table 6:** Quadratic Coefficients for Cowpea Production in Nigeria

Variables	Area		Output		Yield/ha	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
Constant	9.137*** (0.011)	804.84	8.364*** (0.024)	355.756	6.135*** (0.023)	261.308
Linear time (t)	0.052*** (0.004)	14.07	0.096*** (0.008)	12.438	0.044*** (0.008)	5.651
Quadratic time ( $t^2$ )	-0.002*** (000)	-5.89	-0.004*** (0.001)	-7.580	-0.003*** (0.001)	-4.743
$R^2$		0.993		0.982		0.810
$\frac{-2}{R}$		0.991		0.978		0.772

\*\*\* indicates level of significance at 1%

Source: Field survey, 2019

**CONCLUSION AND RECOMMENDATIONS**

The study showed that the use of exponential trend model was ideal model for the analysis of the trends in cowpea area, output and yield/ha in Nigeria. Based on the results of the study, it was concluded that the marginal compound growth rates in cowpea area and output were not sufficient indicators of growth that would require too long a time of 17 and 14 years, to double. In addition, the yield/ha analysis trended negatively, requiring rather a longer time of 68 years to effect a positive impact of the trend. These indicators thus depicted a decelerated



growth pattern in all the parameters of cowpea production in Nigeria within the period under survey. It was recommended that:

1. Since cowpea area and output have shown potentials for increase, concerted efforts should be made to boost cowpea production by devoting more area for its production.
2. However, increased production without measures to control the post-harvest losses and quality control may avail little.
3. Therefore, promotion of agricultural best practices such as Purdue Improved Cowpea Storage (PICS) and adoption of pod borer-resistant cowpea varieties approved by Nigeria Biosafety Management Agency should be promoted to achieve the dual objectives of increased production and market successes.
4. In addition, the declined yield per hectare could be reversed by investing in good agricultural practices and in cowpea cultivars that have proven potentials to return greater yield per ha.

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