Growth, Instability and Trend Analysis of Rice Production Indicators in Nigeria

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Abstract

Purpose

The research looked at the trends and decomposition of milled rice production indicators in Nigeria.

Research Method

It relied on secondary-time series data on rice output, yield, and cultivated area) obtained from the FAOSTAT database. The data ranged from 1960/61 to 2019/20 production cycle. The descriptive statistics, compound annual growth rate (CAGR), decomposition analysis, and Instability Index were used to analyze the data (II).

Findings

The highest yield performance (2.38 tonnes/ha) came between 1978 and 1992. The cultivated area increased steadily during the study period. The study found that time trend significantly influenced changes in harvested area, yield, and rice production at 1%, with CAGR values of 15%, 1%, and 16% between 19660-61 and 2019-20, indicating some weaknesses in Nigeria's rice yield during this period. Increased rice harvested area effect was the primary source of growth during the period, according to the decomposition analysis (1961-2020). The area effect on rice production in Nigeria was found to be 58%, compared to 2% for the yield effect and 40% for the interaction, implying that increased

output in Nigeria is still largely dependent on cultivated area expansion. During the study period, yield performance was the most volatile, with an instability index of 3.17%, while milled rice production and area under rice cultivation had instability indexes of 0.94% and 0.82%, respectively.

Research Limitations

The major limitation is lack of current data on rice production indicators up to 2022.

Originality/Value

It employs decomposition techniques to assess the contributions of yield and cultivated area to rice output in Nigeria, and Cuddy Della Valle Index to determine the volatility of rice production indicators.

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1. Introduction

The COVID-19 pandemic of 2020 did not only re-ordered global food dynamics, but it also significantly eroded poverty reduction gains made in the previous decade [1]. According to World Bank report, in 2020, more than 100 million people fell into poverty as a result of the epidemic by 2020, with the number growing in Asia and Africa. During this time, the population of the undernourished grew by 1.5%, from around 8.5% to 1.5% [2]. As a result, Asia and Africa continue to home 50% and 33%, respectively, of the world's 768 million undernourished people. Similarly, by 2020, 5 and 3 out of every 10 people in Asia and Africa, respectively, would be locked in severe food shortages [2]. According to research, 2.37 billion people would face moderate or severe food insecurity by 2020. With an anticipated 660 million people still living in poverty in 2030, it looks that the United Nations' planned strategy to abolish poverty, the Sustainable Development Goals, may not be possible [2]. Around 12% of Africa's population is highly destitute, resulting from poverty, food scarcity, and food insecurity [3]. Four out of every ten Nigerians live below the poverty line, and three out of every ten are vulnerable to poverty. Farmers in rural areas, who account for more than half of the population, have been struck the worst. This feature of Nigerian poverty and food insecurity is concerning, with major policy consequences.

Scholars, on the other hand, have lauded Nigeria's economic potential if the agriculture industry and its drivers are vigorously promoted. Rice, a key staple meal in Nigeria and internationally, is one of the food sources that might assist Nigeria in addressing the concerns of poverty and food insecurity. The most prevalent rice types are Asian (Oryza sativa)

and African (Oryza glaberrima). Rice (Oryza sativa) is one of the crops that has long served as a main source of food, profit, and employment in Nigeria. It's cultivated all around the country in a range of industrial structures, including swampy lowland, upland, irrigated, and mangrove. Nigeria is a global reference point for rice-producing countries. Nigeria is now the leading rice producer in Africa. Between 1970 and 2017, it had the biggest reduction in yield performance (9.86 million tons) [4].

Furthermore, rice is becoming a more expensive meal in Nigerian homes. Given Nigeria's expanding population, mounting worries regarding rice production and the proportion of household income spent on it are understandable. If present global processes and population growth trends continue, another 2.4 billion people, predominantly in Nigeria, would reside in developing nations by 2050 [5]. The number of urbanized regions is anticipated to treble between 2000 and 2030[6]. Agriculture is critical to the Nigerian economy. Agriculture is the major source of sustenance for 75% of Nigeria's poorest population [7][8]. Nonetheless, more than 20% of the rural population experiences regular food supply security challenges [4].

