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Trend Analysis of Productivity of Some Selected Cereal Crops in Nigeria: 1983-2008.

Tahir, Hussaini. Mairiga
Department of Economics, Faculty of Social and Management Sciences, Bauchi State University, Gadau. Bauchi Campus, Bauchi. Bauchi State – Nigeria.
mairiga2013@gmail.com

Abstract
The study aimed at examining the trends of productivity of maize and sorghum in Nigeria between 1983 and 2008. Time series data in respect of annual yield (Kg/hectare) of the selected arable crops covering the period of study were obtained. Productivity was assessed using area harvested i.e. the quantity of crop produced per unit area harvested, given that yield growth rate remains the most commonly used indicator of productivity growth in a developing country's agriculture. Trend analysis of the productivity of the crops was undertaken to determine changes across period of production. Trends of crops' productivity were analyzed using graphical methods. Ratios and percentages were used to measure productivity (yield) growth rates of the selected crops of study. Data fitted on line graphs using Linear, Exponential, Polynomial and Logarithmic functional forms with trend lines created through the line graphs and extended over five (5) periods enabled quantitative analysis of the data and forecast. Polynomial function which gave the best fit in terms of the magnitude of the coefficient of determination (R^2) was chosen and presented. Trend analyses show a stagnating and or declining growth rate for the crops of study while the current and future trends of productivity as depicted by the R^2 values in respect of maize was strong at 0.678 and relatively weak for sorghum at 0.292. It is recommended that measures conducive for farmers to achieving stable yields for enhanced performance of crops in terms of productivity, pricing and marketability and expansion of cultivable land be adopted.
Keywords: Productivity, Growth Rate, Functional Form, Analytical Trend, Coefficient of Determination.

1.0 Introduction

The role of agriculture in economic development of most countries can hardly be overemphasized (Timmer, 2003). And as Henao and Baanante (2006) assert the economic development of Africa, more than any other region, depends on development of the agricultural and agro-industry sectors, which are fundamentally affected by productivity and land resources; particularly for Sub-Saharan Africa. Agriculture as the main stay of Nigerian economy, provides primary means of employment for Nigeria and accounts for more than one third of total gross domestic product (GDP) (Kolawole and Ojo, 2007), with more than 70% of the working adult populations employed in the agricultural sector directly or indirectly.

Agriculture, in the 1960s, was both the mainstay of the Nigerian economy and the chief foreign exchange earner (Chigbu, 2005); and accounted for well over 80 percent of the export earnings and employment; about 65 percent of the GDP (gross domestic product) and about 50 percent of the government revenue (FGN, 2000). As noted by the Vision 20: 2020, National Technical Working Group (NTWG) on agriculture and food security, agriculture has always played a key role in the nation's economy, currently contributing about 42% of Gross Domestic Product (GDP) as against 13% for Oil & Gas; and employing two thirds of the entire labour force, but, over the past 20 years, value added per capita in agriculture has risen by less than one (1) percent annually (NTWG, 2009). The competitiveness of agriculture was eroded with the discovery of oil and subsequent neglect of the agricultural sector. However, Oil is a limited asset and subject to unpredictable fluctuation in price; hence a non-sustainable resource. Therefore, its production has a potential ending thus indicating that, since agriculture accounts for a major share of the country's GDP and generates a large amount of employment; Nigeria's strategy for stimulating the growth of non oil sector should focus on agriculture. And, as Ukeje (2002) observed, Nigeria's enormous resource base if well managed could support a vibrant agricultural sector capable of ensuring the supply of raw materials for the industrial sector as well as providing gainful employment for the teeming population.

The agricultural sector comprises crop production, fishery, livestock and forestry. Crop production is the dominant activity accounting for 35.64% from 2000-2007, relative to livestock (2.83%) and forestry (0.59%) from 2000-2007 (Balami *et al*. 2011). According to NEARLS (1996), the major cereal crops in Nigeria are rice, maize, sorghum, wheat, pearl, millet, sugar cane and fonio millet with rice ranking as the sixth major crop in terms of the land area while sorghum account for 50% of the total cereal production and occupies about 45% of the total land area devoted to cereal production in Nigeria. Cereals are a major contributor to agriculture and food security in Nigeria; consist of between 55 - 60% of subsistent farmers output, and provide incomes as well as form the basis of many a households' diets both in the rural and urban areas (Balami *et al.* 2011).

