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Research article

Cassava production in Nigeria: trends, instability and decomposition analysis (1970–2018)

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ABSTRACT

This study analyzed the compound growth rate (CGR) and the contributions of yield and area to cassava production output in Nigeria. During the period, TE1970 – TE2018, production followed an upward trajectory from 9.3 million tonnes (1970) to 59.5 million tonnes (2018) while yield oscillated between 7.9tonnes/ha (TE2014) and 11.9tonnes/ha (TE2010). At this period, the CGR per year for yield declined (-0.2%), harvested area increased (10.9%) and production increased (10.6%). The decomposition analysis for the period revealed that, increase in output was largely due to expansion of harvested area (152%) while the interaction between area and yield effect declined production output by 45.8%. Regrettably, during the period, cassava yield also declined production output by 5.8%. The study also found that harvested area has the highest instability index (11.8). In order to further increase and sustain cassava production in Nigeria, intense planting of high yield cassava stems instead of solely expanding cropped area is recommended.

1. Introduction

The trauma of the global pandemic, COVID-19, in the distressed economies across Africa deserves some proposals for aggressive interventions in order to prevent it from worsening the food security challenges in the continent. The pandemic is gradually pushing African economy to its brink. Thus, the new economic imperatives demand much more from the agricultural sub-sector. Nigeria, the most populous country in Africa, is majorly a mono-economy with her crude oil as the major source of revenue to finance her budget. However, in the last one decade, the country has been impacted by the serial shocks in the global oil sector. There are concerns that further shocks in the future may worsen the whole economy architecture including agriculture if appropriate measures are not promptly taken. One of the lowest hanging fruits is to reposition the agricultural sector by putting in place insightful reforms that can enhance ease of doing agribusiness. This is predicated on the fact that a revitalized agribusiness sub-sector can transform the economy of Nigeria. Instead of adopting the global agribusiness approach and practices, agriculture in Nigeria and countries in the sub-Saharan Africa (SSA) has been largely run as part of the development programmes, without deference to effective and efficient resource management. Hence, farmers depend hugely on subsidized farm inputs like fertilizers, seeds, stems, seedlings etc from government on annual basis without adequately accounting for its efficient use. Governments do these to encourage farmers to continually produce food and raw materials for the agro-allied industries. However, the twin-challenges (less economic activities due to the pandemic and unpredictable movement in crude oil price) confronting the country at this period may bring more economic hardship to: the farmers, who may not be able to get enough input in good time due to poor response from governments; and the consumers, who may face serious hunger due to farmers' inability to produce enough for the market. This may further threaten the fragile socio-economic and political stability of the country. Despite all these, cassava production, being an important food crop among Nigerians, remains a possible and reliable alternative to: confront this impending hunger; and subtle means for sustaining the rural economy while the macro-economy heals back gradually. A cue can be taken from the way Thailand and Indonesia are promoting cassava production as a catalyst for their development. Yet, the available indicators show that Nigeria has the potentials (available arable land and labour) to do it better if appropriate measures are put in place.

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Cassava, a perennial woody shrub with an edible root, was first cultivated in South America and introduced to Nigeria in the sixteenth century (Adeniji et al., 2005). However, cassava is considered food for the poor, and has been a widely criticized crop for its propensity to deplete soil nutrients and open the farmland to erosion (Hershey et al., 2001). In view of this, a large proportion of cassava crops are grown on marginal lands (bad topography) that are usually not competitive (not too good for other crops) and some others are not tractor friendly. Another complication around cassava production is that, the type of land tenure system in Nigeria and other countries in sub-Saharan Africa does not allow for large farm holdings suitable for mechanization. The majority of cassava farmers cultivate small farm area which are not conducive or economical for mechanization. Yet, Abass et al. (2014) have argued that without mechanization, using improved inputs alone will not sufficiently boost cassava production in Nigeria. Despite these challenges, cassava is one of the fastest expanding staple food crops in cassava consuming countries and has continued to gain prominence among farmers while the industrial demand is also rising consistently (Food and Agricultural Organisation FAO, 2018). Globally, cassava has experienced consistent growth of well above 3% annually (FAO, 2018). According to FAO (2018), as of 2018, world cassava production stood at about 278 million tonnes; Africa total production was about 170 million tonnes (about 56% of world production) (FAOSTAT, 2019). At the same period, Nigeria produced about 60 million tonnes (FAOSTAT, 2019).

Despite being the largest producer of cassava in the world, more than 90% of cassava produced in Nigeria are consumed locally (Denton et al., 2004). China imports more than 80% of the total world cassava products processed into pellets and starch (FAOSTAT, 2019). The current bilateral trade agreement between Nigeria and China could further energize Nigeria's export of cassava to China in large quantity but, the current production could not even meet the local demand for food and industrial use. This supply deficit should serve as motivation for cassava farmers to produce more. According Nwokoro et al. (2002) and Kormawa and Akoroda (2003), close to 84% of domestic cassava production is available for consumption while the remaining 16% is available for industrial use in Nigeria with a caveat that more proportion could go into the industrial sector in future. In the current global cassava export charts, Thailand, Indonesia, Vietnam and Ghana are also among high cassava exporting countries (FAOSTAT, 2019). World cassava market, where cassava products are sold in different forms, is worth over $4 billion US dollars. Despite the available huge opportunities at the international cassava market (International Fund for Agricultural Development IFAD, 2000; and Prakash, 2008), most countries in the SSA still scantly participate in the market. The problem of land tenure system and other challenges militating against ease of doing business are factors discouraging investors from investing in cassava production in Nigeria despite the increasing value at the global market.

