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Analysis of Trend, Growth, and Instability Index in Output, Harvested Area, and Yield of Oil Palm Fruit in Nigeria

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ABSTRACT
The research examined the trend, growth rate, and instability index related to the output, harvested area, and yield of oil palm fruit in Nigeria. Utilizing secondary data sourced from the Food and Agricultural Organization (FAO) covering the period from 1961 to 2022, the study revealed inconsistent patterns in the trend of output, harvested area, and yield of oil palm fruit across the specified timeframes. The compound growth rates identified were 1.11% for output, 1.03% for harvested area, and 0.08% for yield. The Cuddy-Della Valle instability index (CDI) and the Coppock Instability Index (COI) were calculated at 13.87 and 46.57 for output, 13.87 and 46.02 for harvested area, and 2.52 and 37.88 for yield, respectively. These instability indices were relatively low, indicating limited activity within the oil palm fruit sub-sector in Nigeria. A decomposition analysis of the total effect of the output showed that the area effect accounted for 94.20%, the yield effect for 3.19%, and the interactive effect for 2.61%. The findings indicate that the area effect is the predominant factor driving the growth of oil palm fruit production in Nigeria. Consequently, it is recommended that various programs such as; small grower schemes, oil palm farmers' cooperatives, and off-takers scheme be implemented within the sub-sector to stimulate increased activities, production, and yield. Also, the oil palm fruit farmers should be provided with quality seeds and financial resources in addition to broadening research efforts aimed at developing high-yield varieties.

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Nijerya'da Yağ Palmiyesi Meyvesinin Üretim, Hasat Alanı ve Verimindeki Eğilim, Büyüme ve Istikrarsızlık Indeksinin Analizi.

ÖZET
Araştırmada, Nijerya'daki yağ palmiyesi meyvesinin çıktısı, hasat alanı ve verimi ile ilgili eğilim, büyüme oranı ve istikrarsızlık endeksi incelenmiştir. Gıda ve Tarım Örgütü'nden (FAO) alınan ve 1961-2022 dönemini kapsayan ikincil veriler kullanılarak yapılan çalışma, belirtilen zaman dilimleri boyunca yağ palmiyesi meyvesinin çıktısı, hasat alanı ve verimi eğiliminde tutarsız kalıplar ortaya koymuştur. Belirlenen bileşik büyüme oranları çıktı için %1.11, hasat alanı için %1.03 ve verim için %0.08'dir. Cuddy-Della Valle istikrarsızlık endeksi (CDI) ve Coppock İstikrarsızlık Endeksi (COI) sırasıyla çıktı için 13.87 ve 46.57, hasat alanı için 13.87 ve 46.02 ve verim için 2.52 ve 37.88 olarak hesaplanmıştır. Bu istikrarsızlık endeksleri nispeten düşük olup, Nijerya'daki yağ palmiyesi meyvesi alt sektöründe sınırlı faaliyet olduğunu göstermektedir. Çıktının toplam etkisinin ayrıştırma analizi, alan etkisinin %94.20, verim etkisinin %3.19 ve etkileşimli etkinin %2.61 olduğunu gösterdi. Bulgular, alan etkisinin Nijerya'da yağ palmiyesi meyvesi üretiminin büyümesini yönlendiren baskın faktör olduğunu göstermektedir. Sonuç olarak, artan faaliyetleri, üretimi ve verimi teşvik etmek için alt sektörde küçük yetiştirici planı, yağ palmiyesi çiftçileri kooperatifi, alıcı planı gibi çeşitli programların uygulanması önerilmektedir. Ayrıca, yağ palmiyesi meyvesi üreticilerine, yüksek verimli çeşitlerin geliştirilmesine yönelik

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araştırma çalışmalarının artırılmasının yanı sıra, kaliteli tohum temini ve finansal kaynakların sağlanması da önemlidir.

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INTRODUCTION

The oil palm tree *(Elaeis guineensis)* is one of the major cash crops in southern Nigeria (PIND, 2011; Patrick et al., 2013; Ojo et al., 2017; Akpan et al., 2020). During the pre-independent era, the country contributed nearly 50% of the global palm oil exports. By the mid-1960s, Nigeria commanded approximately 43% of the global market share of palm oil (PIND, 2011). However, the prominence of Nigeria in palm oil production diminished as Indonesia, Malaysia and Thailand emerged as leaders, largely due to Nigeria's increased emphasis on crude oil extraction (Olufemi, 2015; Busari et al., 2022). Currently, Nigeria ranks fifth in global palm oil production, generating about 1.50 million metric tons annually, which constituted about 2% of the total global output in 2023 (FAO, 2024). Despite Nigeria's fluctuating oil palm fruit production, the sub-sector's importance is growing due to its role in job creation, industrialization, and rural income generation (Akpan et al., 2019; Udoka et al., 2019). The oil palm crop produces various derivatives, with palm oil being the most widely used and a staple in many Nigerian diets. The palm oil is rich in carotenoids, vitamins, tocopherols, fatty acids, vitamin E, and emulsifiers among others (Gonzalez-Diaz and García-Núñez, 2021).

The demand for oil palm fruit and its derivatives in Nigeria has shown a consistent rise over the years. For instance, the domestic consumption of palm oil, primarily for food purposes, was recorded at 1.65 million metric tons in 2020, increasing to 1.71 million metric tons in 2021 (USDA, 2022). In contrast, domestic production has been inconsistent and fallen short of demand with about 1.275 million metric tons in 2020 and 1.400 million metric tons in 2021, resulting in supply deficits of 0.375 million metric tons and 0.310 million metric tons for the respective years (USDA, 2022). These supply shortfalls have led to an increased demand for imports, which poses significant financial challenges for the nation's economy. Should this trend persist without suitable interventions, it could lead to the neglect of other sectors, exacerbating more, the poverty crisis in Nigeria (Abbas et al., 2018, Ephraim et al., 2022). Presently, with a population exceeding 200 million, the demand is anticipated to grow alongside the ongoing supply deficiencies. The USDA (2022) reports that Nigeria is the largest consumer of palm oil in Africa, with an annual consumption of 1.79 million metric tons, followed by Egypt at 1.225 million metric tons in 2022. In 2020, the production of oils and fats in Sub-Saharan Africa reached 6 million metric tons, while domestic consumption was 11.2 million metric tons, resulting in an import requirement of 7.4 million metric tons (USDA, 2022). Furthermore, a report from 2019 indicated that Nigeria's total consumption of fats and oils had risen to approximately 3 million metric tons, with palm oil accounting for 44.7% of this figure (PWC, 2019).