The trend in production indicates that the cultivation and output of cereals has been on the increase. Balami *et al*. (2011) for example, observed that, for the yearly percentage changes, taking year 2000 as the base year, shows that maize has grown from a low of 126% to 199% in year 2010, millet, from 60% to 94%, sorghum from 94% to 153%, rice from 80% to 127%, while acha from 84% to 109%, from 2000 to 2010 respectively. But, the increase in cereal output is large, due to increased cultivation of land area rather than productivity (NTGW, 2009; Nkonya *et al.* 2010 and Balami *et al.* 2011).

According to the Food and Agriculture Organization (FAO), the world as a whole has been making progress towards improved food security and nutrition given the substantial increases in per capita food supplies achieved globally and for large proportion of the developing world (FAO, 2002); but progress was slow and uneven. Prahbu and Hesey (1999) also observed that, phenomenal growth of cereal crop productivity has been witnessed in the developing world: rice in Asia, wheat, globally in irrigated and favorable production environments, and maize in Mesoamerica and selected locations in Africa and Asia. The extraordinary growth in cereal crop productivity, aptly termed the Green Revolution, according to Prabhu and Hesey (1999), resulted from an increase in land productivity and occurred in areas of growing land scarcity and/or areas with high land values. It was always associated with strong market infrastructure and supportive government policies. However, in the recent past, indicators show a decrease in the growth rate of productivity of cereal crops, especially in the intensively cultivated lands. This reduction in productivity growth, according to Prabhu and Hesey (1999) can be attributed to degradation of the land resource base due to intensive cultivation, declining infrastructure and research investment; and the increasing opportunity cost of labor.

In contrast, Prabhu and Hesey (1999) further note that cereal crop output and productivity growth rates had been particularly low in sub-Saharan Africa over the last few decades. Balami *et al.* (2011) observed that factors militating against the realization of potentials of cereal growth in productivity in sub-Saharan Africa include: failure to modernize agriculture on a large scale, poor access to credit, high cost of farm inputs, low adoption of research findings, outdated land tenure system, weakened extension services, over emphasis on inefficient fertilizer procurement and distribution and poor and inadequate access to markets. In many parts of the region, rapid population growth has outstripped more modest gains in food crop production.

The changing global trends pose food security threats to countries such as Nigeria, which are food import dependent. The Food and Agriculture Organization (FAO) asserts that the level of Nigeria's self sufficiency in cereals has been falling resulting in rapid growth in the amounts of cereals imports, especially rice imports, which increased 130 percent in 2001 over the previous five year average (FAO, 2001).

In view of the overriding need to enhance the level of agricultural productivity, particularly of food grains, in the face of increasing population and declining agricultural output/yield in developing countries such as Nigeria, the importance of determining empirically quantitative relationships that provide estimates of changes in current and expected output and yield associated with input use cannot therefore be overemphasized.

The main objective of this study therefore, is to examine the trend of productivity of maize and sorghum in Nigeria between 1983 and 2008.

2.0 Methodology

The Nigerian savannah ecology is the major cereal production area in Nigeria. It accounts for about 665,600 square kilometres (about 67 million hectares), which also represent about 70% of the geographical area of Nigeria (Idem and Showemimo, 2004). It is located between latitude 07° to 14°N and longitude 03° and 15°E. Ogungubile and Olukosi (1991) assert that 85% of country's land mass lies within the savannah region. Rainfall is primary source of agricultural water for cereal crop production in Nigeria. The rain fall distribution ranges from a unimodal patter of the Sudan, Sahel and the Northern Guinea with annual precipitation of 400 – 600 mm to the bimodal pattern of the Southern Guinea with annual rain fall of 1100 – 1400 mm (FAO, 1996). The inter-annual variability of rainfall particular in the northern part is large, often results in climate hazards, especially floods and droughts with devastating effects on food production and associated with calamities and sufferings (Ismaila *et al.* 2010)

2.1 Scope of study

The study was designed to cover a period of 26 years (1983 – 2008) with a five (5) year forecasting period to 2013. Series data in respect of annual yields (kg/hectare) of the selected cereal crops obtained from the Food and Agriculture Organization (FAO) statistical database, FAOSTAT; were used for the study.