Evidence from FAOSTAT (2019) revealed that, as at 2018, Indonesia made the most tremendous improvement in terms of output per hectare between the periods of 1970 and 2017 (Table 1). This is closely followed by Vietnam, Ghana and Benin. Whereas during this period, Nigeria performed poorly as its output per hectare dipped by 3.2 tonnes/ha. However, during this period, cassava production in Nigeria has soared by about 49 million tonnes. Behind Nigeria's total cassava production of 60 million tonnes are Thailand (31 million tonnes), Indonesia (19 million tonnes) and Ghana (18 million tonnes). Between the periods, TE1970 and TE2017, cassava output growth in Thailand and Ghana are most striking after Nigeria's output. The values of compound Growth Rate (CGR) for production of cassava in Ghana, Benin and Vietnam are 15% 13% and 11% respectively (Table 1). The corresponding CGR values for yield are 5%, 6% and 5%. Regrettably, Africa's share in total world export is about 10% while Thailand and Viet-Nam/Indonesia contribute about 80% and 10% respectively to the world cassava export (International Fund for Agricultural Development IFAD, 2000; and Prakash, 2008). The world now recognizes that growing high yield cassava spurs development especially in agrarian countries (Hershey et al., 2001). The problem of how to produce beyond domestic demand and sustain supply to the international markets is one of the challenges most countries in SSA have been trying to solve for four decades. Experts have opined that countries that have enduring institutional structure to sustain cassava production have continually increased their participation as economic agents at the world cassava market.

1.1. Cassava production and increasing demand in Nigeria

The demand for cassava roots and products are high and fast rising. However, the current food production is far from being able to meet the food needs of the geometrically growing population in the sub-region (Poverty, Oxford and Human Development Initiative, 2017; and FAO, 2018). Nigeria currently holds the record of the largest producer of cassava in the world, but the trend in yield performance (production per hectare) remains low. This low yield may be linked to ineffective agronomic practices and inefficient management of production resources. This line of argument has been robustly debated in the literature (Tadele and Assefa, 2012; and Fakayode et al., 2008). According to Moyo (2016), poor management of agricultural lands has consistently affected sustainable production of food in sub-Saharan Africa [SSA]. This has largely contributed to poor performance of the agricultural sector in terms of efficient use of productive (Denning et al., 2009; and Tadele and Assefa, 2012) despite the fact that more than 60% of Nigerian population is in agriculture (Mgbenka et al., 2016; and Moyo, 2016). However, there are increasing concerns that sustaining the availability of cassava products to Nigerian households may be significantly affected by the increasing demand by the expanding agro-allied firms/industries which are using cassava as critical input. In view of this, Juma (2015) advocated

Table 1. Yield and production of cassava by major contributing countries to world cassava market.

	Yield (tonne/ha)			Production (tonnes)			CGR	
	1970 (A)	2017 (B)	(A) - (B)	1970 (A)	2017 (B)	(A) - (B)	Yield	Production
Angola	3.56	11.61	8.06	1600000	11747938	10147938	0.086	0.145
Benin	4.40	15.55	11.15	510000	4341848	3831848	0.056	0.129
Ghana	7.50	19.13	11.63	1550000	18470762	16920762	0.051	0.148
India	14.79	20.96	6.17	5214100	4171000	-1043100	0.040	0.010
Indonesia	7.49	24.45	16.95	10478310	19046000	8567690	0.055	0.038
Thailand	15.32	23.07	7.76	3431000	30973292	27542292	0.026	0.075
Vietnam	7.21	19.28	12.07	945000	10267568	9322568	0.054	0.108
Brazil	14.55	14.36	-0.20	29464272	18876470	-10587802	0.0081	-0.0076
Congo	4.61	10.76	6.15	461000	1409211	948211	0.038	0.052
Nigeria	11.91	8.76	-3.15	10206000	59485947	49279947		

Source: Author's computation from FAOSTAT, 2018.

innovative approach to agriculture and food (cassava) production. This is a way to avoid waste of productive resources i.e land and protect the environment while exploring the soil for sufficient food production with a view to ultimately achieving zero hunger.

The increasing importance of cassava (*Manihot esculenta*) among crops grown in Nigeria is not only connected to its increasing demand as food but also as food security (FAO, 2018). Cassava products are dietary staple food in Nigeria and other countries in SSA. Nigeria is populated with about 200 million people, and 7 in every 10 Nigerians consume, at least, a product of cassava once in a day (Njoku and Muoneke, 2008). These products include: cassava flakes (gari), cassava flour (pupuru and lafun), cassava paste (fufu) which are derived from cassava roots. It is a widely acceptable energy food source to over 600 million consumers of cassava across the globe (Hershey et al., 2001; and FAO, 2015). Its relatively higher energy yield per hectare [71 tonnes/ha] (El-Sharkawy, 2003). This could have endeared it directly to farmers and indirectly to consumers. These cassava products (paste & flakes) are prepared using hot water to make it into solid food that can be eaten with soup source (e.g vegetables, draw soup etc). Besides the rich carbohydrate content of the root, the leaves are also good soup ingredients and it is frequently consumed by people living in the southwest and southeastern parts of Nigeria. Cassava has been found to contain calcium, vitamins B and C, and other essential minerals (Montagnac et al., 2009). However, the quantity of nutrients in cassava is dependent on the varieties, age at the harvest time, soil conditions, climate and other environmental factors (Cock, 1982; and IITA, n.d). Evidence from recent research break-through has shown a blend of some cassava varieties fortified with missing micronutrients [e.g vitamin A] (Okwulehie et al., 2014; and Howe et al., 2009). The deployment of clear cut technologies in producing different varieties and processing of cassava products has indescribably increased the satisfaction attributes of cassava. In view of these, cassava products which used to be associated with the poor have become more acceptable to more consumers across income groups. The implication of this therefore is, if supply of cassava does not grow at the same rate as demand, the cassava market equilibrium will be altered, and in response, prices of cassava products will always fluctuate accordingly.