The Nigerian government has initiated various strategies aimed at revitalizing the declining fortunes of oil palm fruit production, which is primarily dominated by smallholder farmers (Patrick et al., 2013, Udoka et al., 2019; Akpan et al., 2019). These interventions have included import restrictions, financial support for stakeholders, and infrastructural enhancements, among other measures. Notably, in 2015, the Federal Government (FG) prohibited the importation of palm kernel and palm oil products to boost domestic production (CBN, 2015). In 2019, the FG implemented a closure of its land borders to enforce the ban on imported palm oil derivatives. Furthermore, approximately ₦30 billion was allocated as loans to oil palm farmers to improve their productivity. The CBN also introduced the Anchored Borrower Program (ABP) in 2015, aimed at providing indirect financial assistance to small-scale oil palm farmers to enhance overall production. In 2020, the CBN allocated ₦34.3 billion to significant palm oil enterprises with the goal of expanding cultivated land from 20,000 hectares in 2020 to 100,000 hectares by 2025, thereby increasing production and creating employment opportunities for the youth. Despite these efforts, the anticipated results have not materialized, as Nigeria's prominent position in the global oil palm fruit and derivative market remains elusive. The annual growth rate of output continues to be marginal (FAO, 2024). In 2019, major palm oil companies listed on the Nigerian Stock Exchange (NSE) reported a decline in revenue. Additionally, global market dynamics have hindered the FG's objectives to enhance oil palm fruit and derivative production. For instance, the average price of crude palm oil fell from US$751 per metric ton in 2017 to US$601 per metric ton in 2019, representing a decline of 19.97% (Vanguard, 2020).

The implementation of various intervention programs within the sub-sector, coupled with the influence of external factors, has created a pressing need to examine the trends and characteristics of instability in the production, yields, and harvested areas of oil palm fruit in the country. While the imperative to enhance oil palm fruit

production, yields, and harvested areas is clear due to their significant role in the nation's economic development, the associated instability in these variables may lead to several detrimental consequences. For example, such instability can discourage investment in oil palm fruit production due to the perceived risks and increasing uncertainties. Furthermore, the income of farmers and their ability to make optimal farming decisions are adversely affected by rising instability in output, yield, and cultivated land. Additionally, fluctuations in farm output and yield can disrupt price stability, influence consumer preferences, and impact the purchasing power of low-income households (Akpan, 2012, Akpan et al., 2012a; Akpan et al 2012b, Akpan et al 2012c).

As noted by Abu and Adakole (2017), Ikuemonisan et al. (2023), and Antia-Obong et al. (2024), various arable crops in Nigeria have showed differing levels of compound growth rates and instability in output, harvested area, and yields across the different time frames. This underscores the significance of the time component in crop production and yields, alongside the inherent instability within the agricultural sector. The production decomposition analyses conducted by Abu and Adakole (2017) and Ikuemonisan et al. (2020) for some arable crops in Nigeria yielded mixed results, highlighting the importance of area, yields, and their interaction effects on the variability of crop output. A comprehensive examination of the data concerning oil palm fruit is particularly timely, given the critical importance of food security for the Nigerian population. While some researchers (Akpan, 2019; Akpan et al., 2024) have reported a positive compound growth rate in oil palm fruit and its derivatives production in Nigeria, such findings are insufficient and necessitate updates to accurately reflect the current circumstances.

As asserted by Akpan et al 2012b, Akpan et al 2012c and Rani et al., (2021), the fluctuations in agricultural production, arable land, and crop yields are increasingly influenced by a multitude of factors, including rising farm insecurity, banditry, terrorism, conflicts between herdsmen and farmers, erratic rainfall patterns, inadequate irrigation, a surge in natural disasters, and corrupt agricultural policies, among others. It is evident that instability is a prevalent issue within the agricultural systems of numerous developing nations, including Nigeria. Given that agricultural practices remain largely reliant on natural conditions, such as weather, it is reasonable to conclude that farm outputs, the extent of harvested land, and crop yields will continue to experience significant variability over time. Understanding the true nature of growth rates and the levels of instability in the production, harvested area, and yields of oil palm fruit is essential for informing policymakers about effective strategies for policy development. To fulfill this primary aim, the study specifically examines the trends, growth rates, and instability indices of oil palm fruit production, harvested area, and yield in Nigeria. The study also identifies the contributions of yield, area, and interaction effects on the output of oil palm fruit in the country.

MATERIALS AND METHOD

Study Area

The research was carried out in Nigeria, a country rich in agricultural, marine, and forest resources. The extensive availability of both human and natural resources facilitates the cultivation of a diverse array of agricultural products. Over sixty percent of the population is engaged in agricultural activities, which include the production of cassava, groundnuts, oil palm, cotton, rubber, cocoa, rice, maize, aquaculture and artisanal fishing, coconut, livestock, yams, various beans and legumes, sorghum, carrots, and a variety of vegetables, among others.

Data source

The research utilized secondary data obtained from Food and Agricultural Organization (FAO), extended from 1961 to 2022.

Model Specification

Analytical Techniques

The study utilized a compound growth rate to analyze the growth rate in oil palm fruit production, harvested land area, and yield. This approach was selected based on the expectation that the subsector comprising the oil palm fruit output production, harvested land area development, and yield would display exponential growth trends over the years, influenced by diverse intervention policies and programs implemented by the federal and other tiers of governments to enhance the productivity of the subsector.