Nigeria is the continent's biggest rice consumer, one of Africa's major rice producers, and one of the world's largest rice imports, according to [9][10]. It is not only a crucial food security crop, but also a revenue crop because small-scale growers often sell 80 percent of total production while consuming just 20 percent. Rice is the most profitable cash crop for Nigerian farmers.

With a per capita intake of 32kg, rice is one of Nigeria's most popular basic foods. Consumption has climbed at a rate roughly four times the world average over the previous decade, reaching 6.4 million tonnes in 2017 – accounting for 20% of Africa's consumption. In 2011, rice accounted for 10% of total household spending and 6.6% of food spending. Given the importance of rice as a staple grain in Nigeria, the government has prioritized expanding output during the previous seven years. Rice output in Nigeria peaked at 3.7 million tonnes in 2017, indicating significant development [11].

Despite this development, Nigeria's rice statistics show that there is huge room for further productivity and production. Yields have been consistent at 2 tonnes per hectare, or nearly half of the Asian average. Furthermore, as the population rises and people relocate from rural to urban regions, guaranteeing food security in vital commodities becomes more critical. However, reaching self-sufficiency in rice production will be difficult with a system that is nearly exclusively based on cultivated area growth, human physical strength, and other manual means.

Despite the immense hurdles of researching rice, great efforts have been achieved toward reinventing rice production in order to boost efficiency and sustain high-quality rice production [1][12]. Several studies have looked at agricultural output growth patterns [13][14], but studies on rice production indices in Nigeria are uncommon. While the output of rice in Nigeria continues to grow, little is known about the influence of yield and the interplay between yield and planted area on output. Furthermore, the literature on the stability of rice production indicators, which is intended to give hints, is restricted in terms of market efficiency. As a result, this research looks at the trajectory in rice production indices in Nigeria over the previous five decades to highlight difficulties and priorities for rice production in Nigeria. Analyzing the trend and breakdown of rice production indicators and presenting them in an accessible style may give the academic community with fresh insights. As a result, this study investigates the driving forces for rice production in order to uncover

characteristics that have a substantial impact on sub-sector growth. The importance of this question is highlighted by the fact that the challenges associated with expanding development infrastructure and increasing industrial drive pose a serious threat to achieving agricultural growth solely through the expansion of cultivated/harvested rice seeds rather than high yield rice seeds.

2. Literature Review

2.1. History of rice types in Nigeria

Nigeria grows three varieties of rice. African rice, Oryza glaberrima, Asian rice, O. sativa, and, most recently, WARDA's hybrid rice, NERICA, which is only available to farmers through WARDA's PVS program, are among them. Ref [15] claims that the African Rice O. glaberrima evolved "some 3500 years ago from the wild rice O. barthii and its offspring, domesticated probably in the inland delta area of the Niger, from where it spread through the upper Niger valley to the rest of West Africa." African rice is farmed as both a field crop and a paddy crop. Rice has been farmed in the Niger-Benue trough, Sokoto-Rima, and Chad Basins for long enough that a rice civilization going back to 1500 BC has emerged [16]. There are notable deep-water variants of O. glaberrima that are peculiar to the interior Niger Delta, the Sokoto-Rima Valley, and other floodplains in Nigeria's far north. It is also a widespread rice type in the floodplains of Benue. When the floodwaters rise, the rice, like the weedy wild rice, O. barthii, may be picked from boats, a practice that American Indians also utilize to collect Zizania aquatica. O. glaberrima is known as hakorin Montol (literally, the Montol people's teeth due to its grain size) and jatau (red) throughout Hausa region and the Chad Basin. Despite its importance, indigenous African rice was once one of the least-known primary crops, when scientists began to use biotechnology techniques to unleash its enormous genetic potential [17].