Major cassava producing states in Nigeria are Benue, Kogi, Cross River, Ondo, Imo, Akwa Ibom, and Rivers states (Daniels et al., 2011). Experts have argued that the cassava production is one of the well-developed agricultural crops in Nigeria because of its relatively well established and processing techniques. Cassava can be processed into varieties of products – e.g food and starch for industrial use. According to International Institute of Tropical Agriculture (IITA), cultivating cassava comes with a lot of convenience. Some of which include: its ability to do well in poor soils, its labour requirements are low, it can be inter-cropped with other crops, it matures within a period of 6 months–3 years after planting. According to Hauser et al. (2014), the most preferred precipitation for cassava plant is an annual rainfall of 1000 mm or more. It thus implies that an average of 50mm rainfall per month spreading over a period of 6 months can sufficiently meet the water need of cassava plant. The plant does not tolerate extremely stony or sandy, clayey, salt affected, waterlogged and shallow soils but performs excellently well on well-drained soils rich in aluminium and manganese. Notwithstanding, cassava is highly tolerant to erratic weather condition including a range of rainfall (El-Sharkawy, 2003).

Evidence across States in Nigeria shows that government investments and intervention to enhance cassava production have resulted to increased output and also stimulated the rural economy. Local processing of cassava has created jobs for many rural women and the local fabricators and thus, has significantly stimulated the rural economy in SSA. Similarly, it has also influenced the agricultural input supply market. Therefore, it contributes to capital formation and securing markets for the agro-industry in Nigeria. However, whether or not, the present cassava production (supply) can meet the increasing demand for cassava as food and industrial use remains a serious concern. Cassava, the cheapest and most accessible food for the poor, looks set to be pulled away by the cassava allied-industry if nothing is done to sustain or increase per capita production in Nigeria.

1.2. Agricultural development and land constraints

The consensus among development economists is that there is a strong connection between land tenure situation and economic well-being of the people particularly farmers (Merlet, 2007). However, the myriads of issues associated with land are increasingly creating the bottlenecks against business particularly agribusiness development across the world. The effect of this on cassava production is high because cassava has a long gestation period and the annual turnover is not as high as food crops with short gestation. Until the advent of large cassava based industries in across the world (Asia, Latin-America, Europe, Africa), cassava food was frequently consumed majorly by rural poor, it was not demand. For this reason, investing in cassava production was not attractive to large scale investors. However, for industrial purpose, the demand for cassava production has increased and it needs more cropping area for cultivation in addition to planting high yield performing variety. Regrettably, the inability to secure large expanse of land by big agro-investors due to land tenure situation have made subsistence cassava farming still popular. Therefore, the competitiveness for agricultural land in peri-urban is not yet favourable for the majority of these smallholder farmers who cannot afford the exorbitant land rents. The challenges from land are multi-dimensional and are more complex in the developing countries particularly in Nigeria with the intensity of rapid urbanization.

Although land is a major constraint to agriculture/agribusiness development however, it can be appropriately addressed through land policy. Land policy consists of government action(s) designed to modify existing land tenure institution in the interest of national objectives in general and particularly as an instrument for achieving greater equity and social justice. In terms of land availability and usage for agriculture/agribusiness in Africa, the land tenure system is what is vitally important. The land tenure system comprises the customary and legalized rights to the use and control over lands. It is essentially the body of rights and relationships developed between and among humans to govern their behavior in the use and control of land and other resources it harbours. In Nigeria for example, the land tenure system features a wide varieties of traditional rights, duties and restrictions concerning the use and control of lands, which are generally referred to as communal land tenure system. Under this system, land is held not by individuals but by the families, village or clans or even by the traditional ruler who acts as trustee for the group under his authority. The right to use land is based on usufruct system in which land belongs to a community member as far as it is being used but once it is not used, it reverts back to the community and indeed can be used by another person. In such as system, no community member can sell land to a stranger/foreigner.

In modern times in Nigeria and other countries in Sub-Saharan Africa (SSA), individual title to land has become common place in an increasingly money conscious and acquisitive society. This quest for individually-owned land has given rise to the phenomenon of land speculation in which some group of individuals, who have no intention to put a piece of land into any productive use, acquire it by outright purchase and hold on to it for a long period of time sufficient to increase the commercial value of the land which is later disposed off at 10–100 times the initial purchase cost 5–20 years after. The pace at which these speculators are encroaching agricultural lands in the peri-urban and rural communities is increasing thus denying farmers from cultivating the lands. Speculation has been made possible through lack of or inadequate land policy/reform that prevents speculators from engaging in this nefarious activity that has compounded land access problems/issues in SSA's urban and peri-urban areas. Land speculation is often made possible by the high rate of urbanization in African cities and their adjoining peri-urban areas. It is also fueled by the current defective/very defective public land policy in most of African countries (Osemeobo,

1992). Thus, both the traditional system of land tenure and the new and growing tendency to individual land ownership are sources of concern for agricultural development needs of Nigeria and other countries in SSA.

2. Cassava development in Nigeria

Cassava products are increasingly becoming popular in Nigerian food and agricultural markets. Thus, it provides a strong incentive for more economic agents to be involved in the cassava market. According to FAO (2018), cassava is a choice crop for rural development, poverty alleviation, economic growth and ultimately, food security. It is in view of the above that critical stakeholders have continued to contribute immensely to the debate on the development of cassava sub-sector in Nigeria. Eke-Okoro and Njoku (2012) captured the phases in the past efforts to improve cassava production in Nigeria as: the emergent stage that spread from 1940 to 1953; primitive stage that stretched from 1970 to 1995 and the anticipatory stage that spanned from 1996 to date. Other periodic classification (phases) of cassava development in Nigeria are also found in the literature.