(a) Measuring a compound growth rate of variables

To estimate the exponential growth rate in oil palm fruit output, harvested area, and yield, equation 1 was specified according to (Udoh and Akpan 2019; Akpan et al., 2024) as thus:

$$log_e\left(Y_o, Y_a, Y_y\right) = \delta_0 + \delta_1 t + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, Y_o, Y_a, Y_y are the output in tons, harvested area in hectares, and yields in tons/ha of oil palm fruit across the years under review. Variable "t" represents the time variable measured in years. An Ordinary Least Squares (OLS) estimation method was employed to generate the parameter δ_1 required for estimating the compound growth rate of each dependent variable. The use of the OLS technique was deemed necessary due to its simplicity and suitability as the estimation method for the specified growth rate model. Given a simple compound growth model as in equation 2, and comparing it with the exponential growth model in equation 1; a compound growth rate is derived as shown in equation 3,

$Y_t = Y_0(1+r)^t$ ……(2)

Comparing with an exponential equation

$r = \left(e^{\delta_1} - 1\right) x\ 100$ Or (antilogb_1 – 1) x 100……(3)

Where r is the measure of a compound growth rate or exponential growth rate for a specified variable expressed in a percentage.

Measuring series instability index

The study used the coefficient of variation (COV), Cuddy-Della Valle index (CDI), and Coppock Instability Index (COI) to assess the instability in output, yield, and harvested land area of oil palm fruit in Nigeria. The estimation details of each of the estimates are provided in the subsequent sections.

Coefficient of Variation (COV)

The Coefficient of Variation (COV) is the most common index used to measure variability/instability in series. It assesses the relative dispersion of data around the mean value. The index is known to overestimate the level of instability in time series which is characterized by long-run trend. It does not explain properly the trend component inherent in a time series. A higher COV indicates higher variability and vice visa.

$$COV = \frac{standard\ deviation}{mean} \quad \ldots\ldots(4)$$

Cuddy-Della Valle index (CDI)

The Cuddy-Della Valle index de-trends the annual series and shows the exact direction of the instability (Cuddy and Valle, 1978). It eliminates the influence of trends in the coefficient of variation (CV) by utilizing the coefficient of determination. Hence, it is a better measure of instability in agricultural production, harvested area, and yields compared to the coefficient of determination (Wasem, 2001). A low value of this index indicates low instability in series and vice-versa. The CDI expression is presented as;

$$CDI = CV\sqrt{1 - R^2} \quad \ldots\ldots(5)$$

Where CV is the coefficient of variation in percent, and R^2 denotes the coefficient of determination obtained from time trend regression on output, harvested area, and yield of oil palm fruit in the country. The levels of instability are categorized within the following ranges: Low instability = (from 0 – 15); Medium instability = (greater than 15, but less than 30) and High instability = (>30). Note that, an adjusted coefficient of determination can also be used.

Coppock Instability Index (COI)

The Coppock (1962) instability index measures instability through log variance method. The higher the Coppock instability index represents a higher instability and vice versa.

$$Coppock\ Instability\ Index\ (COI) = Antilog\left(\sqrt{logV} - 1\right)x\ 100 \quad \ldots\ldots(6)$$

Where,

$$logV = \frac{1}{N-1}\sum(logX_{t+1} - logX_t - M)^2 \quad \ldots\ldots(7)$$

$$M = \frac{1}{N-1}\sum(logX_{t+1} - logX_t) \quad \ldots\ldots(8)$$

Where,
X_t = Time series variable under consideration (log of output/area/yield) in period t.
M = Mean value of the first differences of logarithm
N = Total number of observations
V = Value of Variance log obtained by substituting the values of first differences and M in equation 7.

Oil palm Output Decomposition

The analysis of the growth rate and instability indices do not account for the relative contribution of the harvested area and yields as well as the interaction component to the total production of oil palm fruit. The need for decomposition of the oil palm fruit output is necessary to isolate the relative contributions of the yield and area effects as the interactive effect on the oil palm fruit production. Therefore, the decomposition analysis was carried out to achieve this objective. The initial assumption is as follows:

Production (total effect) = Yield effect + Area effect + Interaction effect

$$P = \frac{A_0 \Delta Y * 100}{\Delta P} + \frac{Y_0 \Delta A * 100}{\Delta P} + \frac{\Delta Y \Delta A * 100}{\Delta P} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where,
A_0 = Harvested area in the base year
ΔA = Current harvested area minus the base area
Y_0 = Yield in the base year
ΔY= Current yield minus the base yield
ΔP = Current production minus base production
All analyses specified in the study are done for seven (7) periods i.e. 1961–1970, 1971–1980, 1981–1990, 1991–2000, 2001–2010, 2011–2022, and 1961 – 2022.

RESULTS and DISCUSSION

Trend Analyses of output, harvested area, and yield of oil palm fruit in Nigeria

The trend diagrams representing the production, yield, and harvested area of oil palm fruit in Nigeria from 1961 to 2022 are illustrated in Figures 1, 2, and 3, respectively. The production of oil palm fruit displayed a fluctuating pattern, characterized by significant peaks and troughs throughout the examined timeframe. Starting at 6.75 million tons in 1961, the oil palm production saw a decline until 1964, when it reached 6.5 million tons. From 1965 onwards, the trend continued to decline on average, eventually peaking at 6.8 million tons in 1997. After this peak, a gradual increase was noted until 2004, culminating in approximately 8.7 million tons. However, between 2005 and 2015, the country experienced stagnation in oil palm fruit production. In contrast, from 2016 to 2022, the sector experienced a resurgence, characterized by a steady increase in output, which reached a peak of 12.68 million tons in 2022.