2.2 Method of data analysis

In examining the trend of productivity of the selected cereal crops in Nigeria between 1983 and 2008, trend analysis of the productivity of the crops of study was undertaken to determine changes across period of production. Productivity was assessed using area harvested i.e. the quantity of crop produced per unit area harvested given that, yield growth rate remains the most commonly used indicator of productivity growth in a developing country's agriculture (Oni *et al;* 2009).Trend of crops' productivity was analyzed using graphical methods. Ratios and percentages were used to measure productivity (yield) growth rate of the selected arable

crops of study. Data were fitted on line graphs using four functional forms namely, linear, exponential, polynomial and logarithmic functional forms with trend lines were created through the line graphs and extended over five (5) periods to enable quantitative analysis of the data and forecast; using tools in Microsoft Excel. Polynomial function gave the best fit in terms of the magnitude of the coefficient of determination (R^2) and was chosen and presented.

3.0 Results and Discussion

Trend of productivity and growth rate in the agricultural sector varies from crop to crop.

The trends of productivity and growth rates in respect of cereal crops (maize and sorghum) are presented in Table1 and Figure 1

Table1: Productivity trend and growth rate of cereal crops (maize and sorghum) in Nigeria (1983-2008)

Year	Yield of maize(kg/ha)	Growth rate (%) of maize	Yield of sorghum(kg/ha)	Growth rate (%) of sorghum
1983	9707		16202	
1984	11390	17.34	10449	-35.51
1985	11735	3.03	10101	-3.33
1986	12679	8.04	10540	4.35
1987	13533	6.74	10631	0.86
1988	16401	21.19	10850	2.06
1989	13950	-14.94	9752	-10.12
1990	11301	-18.99	10000	2.54
1991	11299	-0.02	9691	-3.09
1992	11181	-1.04	10795	11.39
1993	11848	5.97	10796	0.009
1994	12720	7.36	10800	0.04
1995	12666	-0.42	11480	6.30
1996	13261	4.70	11442	-0.33
1997	12510	-5.66	11075	-3.21
1998	13200	5.52	11328	2.28
1999	15998	21.20	11261	-0.59
2000	13001	-18.73	11200	-0.54
2001	13999	7.68	11000	-1.79
2002	14899	6.43	11000	0
2003	14999	0.67	11559	5.06
2004	16002	6.69	12200	5.55
2005	16598	3.72	12600	3.28
2006	18182	9.54	13500	7.14
2007	17049	-6.23	11595	-14.11
2008	19571	14.79	12233	5.50

Average growth rate of maize = 3.25%

Average growth rate of sorghum = -0.63%

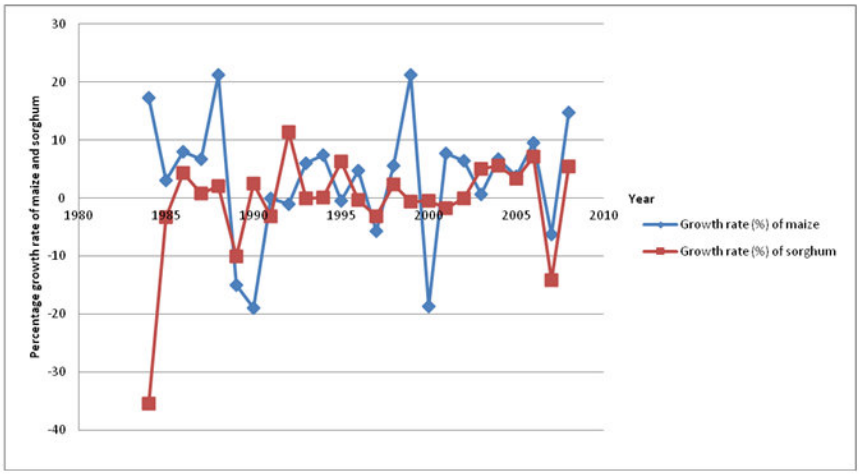

Fig.1: Productivity growth rate of maize and sorghum in Nigeria (1983-2008)