2.1. Remarkable interventions in Nigeria cassava history

However, for the purpose of this study, two periodic phases in cassava development are chosen to systematically analyze the compound growth rate (CGR) and the contributions of yield and area to the highly celebrated cassava production output in Nigeria: "Pre – Implementation Period of Medium Term Research Plan (MTRM) of the National Agricultural Research Strategy Plan (NARSP) (1970–1995)" [Period I] and the "Implementation and Post Implementation Period of Medium Term Research Plan (MTRM) of the National Agricultural Research Strategy Plan (NARSP) (1996–2018)" [Period II].

2.1.1. Pre – Implementation Period of Medium Term Research Plan (MTRM) of the National Agricultural Research Strategy Plan (NARSP) (1970–1995) – PERIOD I

This period coincided with the marked collaboration between national and international institutions for the development of cassava in Nigeria. One of the most striking event around this period is the development of some improved cassava varieties. This international collaboration was championed by International Institute of Tropical Agriculture (IITA). This collaboration was timely because it heralded the development of highly resistant cassava varieties to withstand the virulence of cassava bacterial blight (CBB), cassava mosaic virus disease (CMD), cassava anthracnose disease (CAD), cassava mealybug (CMB) and cassava green mite (Akoroda et al., 1985). Besides, IITA, Ibadan also developed some cassava varieties with attributes of high yield with minimal cyanide content which include – "TMS 4 (2)1425 and TMS 30001". The National Root Crops Research Institute, Umudike, in the late 1980 also developed five cyanide-free cassava varieties (Sweet cassava varieties) namely: "NR 84175, NR 84292, NR 84104, NR 8959 and NR 8421" (Eke-Okoro and Njoku, 2012). The political instability between 1993 and 1995 was torturing to cassava farmers and researchers. Funds were neither timely nor sufficiently released to complete ongoing research on disease resistant cassava varieties at the period. Farmers' access to fund and input was also restricted at this period. Unfortunately, one of the sore points of the period is that the negative production pressures of the new strains of cassava mosaic virus could not be resolved.

2.1.2. Implementation and Post Implementation Period of Medium Term Research Plan (MTRM) of the National Agricultural Research Strategy Plan (NARSP) (1996–2018) – PERIOD II

This period is heralded by pre-emptive - CMD cassava development period. The first assignment in this period was to address the threats against sustainable production of cassava. One of such threats was the negative production pressure. To mitigate against this pressure, Nationally Co-Ordinated Research Programme (NCRP) was approved for cassava in 1996. This decision was indeed strategic to the implementation of policy strategies to improve cassava production in during this period. According to Eke-Okoro and Njoku (2012), notable among the achievements at this period are: "a) successful development of cassava varieties that are not only suitable for intercropping but are also resistant to virulent pests and diseases; b) well-developed techniques for long preservation of cassava stems; and c) increase the number of well-trained extension agents with adequate knowledge on the art of rapid multiplication of cassava. The NCRP also had break-through in cutting edge technology that tremendously increased cassava production from 23.3 million tonnes/annum in 1994 to 45.6 million tonnes/annum in 2010. As a result of these efforts, the annual production of cassava in Nigeria has sustained the rating of the highest producer of cassava globally (FAO, 2018). However, in 2014/2015, the dwindled revenue from crude oil affected many sectors of Nigeria economy including agricultural production particularly cassava production.

2.2. Problem statement

Breaking the jinx of perpetual low yield of cassava in Nigeria remains a challenge. The current cassava output is about 60 million tonnes produced from close to 6.5 million hectares at the rate (yield) of 9.1 tonnes/ha compared to Ghana's 20 tonnes/ha and Indonesia' 24 tonnes/ha. At 20 or 24 tonnes/ha, Nigeria should produce at about 130 million or 156 million tonnes accordingly from the same land space of 6.5 million hectares. Increasing evidence points to that the current land tenure system constrained agribusiness development thus, to continually expand cultivation area without adequate recourse to high performing yield crops is definitely not sustainable. This position is well established in the literature (Fakayode, Babatunde and Ajao, 2008). Inadequate adoption of contemporary innovations and technology have constrained cassava productive efficiency to less than 60% in most countries in sub-Saharan Africa including Nigeria (Ajibefun, 2015; and Federal Department of Agriculture (FDA), 1995). The call to address this seemingly difficult challenge has again come to the fore as the demand for cassava is increasingly gaining momentum among various consumers. Besides, in the last two decades, government agricultural policies have been favourable to production of cassava in order to the sub-sector to drive the country's economic growth. Some of these policies mandated bakers to include 10% cassava in their flour mix for bread production and flour mills to pre-mix cassava flour with wheat flour before supplying same to bakeries and confectioneries (Technical for Agricultural and Rural Cooperation (CTA), 2005). However, there are concerns that cassava production is not immured to production instability. Increasing number of authors have argued that production instability often exposes the economy to food price fluctuations that are capable of distorting consumption habit and compromising consumers' welfare (Moledina et al., 2004; Kronher, 2014; Sulewski and Kłoczko-Gajewska, 2014; Sekhar, Roy and Bhatt, 2017; and Ikuemonisan and Akinbola, 2019). The literature seems to be silent on cassava production instability in Nigeria.