2.2. Contributions of Rice to National Economic Growth and Development

Rice is a staple cuisine in the majority of African countries and around the world. As a result, it has the potential to contribute significantly to overall GDP, to be a source of export revenues, and to provide employment. Furthermore, enormous rice production is an essential component of poverty alleviation [1]. Enhanced agricultural efficiency and expansion are being fueled all over globe by technological advances and investments that can have substantial advantages to the poor throughout the economic system: instantly through boosted agricultural earnings and job opportunities, and indirectly through increased food availability and reduced food costs, as well as interest created by raised agricultural incomes for non-farm goods and services generated by the very large, labor-intensive non-agricultural sector. The imbalance between rice demand and supply, on the other hand, is undermining the economy and contributing to money flight. This has been established in several research [18][19].

2.3. Review of Past Studies

Ref [20] studied the patterns in rice production indices in Bangladesh during the previous 36 years to forecast future rice output. The area, yield and production trend, and growth rates of rice were explored in this study from 1984-1985 to 2019-20, and the areas were carefully demarcated based on their rice production performance. High-yielding cultivars adapted at the following rates over the research period: 72% for Aus, 73.5% for Aman, and 98.4% for Boro season. Boro rice output climbed by 0.97% each year from 1969-1970 to 2019-20, but Aus and Aman season shares declined by 0.48% and 0.49% per year, respectively. Mymensingh (13.9%), Rangpur (9.8%), Bogura (8.6%), Jashore (8.6%), and Rajshahi (8.2%) were recognized as the largest providers to the national rice pool based on the average proportion of rice production in Bangladesh. In disaggregated seasons, the analysis found varied cluster regions, with little indication of commonalities across rice-producing regions. The research proposed a more strategic strategy that would concentrate on particular characteristics that may drive rice output at the cluster and national levels. Ref [1] examined increasing developments in rice production-related research, with the goal of examining how the suggested recommendations documented in the literature substantially enhance rice productivity and sustain the cultivation of high-quality rice cultivars. This evaluation was conducted in light of the world's growing population, which was used to forecast the trajectory of the production outlook in 2030.

According to Ref [21], rice output in Nigeria rose at a relatively modest rate between 1980 and 2013. The temporal trend variable played a significant role in influencing the amount of rice produced and imported in Nigeria. Rice output and imports in Nigeria rose at a point-in-time pace rather than a compound (over time) rate. The rice demand-supply imbalance is an ongoing trend that will not be reversed unless proper steps are implemented. To address the demand-supply imbalance, continuous rice imports would be required, which would be damaging to the Nigerian economy.

According to Ref [22], the yearly rate of productivity growth in the period 1996-2010 was greater than in the pre-reforms period, and the breakdown of productivity growth into technical change and efficiency change suggests that the latter played a substantial role in the time. During the same time span, the rate of technological regress slowed, and a number of ecological zones actually recorded technical advance.

Ref [23] Oyakhilomen, Abdullahi, and Zibah (2013) explored the patterns of expansion in Nigerian rice consumption and production between 1970 and 2011, as well as its consequences for empowering youths and women. The time series data needed to meet the study's objectives (aggregate rice demand and supply) were collected from the USDA's foreign agriculture service database. In the study, the growth rate model was utilized to compute the instantaneous (I) and compound growth rates (CGR) of rice. The study discovered that rice demand (I=7.5% and CGR=7.8%) was greater than rice supply (I=6.5% and CGR=6.7%). Increased demand for rice above what is provided to the market as a whole, based on this study, could be responsible for rising rice prices in Nigeria. Despite Nigeria's considerable rice producing potential, this comment is made.

2.3.1. Distinct Agricultural and Rural Phases in Nigeria

Ref [24] analyzed and recommended remedies to the weaknesses of Nigerian agriculture policies. According to the report, several key strides in agricultural growth have been found more in Nigeria's different administrations' constant sourcing

and execution of policies and programs across many decades. There are four different agricultural and rural policy periods in Nigeria. The first phase covered the entire colonial period and the first post-independence decade from 1960 to about 1969 (the pre-1970 era); the second from about 1970 to 1985; the third from 1986 to 1994 during the Structural Adjustment Programme (SAP); and the fourth from 1995 to 2009.