The harvested area (ha) for oil palm fruit production exhibited a pattern that closely aligns with the annual production figure This relationship is a result of policies implemented to boost oil palm fruit output, which concurrently affected the area of land harvested. Likewise, the yield trend of oil palm fruit has reacted to various policies aimed at significantly altering the output of this agricultural sub-sector within the country. For example, between 1961 and 1984, the yield stagnated due to multiple factors, including the sector's overall neglect by different government tiers, largely driven by the lucrative returns from crude oil extraction (Eme & Fakayode, 2013). This timeframe coincided with the pre-structural adjustment program (pre-SAP) period, during which agricultural production was not given priority. The import substitution policies of this era were plagued by corruption, lack of sincerity, and substantial instability in the country's macroeconomic environment. Additionally, the palm oil fruit industry faced a shortage of skilled labor, as many young individuals migrated to urban centers or oil-rich regions in pursuit of better prospects (Yakub, 2008; Aloko, 2023). The government also encountered obstacles related to land acquisition, environmental repercussions, and community opposition in executing its plantation initiatives (Ekenta and Ajala, 2017). Moreover, environmental issues, such as the destruction of groves due to development projects, intensified the challenges faced by the industry, leading to decreased palm oil production and adversely affecting local farmers (Okolo et al., 2019). Furthermore, oil palm fruit production faced significant hurdles during this period due to the civil war in the late 1960s and early 1970s, which primarily impacted the regions producing oil palm fruit.

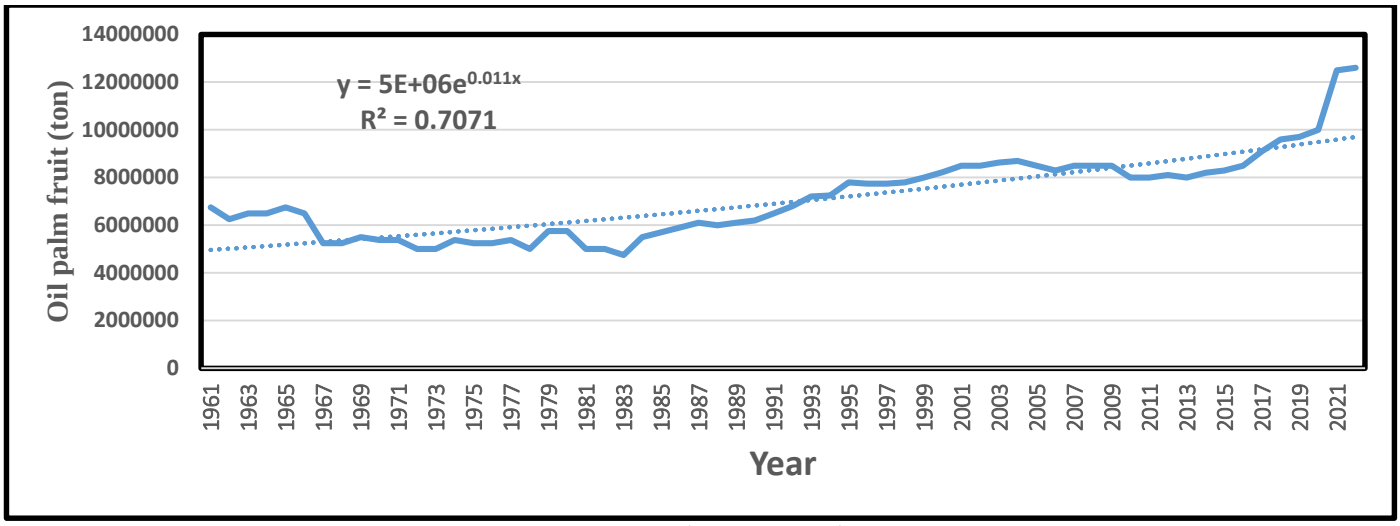

Figure 1: Trend in oil palm fruit production in Nigeria (1961 – 2022)
Şekil 1. Nijerya'da palmiye yağı meyvesi üretimindeki eğilim (1961 – 2022)

As a result, the country lost its significant position in global oil palm fruit production, leading to a scenario where domestic demand exceeded local supply. From 1985 to 2022, the yield of oil palm fruit consistently exceeded 2.5 tons per hectare, although it was characterized by significant fluctuations. This phenomenon can be partially explained by the structural adjustment program policies implemented from 1986 to 1993, which fostered private investment in the sub-sector through the privatization and commercialization of agricultural production and processing. Throughout this period, substantial investments were made in the sector, bolstered by government incentives and the introduction of programs designed to improve financing for small and medium-sized oil palm farmers in the country.