There is no doubt that cassava output has increased tremendously from 9 million tonnes in 1970 to 60 million tonnes in 2018 making Nigeria the highest producer of cassava in the world (FAO, 2018). However, the literature seems scarce on the trend of cassava production in Nigeria with clear calibration for the trends in cassava production and contributions of harvested area and yield in the increasing cassava production in Nigeria. Therefore, this study questions the factors propelling cassava production with the intention to ascertain factors that substantially influence growth in the sub-sector. The import of this question becomes real as the associated challenges with expanding development infrastructure and increasing industrial drive pose a serious threat against achieving agricultural growth only through expansion of cultivated/harvested instead of high yield cassava stems. The agricultural land in the peri-urban areas is under threat in view of the increasing land speculation and infrastructural expansion to cater for the rapidly

increasing population. Besides, the fact that most cassava producers are smallholders who cannot afford intensive production sets snags on the path of cassava revolution in Nigeria. To put it more pithily, expanding cultivation area to increase cassava output may not be sustainable in the long run because as industry grows, there will be higher demand for labour and land by the industrial sector expected to come from those working in agricultural sector and agricultural land respectively.

In view of the above, this paper attempts to: (i) analyze the trend and growth in area, production and yield of cassava; (ii) evaluate the instability in the growth of area, yield and production of cassava; and (iii) contributions of area and yield to the growth of cassava production in Nigeria.

2.3. Justification

Findings from this study will contribute to the global debate on cassava production. Cassava is capable of putting the country's name among the top stakeholders in global cassava market, if proper strategies are put in place. The knowledge that the country's high production of cassava, over the years, has largely depended on land area cultivated is an evidence of unsustainable pattern of production. Therefore, such findings will provide hints to the policy makers and other stakeholders to put appropriate strategies in place to intensely advocate the need to follow the best agronomic practices and management activities to su1stainably produce cassava, which the country has comparative advantage. One of the cogent reasons for this is that, the rapid rate of urbanization in Nigeria may continue to reduce availability of agricultural land even at a time when demand for cassava products will be increasing. Thus, findings from this study will allow cassava farmers in Nigeria to compare their yield performance to others. Certainly, evidence that their output per hectare (yield) is far less than their counterparts' in Thailand, Indonesia and Vietnam will undoubtedly, stimulate their quest to embrace global best management practices for optimum cassava production.

3. Data and methodology

3.1. Data

The paper relied strongly on secondary (time series) data obtained on area, production, and yield of cassava in Nigeria for the period 1970–2018 from FAOSTAT. However, the analysis spanned across three periods: Period I (1970–1995); Period II (1996–2018) and Pool [the pool – combination of the two distinct periods] (1970–2018).

3.2. Analysis of data

3.2.1. Compound growth rate

The compound annual growth rate (CGR) was preferred to linear growth rate (LGR) in analyzing the growth rate in area, production and yield of cassava because according to (Dandekar, 1980), the LGR is not convenient for comparing two periods. In computing LGR, eliminating seasonal and cyclical fluctuations is not compelling, and the metric does not consider the compound effects in the time series data. The compound annual growth function was specified as semi-log equation as follows (Rehman et al., 2011):

$$lnY = a + bt + e \quad (1)$$

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

However, when the relative change in Y is multiplied by 100, the percentage change or growth rate in Y for an absolute change in variable 't' is obtained while the slope coefficient 'b' measures the instantaneous rate of growth. Therefore, the compound growth rate is then estimated using the following equation (Rehman et al., 2011):

$$CGR = [\text{antilog } b - 1] * 100 \quad (2)$$

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

Since analyzing the growth rate in area, production and yield of cassava does not account for the relative contributions of area and yield towards the total output change, this paper adapted component/decomposition analysis model to achieve same. The literature is replete with evidence of how this model has been used to estimate relative growth performance of individual output in agricultural production (Shadmehri, 2010; and Rehman et al., 2011; Devi et al., 2017).

3.2.2. Instability in cassava production

The study adopted both the simple coefficient of variation (CoV) and CopPock's Instability Index (PII) as measures for instability in cassava production. Measuring the instability in cassava production becomes imperative in view of widespread assertions in the literature that food production risk as well as food price volatility is high in the sub-region (Kronher, 2014; Sulewski and Kłoczko-Gajewska, 2014). More importantly, the welfare implications of these on the mass of poor farmers in the sub-region is costly (Sassi, 2014; Sekhar, Roy and Bhatt, 2017; and Ikuemonisan and Akinbola, 2019). Although Gilbert and Morgan (2010) demanded caution in interpreting standard deviation and coefficient of variation because sometimes, they could hype the risk, instability and volatility in time series.

Production instability signals unpredictable phenomenon which effects can be hurtful to people whose livelihood depend on this line of production. Put more succinctly, it connotes inefficiency and undermines sustainability of production growth. When this affects food production and distribution in developing or low income countries, the effects on the preponderance of the low income farmers can be devastating. In Nigeria, the huge population of participants in cassava market is an evidence of its importance as a source of income and food for almost all. Therefore, experts have deployed different methods to estimate instability (Coppock's instability index) in agricultural production. Ahmed and Joshi (2013) used the trend free measure of variability which is a close approximation of the average year to year percentage variation adjusted by trend. Besides, modified coefficient of variation have also been used to estimate production instability (Singh et al., 2014). Several other studies have also measured the magnitude of instability by an index developed by Parthasarathy (1984). Another index that has been used to measure production instability is Cuddy Della Valle Index (Cuddy and Valle, 1978).

Although, in the literature, standard deviation and coefficient of variation have been prominently used to measure risk and instability in agricultural production however, they have been widely criticized because it over estimates instability. Thus, this study deployed Coppock's instability index (PCII) to measure instability in cassava production in Nigeria simply because of its advantages as highlighted above. The indexes of Coppock's instability measures (PCII) are compared to those obtained from coefficient of variation (CoV).