3. Research Methodology

3.1. Data

This study made extensive use of secondary (time series) data. Data on rice production indicators (production output, yield, and cultivated area) were collected using the FAOSTAT database (FAOSTAT, 2022). The information ranged from 1961 to 2020. The data was analyzed using the time series regression model [25][26]. For the analysis, the time was separated into four sub-periods. The study, however, was divided into four historical periods: Period I (1960/61-1977/78), Period II (1978/79-1992/93), Period III (1993/94-2007/08), and Period IV (2008/09 - 2019/20). The era 1961-2020, on the other hand, was seen as a pool - a composite of the four different periods. According to the literature, production output, yield, and rice cultivation area have all been rendered deterministic functions of time trend [27][28].

3.2. Analysis of Data

From 1960-61 to 2019-20 (59 years), historical data on rice production, and yield were used to compute the Compound Annual Growth Rate (CAGR), Coefficient of Variation (CV), and Instability Index.

3.2.1. Compound Growth Rate

In the study, the CAGR was used to examine the rate of growth in rice acreage, production, and yield[29][30]. The study evaluated the four functional forms of regression model for each of the production indicators as follows:

Simple Linear: $Y = a + bt + e$..... (1)

Semi-log: $lnY = a + bt + e$..... (2)

Exponential: $Y = lna + blnt + e$..... (3)

Double log: $lnY = lna + blnt + e$..... (4)

- 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

For estimating the trend and CAGR for each of the production metrics, the study selected the model with the greatest adjusted R-squared.

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 determined, whereas the slope coefficient 'b' measures the instantaneous rate of growth. As a consequence, using the following equation, the compound growth rate was calculated:

CAGR = [antilog b – 1] * 100…… (2)

The significance level of 'b' was determined from the regression using a decision threshold of 5% and the Ordinary Least Squares (OLS) technique. This calculation is based on the premise that variations in rice output in a given year are reliant on output in the preceding year.

Because evaluating rice area, production, and yield growth rates fails to compensate for the proportional contributions of the area and yield to total output change, this study modified the component/decomposition analysis model to do so.

3.2.2. Instability in rice Production

Production instability denotes an unpredictability, the results of which can be detrimental to those whose livelihoods rely on this line of production. In other words, it suggests inefficiency and jeopardizes the sustainability of production expansion. When this has an influence on food production and distribution in emerging or low-income nations, the implications can be disastrous for the majority of low-income farmers. The enormous number of rice market participants in Nigeria indicates the value of rice as a source of money and nourishment for nearly everyone. As a result, specialists have devised a number of approaches for measuring agricultural production insecurity (Popcock's instability index). Coppock's Instability and CAGR have been completely demonstrated using a coefficient of variation and assessing instability in output, area, and yield in three districts of Marathwada, Aurangabad, Jalna, and Beed over a 30-year period [31]. Several additional studies have employed an index created by Parthasarathy to quantify the amount of instability [32]. Another statistic used to quantify production instability is the Cuddy Della Valle statistic [33].

Although standard deviation and coefficient of variation are commonly employed in the literature to quantify risk and instability in rice output, they have been heavily critiqued for overestimation of instability [34]. For the reasons described above, this study employed the Cuddy Della Valle Index to quantify rice production instability in Nigeria. Indexes of Popcock's instability measures (PII) were compared to indexes of coefficient of variation (CoV).

CoV = Standard Deviation / Mean…… (3)

Cuddy Della Valle Instability Index = $(CoV\sqrt{(1 - R^2)})$…….. (4)

Where CoV is the coefficient of variation and R^2 is the time trend regression coefficient modified by the number of degrees of freedom obtained from the time series variable under consideration (production/area/yield).

3.2.3. Decomposition Analysis

The decomposition analysis was performed using the equation below:

$\Delta P = A_b * \Delta Y + Y_b * \Delta A + \Delta A * \Delta Y$..... (7)

(Yield effect) (Area Effect) (Interaction effect)

Where,

$\Delta P = P_C - P_B$

$\Delta Y = Y_C - Y_B$

$\Delta A = A_C - A_B$

A_B, P_B and Y_B are the area, production and yield of rice for the base year.

A_C, P_C and Y_C are the area, production and yield of rice for the current year.

The analysis was done for 4 periods i.e. Period I (1961 - 1977); Period II (1978 – 1992); Period III (1993 - 2007); and Period IV (2008 - 2020).