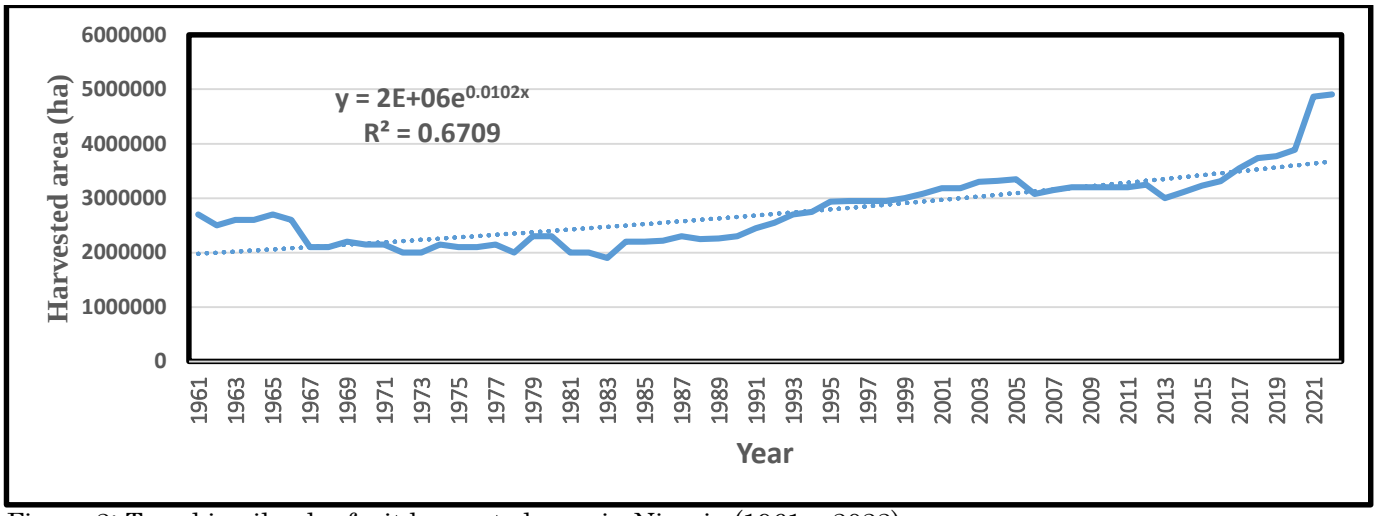

Figure 2: Trend in oil palm fruit harvested area in Nigeria (1961 – 2022)
Şekil 2. Nijerya'da palmiye yağı meyvesi hasat alanındaki eğilim (1961 – 2022)

The Structural Adjustment Programme was implemented alongside various policies that diminished governmental involvement in agricultural production while encouraging privatization (Ojo 1989, Nwosu 1992, Michael and Murat 2019, Shehu et al., 2021). Despite a slight and unsustainable increase in oil palm fruit yields from 1985 to 2022, these yields remained lower than the average outputs recorded in Malaysia and Indonesia.

The Compound growth rate an Instability Index in output, area, and yield of oil palm fruit in Nigeria

The coefficients of variability, compound growth rate (CGR), Cuddy-Della Valle instability index (CDI), and Coppock Instability Index (COI) pertaining to the output, harvested area, and yield of oil palm fruit in Nigeria for the periods 1961–1970, 1971–1980, 1981–1990, 1991–2000, 2001–2010, 2011–2022, and the overall span from 1961 to 2022 are detailed in Tables 1, 2, and 3, respectively.

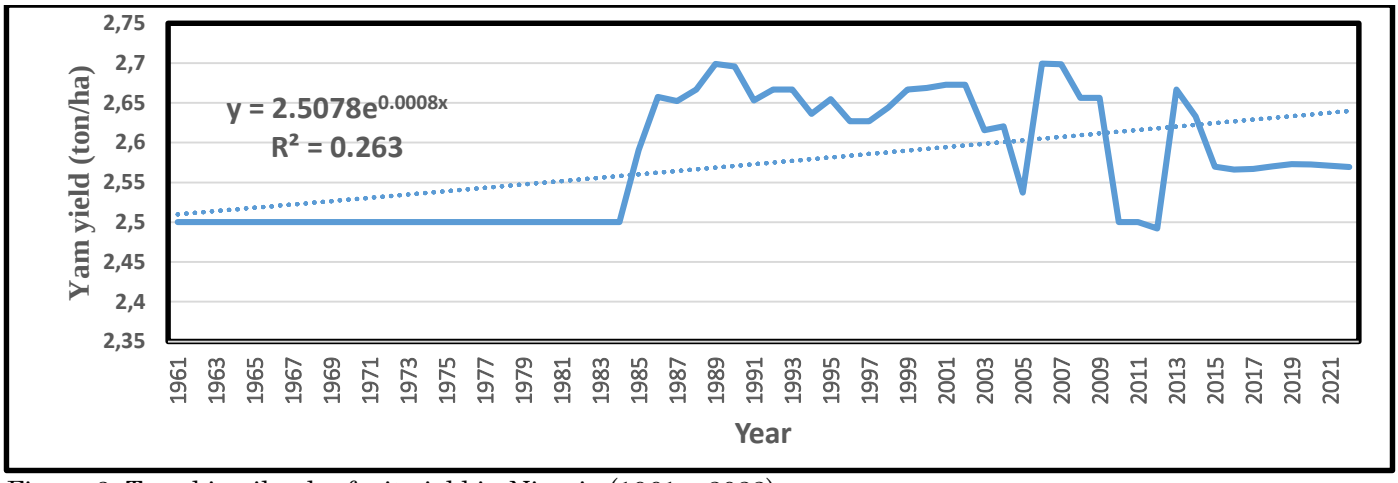

Figure 3: Trend in oil palm fruit yield in Nigeria (1961 – 2022)
Şekil 3. Nijerya'da palmiye yağı meyve verimindeki değişim (1961 – 2022)

Growth rates and Instability Indices in oil palm fruit output (tons) in Nigeria

The analysis indicates that the coefficient of variation (COV) and the compound growth rate (CGR) for oil palm fruit production from 1961 to 1970 were recorded at 10.53% and -2.80%, respectively as presented in Table 1. This decade was characterized by a significant reduction in the output of oil palm fruit within the country. The CGR value indicates that oil palm fruit production declined during this timeframe with an annual decline rate of 2.80%. Furthermore, the coefficient of variation reflects low annual fluctuations in oil palm output during this period, while the negative skewness denotes a persistent trend of marginal growth that was unfavorable.

Table 1: Growth rates and Instability Indices in oil palm fruit output (tons) in Nigeria
Çizelge 1. Nijerya'da palmiye yağı meyvesi üretimindeki büyüme oranları ve İstikrarsızlık Endeksleri (ton)

	1961-1970	1971 - 1980	1981-1990	1991-2000	2001-2010	2011-2022	1961-2022
Mean	6062500	5312500	5625000	7507000	8463200	9383891.80	7134011.32
Std. dev.	638058.04	277951.34	533983.98	549283.37	192608.30	1639091.57	1749761.01
COV (%)	10.5247	5.2320	9.4930	7.3169	2.2758	17.4671	24.5270
Skewness	-0.3012	0.4155	-0.52442	-0.6072	-1.3988	1.1431	0.8669
CGR (%)	-2.8001	0.9656	2.9733	2.3573	-4.3315	4.2165	1.1061
				Instability indices			
CDI	6.2920	4.3011	3.7374	2.3631	1.8734	7.8115	13.4631
COI	40.9601	38.7508	40.5671	39.6581	37.6522	43.2741	46.5696

Note: Prepared by authors.