According to Sandeep et al. (2016) and Boyal et al. (2015), Coefficient of Variation (CoV) to measure the variability in the time-series of cassava production indicators is stated below:

$$\text{CoV} = \frac{Standard\ Deviation}{Mean} \quad (3)$$

According to Coppock (1962) and Rai and Sarup (1989), Coppock's Instability Index is estimated using Eqs. 4, 5, and 6 as follows:

$$\text{Coppock's instability Index(PCII)} = \left(antilog\sqrt{logV} - 1\right) * 100 \quad (4)$$

$$logV = \frac{1}{N-1}\sum[logX_{t+1} - logX_t - M]^2 \quad (5)$$

$$M = \frac{1}{N-1}\sum[logX_{t+1} - logX_t] \quad (6)$$

where,

i. X_t is the time series variable under consideration (production/area/yield) for the i-th year (i = 1,2,3 ... N)
ii. Log values of X_t are obtained for each year and the first differences of logarithmic are then computed.
iii. Mean value of the first differences of logarithm is denoted by M (6)
iv. The value of Var. log is obtained by substituting the values of first differences and M in Eq. (5) above and finally the Instability Index (PCII) is obtained by substituting the value of Var. log in Eq. (4)

This is interpreted thus, a high PCII value is an indication of high instability value.

3.2.3. Decomposition analysis

As performed by Siju and Kombairaju (2001) and Kakali and Basu (2006), the decomposition analysis in this study was performed using the equation below:

$$\Delta P = A_b{}^*\Delta Y + Y_b{}^*\Delta A + \Delta A{}^*\Delta Y \quad (7)$$

Change in Production (Yield effect) (Area Effect) (Interaction effect).where,

$\Delta P = P_C - P_B$ = Change in Production
$\Delta Y = Y_C - Y_B$ = Change in Yield
$\Delta A = A_C - A_B$ = Change in Area
A_B, P_B and Y_B are the area, production and yield of cassava for the base year.
A_C, P_C and Y_C are the area, production and yield of cassava for the current year.

The analysis is done for 3 periods i.e. 1970–1995, 1996–2018 and 1970–2018.

Thus, the total change in cassava production is attributed to area and yield using a model that decomposes production output into three effects viz; yield, area and interaction effects.

4. Results and discussion

4.1. Trend in Area, yield and production of cassava in Nigeria

The triennium ending figures for area, yield and production of cassava in Nigeria were determined from data obtained from FAOSTAT and presented on Figure 1. The triennium ending was considered in the periodic trend to cancel out the inter-year fluctuations.

During the period under review, T1970-TE2018, cassava yield (production per hectare) oscillated between 7.9 tonnes/ha (TE2014) and 11.9 tonnes (TE2010). The corresponding production output at this period are 52 million tonnes and 41 million tonnes respectively. These periods coincided with the dwindled economy as a result drastic fall in crude oil in 2014 and the break-through of Nationally Co-Ordinated Research Programme (NCRP). When compared to cassava yield in Thailand (22.3 tonnes/ha and 18.6 tonnes/ha) and Indonesia (23.4 tonnes/ha and 20.2 tonnes/ha) at the same period, cassava in Nigeria yield performed poorly in the two instances and yield growth was also inconsistent. In TE1970, Nigeria produced an average of about 9 million tonnes at the average of 10.5 tonnes/ha. The area under the cultivation of cassava showed a steeply increasing trend from TE 1989 (1.4 million ha) to TE 1995 (2.8 million ha). At this period, output per hectare declined between 11.2 tonnes/ha and 10.6 tonnes/ha respectively. The decline in output per hectare coincided with the period when cassava in Nigeria was prevalently infested with cassava bacterial blight (CBB), cassava mosaic virus disease (CMD), cassava anthracnose disease (CAD), cassava mealybug (CMB) and cassava green mite. Soon after this period, in 1996, National Co-Ordinated Research Programme (NCRP) was approved. Hence, the collaboration between IITA, Ibadan and National Root Crops Research Institute, (NRCRI), Umudike resulted into some high yielding and low cyanide cassava varieties. This led to a decreasing increasing yield from 10.5 tonnes/ha in TE 1993 to 10.7 tonnes/ha in 1999 but slipped down to 9.6 tonnes/ha in 2001. Despite this decline in yield, output continued to increase as a result of expanded area of cultivation. The decline was linked to the pressure of the new strain of cassava mosaic disease (CMD). Respite soon came when IITA, Ibadan in collaboration with NRCRI, Umudike released new cassava varieties to check this disease. These efforts manifested in the increased yield between TE 2002 (9.7 tonnes/ha and 32.7 million tonnes) and TE 2010 (11.9 tonnes/ha).

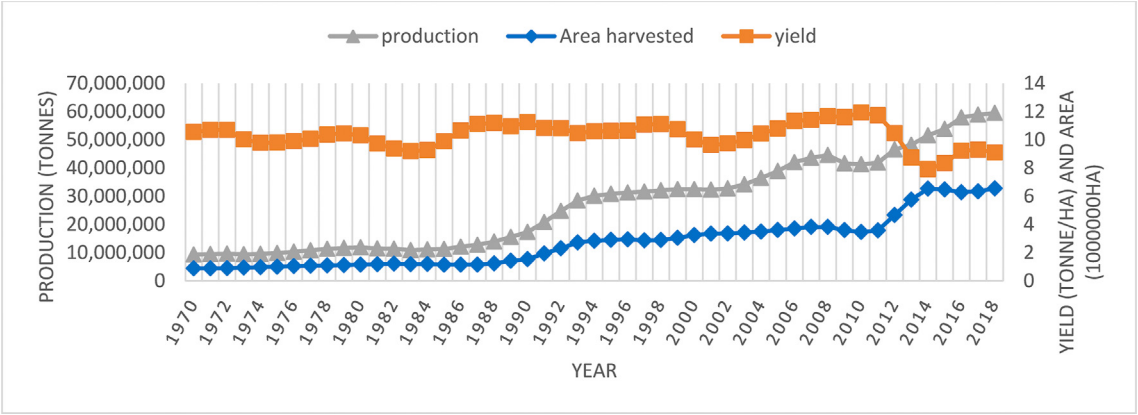

Figure 1. Trend in area, production and yield of cassava in Nigeria (TE1970 – TE2018). Source: FAOSTAT, 2019.