4. Results and Discussion

4.1. Trend in Area, Yield and Production of Milled Rice in Nigeria

Figures 1 and 2 illustrate the Trend in Growth of Rice Production Indicators from Sub-Group Performance and the Trend in Area, Production, and Yield of Rice in Nigeria (1961 - 2020), respectively.

Nigeria had the best production performance (2.3893 Hg/ha) between 1978 and 1992. The area of land dedicated to rice farming in Nigeria has gradually expanded during the research period. This constant rise was driven by an increase in rice consumption in Nigeria to the point where rice became a staple meal in the country, prompting the April 14, 1980 commencement of several government agricultural projects such as the Green Revolution. When the Structural Adjustment Program (SAP) was implemented and all commodity boards were disbanded, rice imports were prohibited. Nigeria produced more than 5.3 million tonnes of milled rice in 2019. The average milled rice and paddy rice production output between 2008 and 2019-20 was 3.40 million tonnes and 5.97 tonnes, respectively. During this time period, the average number of hectares planted to rice was 3.55 million. In contrast, the yield performance was assessed to be 1.75 tonnes, a little increase over the previous period's 1.51 tonnes. This could have been accomplished by emphasizing the use of cutting-edge technology, research, and investment in research, particularly in the areas of improved farming techniques and an affordable rice milling system, as well as efficient farming input distribution, production, and growth.

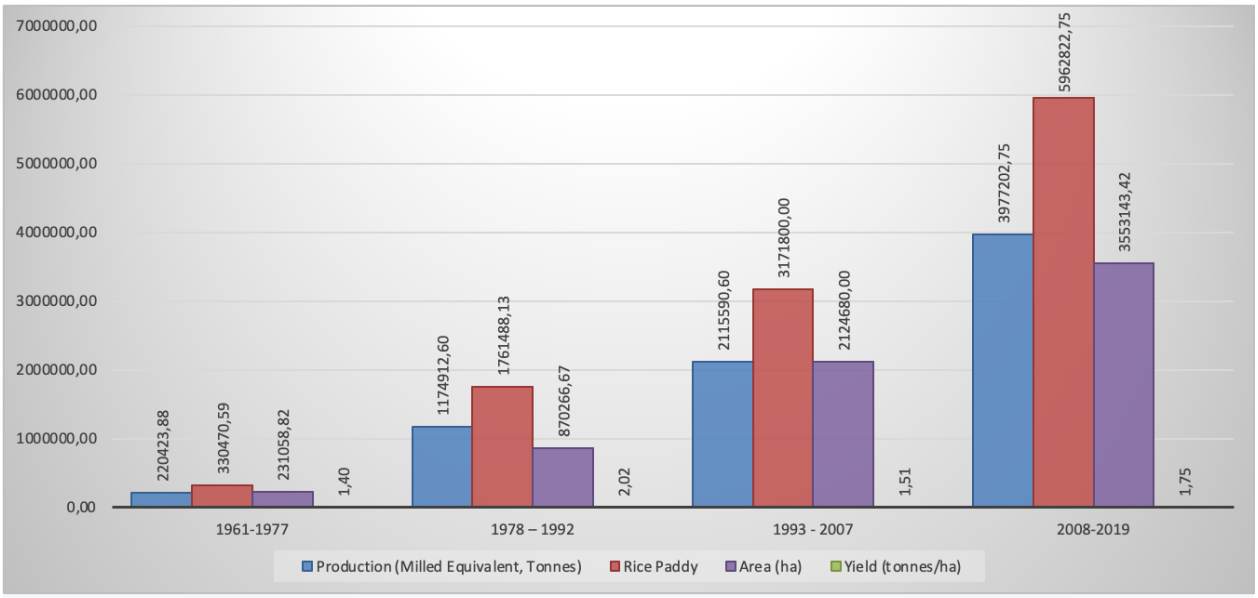

Figure 1. Trend in Growth of Rice Production Indicators viewed from Sub-Group Performance