Result in respect of maize productivity shows a steady rise in total yield from 9,707 Kg/ha in 1983 to 16,401 Kg/ha in 1988, then exhibiting a declining trend to 11,848 Kg/ha in 1993, and subsequent rise reaching its peak, of 19,571 Kg/ha in 2008. Productivity growth rate of maize also exhibited a fluctuating trend with the highest growth rate of 21.20% recorded in 1999 which may be attributable to the previous year's high price and increased output of the crop during the year; while the lowest negative growth rate of -18.73% was recorded in 2000, due to the declining trend of hectrage harvested resulting from a sharp fall in the price of the crop in 1999. Average productivity growth rate of maize stood at 3.25% over the period of study.

The trend of productivity in respect of sorghum however, was marginal over the period of study. The highest productivity level of 16,202 Kg/ha was recorded in 1983. Subsequently, productivity declined to 9,691 kg/ha in 1991, and consequently exhibiting a fluctuating trend with minimal positive and negative changes, over the period of study. Productivity growth rate of sorghum recorded its highest positive point in 1992 of 11.39%, due to the tremendous increase in total output despite the contraction in hectrage harvested and decrease in previous year's price of the crop. A 0% growth rate in crop productivity was recorded in 2002. However, the highest decline in the productivity of -35.51% was recorded in 1984, which may be attributable to the relatively low yield/hectare recorded. The average growth rate of sorghum productivity stood at -0.63% over the period of study.

The result for growth rate of maize follows the findings of Prabhu and Hesey (1999) which explained that maize yields in developing countries, excluding the commercial producers (China, Brazil, Argentina, Chile, and South Africa, who plant a majority of their maize as hybrids), grew at somewhat less than 2% annually during 1956-1995. The analysis demonstrates that productivity growth rate for both maize and sorghum appear to fluctuate randomly, especially, for sorghum. More so, Prabhu and Hesey (1999) had reported that, yield growth rates for maize do not display the patterns found in rice and wheat, the rates appear to fluctuate more randomly.

The predominantly rainfed nature of cereal production in Nigeria, and its subsistence orientation account for its low and fluctuating growth rates. The economic implication of the fluctuating growth rate pattern of cereals output is that, yield, a biological product, is subject to the dictates of nature and cannot be controlled. The minimal growth rate indicates slow development of the agricultural sector, hence low contribution to the Gross Domestic Product (GDP).

Trend analyses show stagnating and or declining growth rates for the crops of study.

3.1 Analytical Trend and Productivity Forecast of Cereal Crops

Time series data in respect of the selected crops of study fitted on line graphs using the polynomial functional form, with trend lines extended over five year period; thereby enabling quantitative analyses of the data and forecasts were chosen and presented in this study. The choice of presenting analyses and forecast results obtained from polynomial functional form was based on the volatility in trend of the series data as depicted by the curved nature of the line graphs and the magnitude of the coefficient of determination (R^2) obtained. The resultant R^2 values, or the coefficient of determination, show the strength of the explanatory variables in explaining the behavior of the dependent variable i.e. the degree to which changes in the productivity of the crops are explained by the time factor.

Analytical line graphs in respect of cereal crops (maize and sorghum) productivity are presented in Figure 2.