The CDI and the COI indices demonstrate that the instability in oil palm fruit output from 1961 to 1970 was relatively low in Nigeria, suggesting minimal activity within this agricultural sub-sector during the specified period. Between 1971 and 1980, the coefficient of variation in oil palm fruit output suggests that the production of oil palm fruit during this decade experienced a modest annual positive growth rate of 0.96% per annum. The CDI was determined to be 4.30, with a COI of 38.75. Notably, this period exhibited lower instability in oil palm output compared to the preceding decade.

In a similar vein, the periods from 1981 to 1990 and from 1991 to 2000 recorded CGRs of 2.97% and 2.36%, respectively. The findings indicate that the production of oil palm fruit experienced a significant increase during these time frames in Nigeria. The coefficients of variation rose significantly compared to the earlier decade, reaching 9.49% and 7.32%, respectively. The CDI and COI for the 1981-1990 period were 3.74 and 40.57 respectively, while for 1991-2000, they were 2.36 and 39.75 respectively. However, there was still low instability in output in these periods.

Conversely, the period from 2001 to 2010 experienced a negative CGR of -4.33%, indicating a detrimental relationship between oil palm fruit output and the time during this decade. The finding suggests that the oil palm fruit production declined significantly during this period. The decline coincided with significant encroachments on oil palm estates due to rising urbanization and other economic activities. Additionally, increased volatility in critical macroeconomic indicators, such as inflation and exchange rates, adversely affected the sub-sector's performance. Nevertheless, the CDI and COI values during this period still suggested a significant low instability

within the subsector.

The years 2011 to 2022 marked a pivotal transformation in the oil palm fruit production landscape of Nigeria. During this timeframe, the sector experienced a remarkable compound growth rate (CGR) of 4.14% alongside a coefficient of variation (COV) of 17.52%. The result implies that the oil palm fruit production increased at the rate of 4.14% per annum during this period. Numerous policies were enacted to enhance the production of oil palm fruits. The CBN and the Federal Government introduced various initiatives, including a ban on the importation of oil palm derivatives, the establishment of the Anchored Borrower Program (ABP) Program aimed at providing financial support to oil palm farmers, and the intensified operations of the Agricultural Credit Guarantee Scheme Fund focused on oil palm production, among others. This period was characterized by a notable increase in oil palm fruit production. Despite this progress, the instability indices, as indicated by the values of CDI of 7.81 and the COI of 43.27 remained relatively low, although they showed improvement compared to previous decades. The instability indices during this period reflected a significant enhancement relative to the other decades examined.

Analyzing pooled data from 1961 to 2022 revealed a COV of 24.53% and a CGR of 1.11%. These findings suggest that, on average, oil palm fruit production experienced an increase or positive growth with a low coefficient of variation from 1961 to 2022 in Nigeria. Nonetheless, the CDI of 13.46 and COI of 46.57 reflected low instability in oil palm fruit output and indicated that activities in the sub-sector were relatively minimal.

Growth rates and Instability Indices in harvested area (ha) of oil palm fruit in Nigeria

The distribution pattern of indicators related to the harvested area exhibits similarities to those of output indicators. Notably, the compound growth rate was negative during the periods of 1961 to 1970 and 2001 to 2010. Throughout all examined periods, the coefficient of variation remained below 30.00%. The instability indices, specifically the CDI and COI, were consistently low across all periods under review. This indicates that the variability in harvested land area during the analyzed decades was minimal. For example, the coefficients of variation for the harvested area of oil palm fruit were recorded at 10.53%, 7.37%, 17.52%, and 23.71% for the periods 1961 to 1970, 1991 to 2000, 2011 to 2022, and 1961 to 2022, respectively. This suggests that the fluctuations in harvested land during these specified periods were relatively low. Furthermore, the observed negative skewness values imply that the harvested land areas decreased persistently during the periods of 1961 to 1970, 1981 to 1990, and 1991 to 2000.

Table 2: Growth rates and Instability Indices in oil palm fruit harvested area (ha) in Nigeria
Çizelge 2. Nijerya'da palmiye yağı meyvesi hasat edilen alanda (ha) büyüme oranları ve İstikrarsızlık Endeksleri

	1961-1970	1971 - 1980	1981-1990	1991-2000	2001-2010	2011-2022	1961-2022
Mean	2425000	2125000	2163000	2831800	3215500	3651037.17	2764765.26
Std. dev.	255223.21	111180.54	142520.95	208787.93	83946.08	639664.23	655466.82
COV (%)	10.5247	5.2320	6.5890	7.3730	2.6107	17.5201	23.7079
Skewness	-0.30117	0.41546	-0.80319	-0.7035	0.20244	1.1147	1.0584
CGR (%)	-2.8001	0.9656	1.8978	2.3676	-0.1802	4.1435	1.0252
				Instability indices			
CDI	6.2919	4.3011	3.4872	2.5402	2.5519	8.4042	13.8706
COI	40.9601	38.7508	39.3707	39.6909	37.7629	43.3150	46.0158

Note: Prepared by authors.

The timeframe from 2011 to 2022 exhibited superior performance regarding the compound growth rate of 4.14% and instability indices including CDI of 8.40 and COI of 43.32 compared to the previous periods. The underlying factors contributing to this improvement are akin to those affecting the output variable. An analysis of the pooled data revealed a COV of 23.71% and a CGR of 1.025% for the harvested area spanning from 1961 to 2022. Furthermore, the overall instability index, as assessed by the CDI (13.87) and COI (46.02), indicates a low level of instability in the harvested area throughout this period.