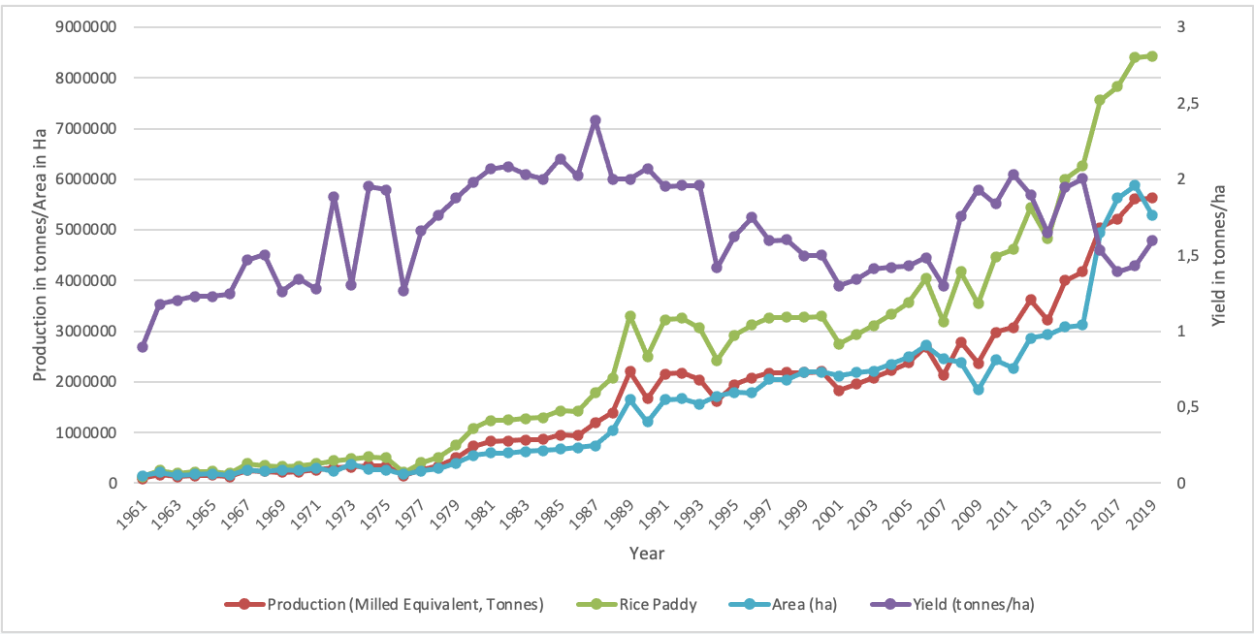

Figure 2. Trend in Area, Production and Yield of Rice in Nigeria (1961 – 2020)

4.2. Compound Annual Growth Rate (CAGR) of Area, Yield and Production of rice in Nigeria

Table 1 shows the CAGR of rice acreage, yield, and production in Nigeria from 1961 to 2020. The pooled data analysis results (1961-2020) show that the CAGR and instantaneous growth rate for rice area (15%), yield (1%), and production (16%) are all positive and significant at 1%. At this moment, the temporal pattern throughout the review period has minimal influence on rice yield increase.

In comparison to India's compound Growth Rate (CAGR) for rice yield, production, and area (4.97%; 5.48%; 0.48%), Nigeria's yield and production rates (1%; 16%) throughout the research period are comparably low, with a high compound

Growth Rate (CAGR) for the area (16%). When compared to India, Nigeria's rice sub-sector performed poorly, with compound growth rates (CAGRs) for area and yield of 0.48% and 5.48%, respectively, over the same time period. This displays inefficient use of land resources and inputs, as well as a failure to improve input technologies.

The low yield R-squared suggests that the semi-log functional form (model) failed to capture the type of movements and growth pattern in rice yield.