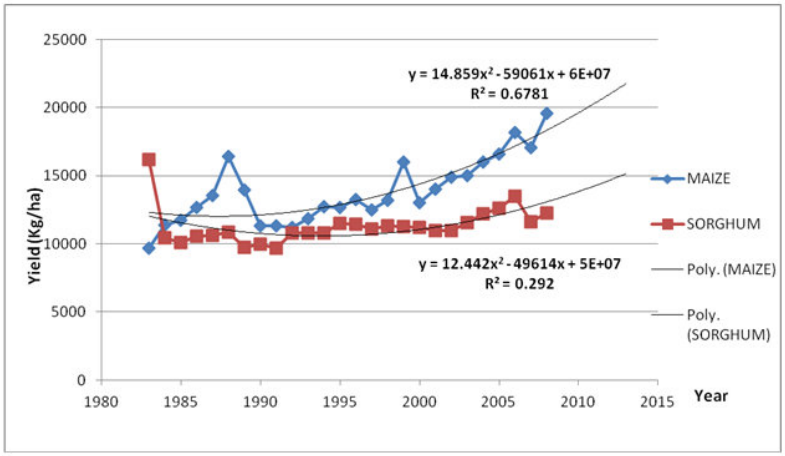

Fig.2: Trend analysis of maize and sorghum productivity via polynomial functional form with five year forecast trend lines.

The result of the analysis showed that the coefficients of determination i.e. R^2 values for maize and

sorghum crops productivity were 0.678 and 0.292 respectively, thereby indicating a positive second order relationship between the yields of the crops and the trend factor (period of production and forecasted five year period). It can be generally concluded that the trend of productivity over the period of study and including the five year forecast period, up to 2013, is strong at 68% for maize while it is relatively weak or below average at 29% for sorghum.

Summary of results in respect of trends of productivity for the selected crops of study (1983-2008) with a five year growth forecast up to 2013 via linear, exponential, polynomial and logarithmic functions; the corresponding line graphs; trend of hectrage and price trend can be found in the appendices I – IV.

4.0 Conclusions and Recommendations

The study examined the productivity trend and growth rates of maize and sorghum between 1983 and 2008; and analytically determined and forecasted the crops trend of productivity up to 2013. Trend analyses showed stagnating and or declining growth rates for the crops, while the trend of productivity over the period of study and including the five year forecast period up to 2013 was strong at 68% for maize and relatively weak at 28% for sorghum. The coefficients of determination, R^2 values obtained reflect a strong positive relationship between the yield of maize and the trend factor on one hand, and a weak positive relationship between the yield of sorghum and the trend factor on the other.

The trend is consistent with findings from previous studies. The major constraints to increased crops productivity in Nigeria include rapid population growth relative to the level of agricultural production, inelastic demand for basic cereals, poor market infrastructure, and little incentive to invest in /adopt productivity enhancing technologies; land degradation and ownership pattern of cultivable lands among others.

It is recommended that measures conducive for farmers to achieving stable yields for enhanced performance of crops in terms of productivity, pricing and marketability and expansion of cultivable land be adopted.

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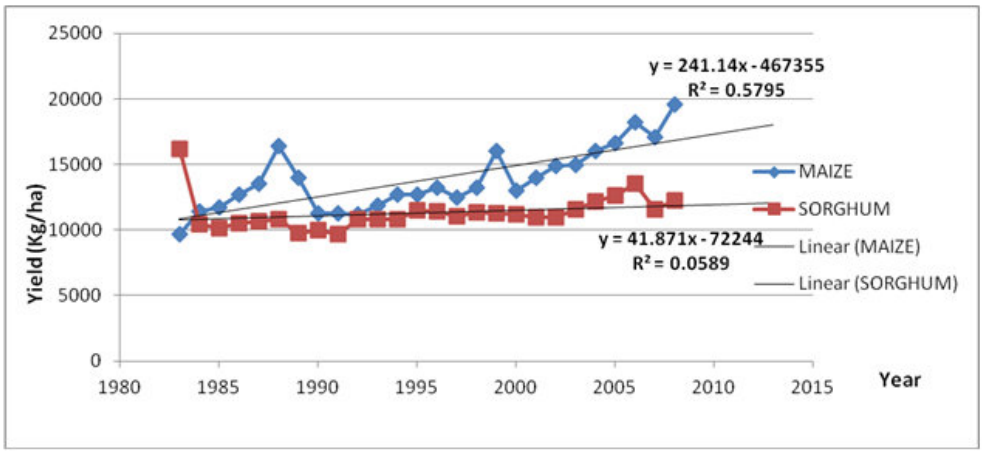
APPENDICES