Growth rates and Instability Indices in the Yields (ton/ha) oil palm fruit in Nigeria

The findings indicated that the COV, CGR, and CDI, for oil palm fruit yield were recorded as zero during the two decades from 1961 to 1970 and 1971 to 1980. This phenomenon can be attributed to the constancy of yield (ton/ha) throughout these periods. Such stability suggests that both the output and the harvested area of land remained unchanged during these times. These decades coincided with a phase of significant oil exploitation driven by heightened global demand, civil war, and the onset of Dutch disease in Nigeria in 1977, among other factors (Otaha, 2012). During this time, the agricultural sector was largely neglected as a source of foreign exchange by all levels of government, which instead became heavily dependent on the crude oil industry. This era is frequently marked by substantial government investment in agriculture through import substitution policies, which were marred by

corruption and a lack of genuine commitment. Consequently, the agricultural sector faced a decline in private sector investment due to an obnoxious policy mandating government participation in agricultural investments within the country.

Between 1981 and 1990, the oil palm fruit sub-sector yield experienced a revival, characterized by a coefficient of COV of 3.38% and a positive compound growth rate (CGR) of 1.06%. Despite the yield variation being minimal and exhibiting a negative skew, it experienced a marginal positive increase during this period in Nigeria. This period aligned with the introduction of several intervention policies, including the Economic Stabilization Act of 1985 and the Structural Adjustment Program policies of 1986, aimed at mitigating economic volatility and fostering private investment in agriculture among others. Nevertheless, the compound growth rate for oil palm fruit yield during this time was not particularly remarkable. The low instability indices, with a CDI of 1.13 and COI of 38.06, indicate that despite the ambitious policies implemented by the federal government, the oil palm fruit yield instability remained persistently low, reflecting limited activity and slow advancement in the sub-sector throughout this period.

Table 3: Growth rates and Instability Indices in oil palm fruit yields (ton/ha) in Nigeria
Çizelge 3. Nijerya'da palmiye yağı meyve verimlerinde (ton/ha) büyüme oranları ve istikrarsızlık endeksleri

	1961-1970	1971 - 1980	1981-1990	1991-2000	2001-2010	2011-2022	1961-2022
Mean	2.5000	2.5000	2.5962	2.6511	2.6329	2.5709	2.5751
Std. dev.	0.0000	0.0000	0.0878	0.0166	0.0669	0.0469	0.0752
COV (%)	0.0000	0.0000	3.3819	0.6262	2.5409	1.8243	2.9203
Skewness	0.0000	0.0000	-0.1269	-0.3721	-0.9828	0.2520	0.2582
CGR (%)	0.0000	0.0000	1.0555	0.0062	-0.2537	0.0752	0.0828
				Instability indices			
CDI	0.0000	0.0000	1.1289	0.6254	2.4263	1.8099	2.5148
COI	36.7918	36.7918	38.0606	37.0229	37.7498	37.4689	37.8786

Note: Prepared by authors.

In contrast, the subsequent decades of 1991 to 2000 and 2001 to 2010 marked a return to a phase of significant decline in productivity within the sub-sector. For these periods, the COV was recorded at 0.62% and 2.42%, respectively, indicating marginal variability. The Compound Growth Rates of 0.0062% and -0.25% for the two respective periods underscore the declining yields within the sector. Additionally, the CDI and COI values of 0.63 and 37.02 for the period from 1991 to 2000, and 2.43 and 37.75 for the period from 2001 to 2010, indicate a notable low instability in yields and a continuous absence of significant activity in the sub-sector. This era of oil palm fruit production was characterized by extensive encroachment on oil palm estates due to rising urbanization and other economic activities necessitating land expansion. Additionally, as noted by PIND (2011) and Shehu et al. (2021), factors such as aging plantations, deteriorating infrastructure, and high labor costs significantly contributed to the poor performance of the sub-sector during these decades.

The swift response of the federal government to rescue the oil palm sub-sector's fortunes from 2011 to 2022 resulted in only a modest improvement in productivity. Notably, initiatives such as the anchored borrowers' program and the Central Bank of Nigeria's (CBN) financial allocations to the sub-sector in 2015 contributed to a slight increase in productivity levels. During this timeframe, the COV and CGR were recorded at 1.82% and 0.075%, respectively. However, this marginal improvement was insignificant as evidenced by the relatively low CDI of 1.81 and COI of 37.47, which still indicated limited activity and low instability within the subsector.

The analysis of pooled data (1961 – 2022) revealed overall figures for COV, CGR, CDI, and COI at 2.92%, 0.083%, 2.52 and 37.88, respectively. These findings suggest that the annual growth rate of the oil palm fruit yield was merely 0.083%, a figure that is insufficient to satisfy domestic annual demand or to enable competitive positioning of the country in the global market. However, during the same time frame, Nigeria's oil palm fruit yield compound growth rate outperformed Côte d'Ivoire (-0.768%) and Ghana (-0.00283%), but fell significantly short of Indonesia (0.508%), Malaysia (0.583%), and Thailand (2.313%) (FAO, 2024).

Decomposition of Output of oil palm fruit in Nigeria

The analysis of the decomposition of oil palm fruit output is presented in Table 4. The findings showed the various components contributing to the total effect, which encompasses the area effect, yield effect, and interaction effect. It was observed that during the periods of 1961 to 1970 and 1971 to 1980, the entirety of the total effect on oil palm fruit output in the country was solely due to the area effect. These periods were marked by significant neglect of the subsector, civil war, and the phenomenon of Dutch disease, which arose from the sudden influx of revenue from crude oil extraction (Otaha, 2012). In contrast, the decade from 1981 to 1990 saw approximately 62.50% of the total

effect attributed to the area effect, 32.61% to the yield effect, and 4.89% to the interaction effect. This era coincided with the Structural Adjustment Program (SAP), which fostered private investment in agriculture. During this time, there was a notable encouragement for farmers and private investors to adopt innovative practices within the subsector.

Table 4. Percentage decompositions of area, yield, and their interaction effects on oil palm fruit production in Nigeria

Çizelge 4. Nijerya'da yağ palmiyesi meyvesi üretimi üzerindeki alan, verim ve bunların etkileşim etkilerinin yüzdesel ayrışımı

Components	1961-1970	1971 - 1980	1981-1990	1991-2000	2001-2010	2011-2022	1961-2022
Area effect	100.00	100.00	62.50	97.18	-10.69	92.62	94.20
Yield effect	0.00	0.00	32.61	2.24	110.00	4.81	3.19
Interaction effect	0.00	0.00	4.89	0.58	0.69	2.57	2.61
Total effect	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: computed by authors.