Table 1. Compound Growth Rate of Area, Yield and Production of Rice in Nigeria within 1961 – 2020

Group	Production Output	Yield	Area
Period I (1961 - 1977)	14.03	6.83*	6.73**
Period II (1978- 1992)	30.11*	1.05	28.76*
Period III (1993 - 2007)	3.39**	-3.98	7.68*
Period IV (2008 - 2020)	19.88*	-5.3	26.58*
Pool (1960-61 – 2019-20)	16.31*	0.71	15.45*
Model	Semi-log	Semi-log	Semi-log
R Square	0.92	0.07	0.94

Source: Authors' Estimation, 2022

4.3. Decomposition of Production of Rice in Nigeria

The outcomes of an examination of the contributions of area and yield to the rise of Nigerian rice production are shown in Table 2. The pooled data analysis (1961-2020) results show that the yield, area, and interaction effects are all positive and contribute 2%, 58%, and 40% of an upsurge in rice production in Nigeria, respectively, showing that the area effect is more highly important at 58% and that Nigeria is still not getting the best with area of land cultivated. This is due to a lack of high-quality breeding stock, poor fertilizer quality, a lack of technical understanding, and a lack of human capital, all of which result in inefficient or under-utilization of land resources.

Table 2. Percentage decomposition of area, yield and their interaction towards increasing production of Rice Production in Nigeria

Effect/Period	1961 - 1977	1978 - 1992	1993 – 2007	2008 – 2020	1961 – 2020
Yield Effect	34.59042254	2.078572	-852.832	25.41993	2.036289
Area Effect	47.46985915	88.15287	1436.573	64.2957	57.94306
Interaction Effect	17.93577465	9.766441	-483.672	10.28717	40.02148
Source: Authors' Estimation, 2022					

4.4. Instability in Area, Yield and Production of Rice

The insecurity index for rice acreage, yield, and output in Nigeria is shown in Table 3. The findings of the measures of instability reveal that yield performance was the most unstable between 1961 and 2020, with an instability index of 3.17%, while milled rice production and area under rice cultivation had instability indices of 0.94% and 0.82%, respectively.

The amount of land under cultivation of rice was the most variable of the production indicators in sub-period I (1961-1977). During the sub-period (1978-1992), rice yield was the most erratic. The insecurity index for rice acreage, yield, and output in Nigeria is shown in Table 3. The findings of the measures of instability reveal that yield performance was the most unstable between 1961 and 2020, with an instability index of 3.17%, while milled rice production and area under rice cultivation had instability indices of 0.94% and 0.82%, respectively.

The amount of land under cultivation of rice was the most variable of the production indicators in sub-period I (1961-1977). During the sub-period (1978-1992), rice yield was the most erratic.

Table 3. Instability Index for Area, Yield and Production

Periods	Production	Yield	Area
Period I (1961 - 1977)	2.33	2.38	2.78
Period II (1978- 1992)	1.04	3.22	1.08
Period III(1993 - 2007)	2.80	2.40	1.09
Period IV(2008 - 2020)	0.89	2.62	1.24
1961 -2020 (TOTAL)	0.94	3.17	0.82

Source: Authors' Estimation, 2022

5. Conclusion and Recommendation

5.1. Conclusion

The changes in milled rice production indices in Nigeria were examined in this study. Rice output is continuously growing, according to the study's findings, with a notable degree of yield instability (3.17). The CAGR result suggests that Nigeria's rice output per hectare was modest over this time. Furthermore, when area, production, and yield growth rates are compared across all time periods, rice performs substantially better in Nigeria.

The area effect (58%) has the biggest percentage contribution to the growth in rice production, according to the decomposition study, meaning that the area of land farmed for rice has been the key element in Nigeria's steady increase or development in rice output. The study discovered a significant level of insecurity in rice yield in Nigeria, which has consequences for maintaining sustainable output and a consistent supply of rice in Nigeria.

5.2. Recommendation

- The study's findings indicate a critical need for proper and precise policy targeting that focuses on the major gaps or setbacks in Nigerian rice production. Furthermore, the government, policymakers, and all other major stakeholders in Nigeria should embrace the policy/program consistency philosophy in order to match food production with rising demand.
- Rice yield volatility has serious implications for food security policy. As a result, a comprehensive approach to developing high-yielding rice varieties, improving agronomic and management practices, and deploying result-oriented extension officers to major rice producing areas that are currently cut off from updated rice production-enhancing information is required.
- Because rice is widely consumed worldwide, Nigeria should increase its share of the international rice market by improving its rice exports orientation strategy, not only for foreign earnings but also for job creation.

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