APPENDIX I

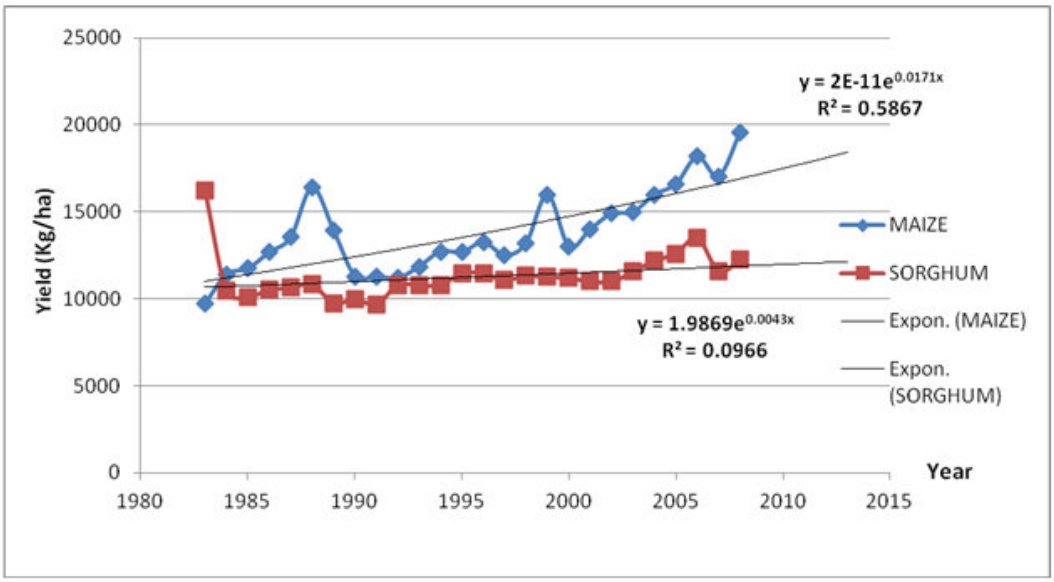
TREND OF PRODUCTIVITY IN RESPECT OF SELECTED CEREAL CROPS (1983-2008) WITH A FIVE (5) YEAR GROWTH FORECAST VIA LINEAR, EXPONENTIAL, POLYNOMIAL AND LOGARITHMIC FUNCTIONS

Functional form / Crops	*Linear*	*Exponential*	*Polynomial*	*Logarithmic*
Maize	$y = 241.1x - 46735$ $R^2=0.579$	$y = 2E\text{-}11e^{0.017x}$ $R^2=0.586$	$y = 14.85x^2 - 59061x + 6E+07$ $R^2=0.678$	$y = 48085\ln(x) - 4E+06$ $R^2 = 0.578$
Sorghum	$y = 41.87x - 72244$ $R^2=0.058$	$y = 1.986e^{0.004x}$ $R^2=0.096$	$y = 12.44x^2 - 49614x + 5E+07$ $R^2=0.292$	$y = 83274\ln(x) - 62146$ $R^2 = 0.058$