Similarly, the period also witnessed output increase up till TE 2008 (44 million tonnes) after which production dropped to 41.8million tonnes in 2011. This period coincided with global economic shock which affected food prices and production. Yield also fell from 11.7 tonnes/ha in TE 2011 to 7.9 tonnes/ha in TE 2014. In TE 2014–2018, the total cassava output harvested from 51.6 million to 59.5 tonnes, The Anchor Borrower Programme (ABP) launched in 2015 could have also contributed to the increased yield in TE 2018 after the shortfall in TE 2014.

4.2. Instability in area, yield and production of cassava

The instability index for area, yield and production of cassava in Nigeria is presented in Table 2. The difference between the index of instability measured by CoV and PCII is too wide apart. It thus confirms the submission that in most cases, standard deviation and coefficient of variation hype the risk, instability and volatility in time series (Gilbert and Morgan, 2010). Therefore, this study interprets only the PCII. The table shows that the values of instability of land put under the cultivation and yield of cassava are more pronounced in Period II [1996–2018] (12.2% and 11.2% respectively). However, instability in cassava output declined from 9.5% in Period 1 (TE1970 – 1995) to 7.6%% in Period II (TE1996 – 2018). In the pooled data, which is the combination of the periods I & II, area allocated to the production of cassava (11.8%) is the most uncertain and closely followed by production per ha (9.9%) and production output (8.7%). Since instability/uncertainty is an indication of unpredictable future outcome (area that can be allocated for cassava production, yield of cassava and cassava output), it thus implies that future market and prices are also uncertain. This demand pressure can further be hyped with increasing number of high volume of cassava demanding ethanol (biofuel) and starch firms. There is evidence that both local and international markets for ethanol fuel and starch as well as other cassava products are expanding, and as many investors who are able to start up production in Nigeria may escalate imbalance in cassava market.

4.3. Compound growth rate of area, yield and production of cassava in Nigeria

The CGR of area, yield and production of cassava in Nigeria between 1970 – 2018 was presented on Table 3. During the period I, TE1970 – 1995, CGR for area (10.8%), yield (0.7%) and production (11.5%) are positive and instantaneous growth rate is significant at 1% apiece for area and production respectively. Thus, it implies that changes in area yield and output per hectare are significantly influenced by time trend during this period.

During the period II, TE1996 – 2018, CGR and instantaneous growth rate for area (9.5%) and production (7.5%) for cassava are positive and statistically significant accordingly at 1% apiece. In this period, both CGR and instantaneous growth rate for yield are negative and not statistically significant. It means that time trend is significant in the growth of area and production of cassava during the period II (1996–2018).

The results from the analysis of the pooled data (TE1970 – 2018) show that CGR and instantaneous growth rate for area (10.9%) and production (10.6%) of cassava are positive and significant at 1% apiece. In this period, the growth in yield of cassava is not influenced by time trend during the period of review. When compared to the values of compound Growth Rate (CGR) for yield and production of cassava in Ghana (5.1%; 14.8%), Benin (5.6%; 12.9%) and Vietnam (5.4%; 10.8%), Nigeria's rate of performance for yield and production (-0.2%; 10.6%) within the period under review is ridiculously low while that of production comes after that of Vietnam. This paints a gloomy and relatively poor performance of cassava sub-sector in Nigeria especially in the face of rapidly growing population and quest to diversify the economy. While Nigeria is still struggling to have an increased share in world cassava market, the growing output could be further jeopardized as agricultural land and farm labour decreases as a result of expanding industrial and other development infrastructure.

4.4. Decomposition of production of cassava in Nigeria

Table 4 revealed the Compound Growth Rate (CGR) and pattern of growth of area, yield and production of cassava in Nigeria. The table revealed the results of the analysis of contributions of area and yield to the growth of cassava production in Nigeria. This is necessary because Figure 1 only presented the analysis of trend in the growth of area, yield and production of cassava and Table 3 showed the CGR for same between TE1970 – TE2018 but did not evaluate the contribution of area and yield to the production growth of cassava in Nigeria. To achieve the latter, changes in cassava is broken into three effects: yield effect, area effect and interaction effect. The decomposition analysis was done for disaggregated data as follows: period I; period II and Pool.

Figure 1 clearly indicated consistent increase in the output of cassava in Nigeria during the period under review. However, the decomposition analysis revealed that in the period, TE1970 – TE1995, only the area effect positively contributed to the increase in cassava production at this period. The 117% compensated for the negative yield effect (-5.02%) and interaction effect (-12.23%). The crux of this is that increase in production of cassava over this period occurred as a result of expanded area of land cultivated. The scenario is not different during the period, TE1996 -TE2018. At this period, both yield and interaction effects were negative and contributed -18.06% and -22.58% respectively to increase in cassava production in Nigeria. The area harvested still contributed largely to the production of cassava. Although the contribution of area harvested is relatively small compared to TE1970-TE1995. This is because the period, 1996–2018, coincided with the period when on-going cassava multiplication programmes for optimum production and high yield in cassava in Nigeria dominated cassava input market (Root and Tubers Expansion Programme (RTEP), 2002). The Anchor Borrower Programme (ABP) could have also contributed to the increased adoption of high yield cassava stems by farmers after it was launched in 2015.