In the subsequent period from 1991 to 2000, the area effect accounted for over 97.18% of oil palm fruit production, while yield and interaction effects contributed 2.25% and 0.58%, respectively. However, in the decade from 2001 to 2010, the yield effect remarkably contributed 110.00% to the output, while area effect exhibited a negative contribution of -10.69%, with the interaction effect contributing 0.69%. During this period, the yield effect compensated for the negative effects of the area of harvested land (-10.69%) and the marginal contribution of the interaction effect. This period's output can be attributed to the expansion of private oil palm estates and the revitalization of existing estates. Additionally, numerous State governments in the South-South region implemented various programs aimed at enhancing oil palm fruit production, integrating these initiatives into their agricultural policy frameworks. The influence of area effect on output was revitalized during the period from 2011 to 2022. In this period, the area effect contributed about 92.62%, while yield and interaction effects were responsible for 4.81% and 2.57% respectively. The introduction of the Anchor Borrower Programme (ABP) in 2015, along with the initiatives of the Nigerian Institute for Oil Palm Research (NIFOR), may have played a significant role in this outcome. A similar observation was noted in the combined data spanning from 1961 to 2022. The contributions of area, yield and their interaction effects accounted for 94.20%, 3.19%, and 2.61% respectively of the overall output effect. Overall, these results indicate that area effect is a key or major factor in explaining the total variation in oil palm fruit production within Nigeria. The results differ from those observed in Malaysia, Indonesia, and Thailand, where the growth of oil palm fruit production is driven by increased yield due to the adoption of advanced technologies rather than expanding land area (FAO, 2024; Hassan et al., 2024).

Summary and Recommendations

The study examined the trends, growth rates, and instability index of oil palm fruit production, harvested area, and yield in Nigeria from 1961 to 2022. The decomposition of the total effect of output into area effect, yield effect and interaction effect were carried out. The analysis was segmented into distinct sub-periods: 1961–1970, 1971–1980, 1981–1990, 1991–2000, 2001–2010, 2011–2022, and the overall period from 1961 to 2022. The trend analysis revealed fluctuations in the output, harvested area, and yield of oil palm fruit across all sub-periods as well as in the aggregated data. The CGR for oil palm output and harvested land area were negative during the periods of 1961–1970 and 2001–2010, while positive growth rates were observed in the remaining sub-periods and the pooled data. The CGR for yield was recorded as zero for the periods of 1961 to 1970 and 1971 to 1980, negative during 2001–2010, and a marginal 0.08% for the overall period from 1961 to 2022. These findings indicate that only a slight positive compound growth rate (below 1.50%) was evident in the output, harvested area, and yield of oil palm fruit in Nigeria from 1961 to 2022. The coefficient of variation across all specified periods was relatively low (under 30.00%), indicating limited variability in the output, harvested area, and yield of oil palm fruit within the country. Furthermore, the CDI and COI for the pooled data concerning output (13.46 and 46.57, respectively), harvested area (13.87 and 46.02, respectively), and yield (2.52 and 37.88, respectively) were also low. Similarly low values were observed for each of the other specified periods regarding output, harvested area, and yield. The result suggests that there was a lack of significant activity in the sub-sector from 1961 to 2022.

Decomposition analyses indicate that during the periods of 1961 to 1970 and 1971 to 1980, the entirety of the growth in output was exclusively due to area effects. This finding suggests that the increases in output during these periods were derived solely from area effect components, with both yield and interaction effects contributing nothing to the total effect. In contrast, the periods from 1981 to 1990 and 1991 to 2000 showed that area effects

accounted for 62.50% and 97.18% of the total growth effect, respectively. During these same periods, yield effects contributed only 32.61% and 2.25% to the total effect, while interaction effects contributed 4.89% and 0.58%, respectively. This indicates that area effects were the primary drivers of output growth during the analyzed periods. In the decade from 2001 to 2010, the area effect was recorded at -10.69%, with interaction effects at 0.69%, and yield effect at a substantial 110.00%, effectively offsetting the negative contribution of the area effect. The periods from 2011 to 2022 and the overall period from 1961 to 2022 further underscored the significant influence of area effects on total output growth, contributing 92.62% and 94.19% to the total effect, respectively, while yield effects accounted for 4.81% and 3.19% respectively.

In conclusion, the oil palm fruit sub-sector witnessed limited annual activities within the time frame under review. This observation implies that the fluctuations in output, harvested area, and yield were relatively low. Specifically, the coefficient of variation for oil palm output, harvested area, and yield remains below 30.00%. Furthermore, the average compound growth rate (CGR) for these parameters across all specified periods was less than 5.00% per annum. Such a growth rate magnitude implies that oil palm fruit production currently lacks the necessary impetus to satisfy domestic demand and significantly enhance export supply. The Cuddy-Della Valle instability index for output, harvested area, and yield is recorded at less than 15.00 units, indicating that the activities within this sub-sector were insufficient to instigate substantial change. Likewise, the COI remains low for output, harvested area, and yield throughout all examined periods. In light of these findings, it is crucial to implement additional programs such as the small grower scheme, oil palm farmers' cooperative, off-takers scheme, and the strengthening of the marketing chain within the sub-sector to stimulate increased activity, production, and yield. To further enhance, oil palm production and yield, the sub-sector must also adopt improved technologies in addition to empowering oil palm farmers through easy access to quality seeds, financial resources, and land. Only in this case can production increases be achieved through high yield in Nigeria as is the case in Malaysia, Indonesia, and Thailand.

Conflict of Interest Declaration

The authors of the article declare that they do not have any conflict of interest.

Contribution of the Authors

Authors contributed equally

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