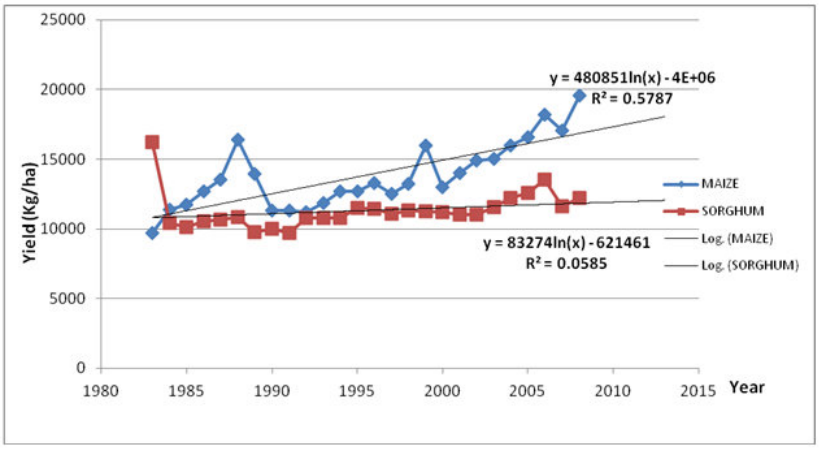
APPENDIX II



Trend Analysis (Line Graphs) in Respect of Maize and Sorghum via Linear Functional Form with Five Year Forecast Trendlines

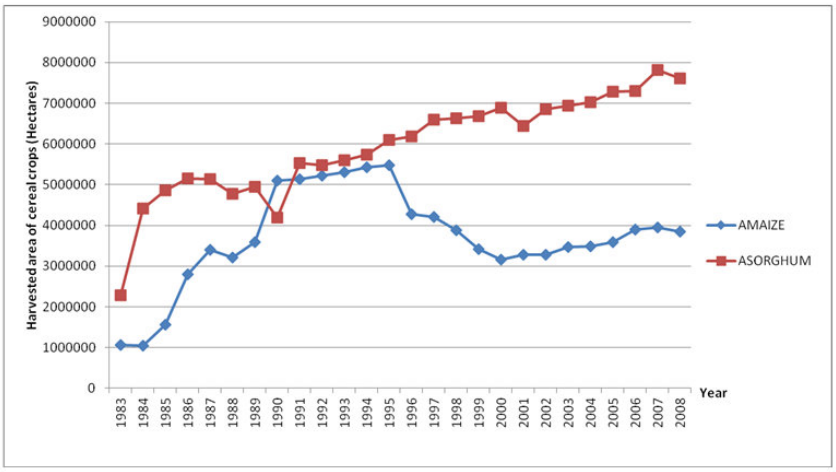


Trend Analysis (Line Graphs) in Respect of Maize and Sorghum via Exponential Functional Form with Five Year Forecast Trendlines



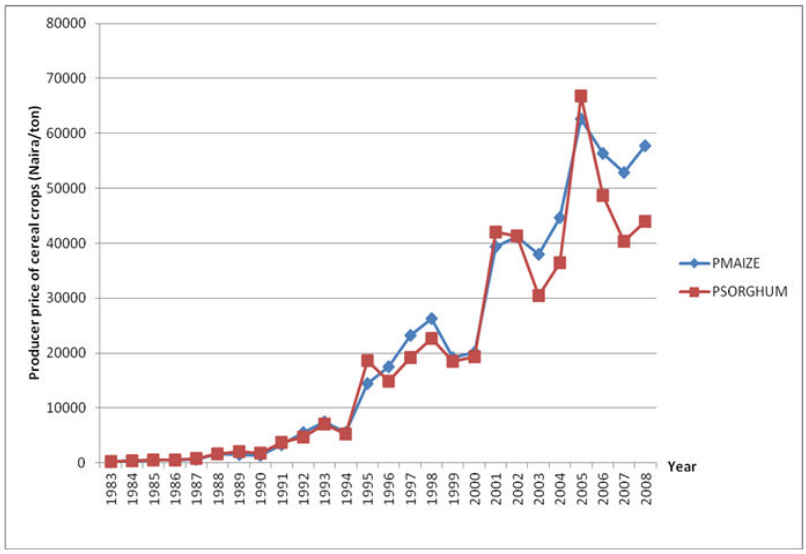
Trend Analysis (Line Graphs) in Respect of Maize and Sorghum via Logarithmic Functional Form with Five Year Forecast Trendlines

APPENDIX III



Trend of Hectrage of Maize and sorghum (Hectares) in Nigeria: 1983-2008

APPENDIX IV



Price Trend of Maize and Sorghum (Naira/ton) in Nigeria: 1983-2008

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