However, in the Pool, TE1970 -TE2018, the contribution of area effect was not only positive but also very high (152%). During this period, the harvested area also compensated for the negative effects of the yield (-6%) and interaction between yield and area effects (-46%).

Table 2. Instability index for area, yield and production.

		Area (ha)	Yield tonne/ha	Production (1000 tonnes)
Period I (TE1970 - TE1995)	CoV	48.30	7.37	50.47
	PCII	11.24	8.33	9.45
Period II (TE1996- TE2018)	CoV	33.71	13.11	23.57
	PCII	12.22	11.26	7.59
Pool (TE1970 - TE2018)	CoV	65.51	10.50	59.11
	PCII	11.81	9.89	8.76

Source: Authors' Computation, 2019.

Table 3. Compound growth rate of area, yield and production of cassava in Nigeria between 1970 – 2017.

	Area	Yield	Production
Period I:	0.0444*** (0.004) [0.108]	0.0028^{NS} (0.002) [0.007]	0.0473*** (0.005) [0.115]
Period II:	0.0394*** (0.004) [0.095]	-0.0081^{NS} (0.004) [-0.019]	0.0312*** (0.002) [0.075]
Pool:	0.0445*** (0.001) [0.109]	-0.0009 ^{NS} (0.001) [-0.002]	0.0437*** (0.002) [0.106]

Source: Authors' Computation, 2019. *** significant at 1%; NS: non-significant. Figures in ( ) and [ ] are standard errors and CGR respectively.

Table 4. Percentage decompositions of area, yield and their interaction towards increasing production of Cassava Production in Nigeria.

Effect/Period	1970–2018	1970–1995	1996–2018
Yield Effect	-5.79	-5.02	-18.06
Area Effect	151.63	117.25	140.64
Interaction Effect	-45.83	-12.23	-22.58

Source: Authors' Computation, 2019.

5. Summary, policy Implications and recommendations

The study analyzed the trend and the decomposition of cassava output growth in Nigeria between the period, TE1970 – TE2018. Findings revealed that there was consistent growth both in harvested area and cassava production (output) in Nigeria but output per hectare was inconsistent through the period under review. In an attempt to assess the Compound Growth Rate of area, yield and production of cassava, the study found that time trend significantly influenced changes in harvested area and cassava production at 1% and the values of CGR are 10.9% and 10.6% accordingly between TE 1970–2018. However, CGR was negative for yield during the periods, TE1970 – 2018 (-0.2%) and TE1970 - 1995 (-0.2%). This signaled the weakness in the output per hectare of cassava in Nigeria.

Findings of this study suggest that major proportion of cassava crops is consumed and only less than 5% is traded at the global level. Moreover, growth of cassava production has been consistently high between 1970-2017 and production grew at a rate as high as 10.6% per year. However, this growth has been largely possible primarily owing to expanded harvested. As cassava production was growing, the harvested area followed the same growth trend of 10.9% per annum. This growth pattern in the two production indicators punctures the impact of yield within the period. During this period, the growth of yield was not only inconsistent but declining at 0.2% annually. Between the period, 2011 and 2017, the downward trajectory of cassava yield became pronounced yet the production kept growing because of the expansion of the cropped area. Also of concern is the index of instability as measured by Coppock (PCII) for harvested area (11.8) and yield of cassava (9.9) during the reference period (1970–2017).

The fact is that depending on this pattern of cassava production system may widen the gap between demand and supply of cassava in the future. A number of cassava farmers cultivate in the peri-urban areas by combining farming with other jobs in order to take advantage of urban infrastructure like markets to sell their products; good roads to transport their products; electricity for processing and have access to information, health facilities and other life enhancing factors. Doing this will allow them to increase their supplementary income. Therefore, as urbanization expands into the farming areas of peri-urban, cassava cropped areas are threatened. The implication is reduction or elimination of the supplementary income. Relocating to the rural communities where these life enhancing facilities are lacking would be the least for consideration by the affected farmers. Urbanization will also drive more youths to migrate from the rural communities to the urban and peri-urban as relatively more lucrative opportunities there become more inviting. The situation may cause more farmers in the peri-urban to abandon cassava farming to engage in other enterprises because of decline in agricultural land. The intensity of urbanization will determine the downward trajectory of cassava production. Another source of concern for farmers in the rural areas is that, farmers are ageing and the capacity to expand their cultivated area may decline in the future. Moreover, the rate at which the youths are migrating from the rural communities may reduce the available labour for farming activities and consequently, low cassava production output. All these will reduce available food for household consumption and may trigger increase in the number of victims of hunger.

Given the instability of available land for farming and declining state of cassava yield in Nigeria, it would be prudent to plan future domestic cassava production in such a way that major share of demand is fulfilled by domestic production. Reducing over dependence on cropped area and intensifying the planting of high yield performing cultivars would increase cassava production and overall welfare of the farmers. Planting high cassava yield of about 20–24 tonnes/hectares instead of the current 9 tonnes/ha variety can increase cassava output from the present 60 million tonnes to about 130–156 million tonnes from the present 6.5 ha of cultivated area.

The study therefore, recommends policy strategies that promote; best agronomic practices, intensive cassava production using improved varieties with minimal land and labour, and adequate support to fund scientific researches on how to develop improved cassava varieties. Above all, appropriate reform on the contemporary land policy with a view to mainstreaming land governance in investment programmes and projects of agriculture will bring boost to agricultural output including cassava.

Declarations

Author contribution statement

Edamisan Stephen Ikuemonisan: Conceived and designed the experiments; Analyzed and interpreted the data.

Taiwo Ejiola Mafimisebi, Kemisola Adenegan: Contributed analysis tools or data; Wrote the paper.

Igbekele Ajibefun: Analyzed and interpreted the data.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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