



Comparison in Trend Analysis of Annual Rainfall Variability on Grain Yield Pattern in Gusau Station, Zamfara State, Nigeria

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Abstract

Rainfall is a major determinant of agricultural production in any agro ecological zone like Gusau. Its seasonal and annual characteristics such as the onset and intra- seasonal rainfall distribution that promote good crop yields are, however, characterized by marked fluctuations. This study compared 15 years (1996-2010) trend in annual rainfall variability on three grain crops yields (millet, sorghum and maize) in Zamfara State, Nigeria. Annual rainfall records for 15 years (1996–2010) for Gusau station were obtained from the Nigerian Meteorological Services Department, Lagos. Grain yield data for Millet, Sorghum and Maize from 1996-2010 were also obtained in kilogram per land hectare from the Zamfara State Agricultural Development Project (ZADP). The results of the various statistical tests were shown using graphs and statistical tables. The study revealed that both the five-year and ten-year moving averages for annual rainfall series showed lengthy and dry periods below the long-term mean from 1996-2001 with steady increases above the mean. In comparing the trends in the annual rainfall totals and pattern of grain yield within these periods, each grain yield pattern for the period was plotted in percentages against the years and it was observed that millet and sorghum were drought resistant because their values fell close or above normal indicating that they were able to cope with a decline in rainfall amount while maize was below normal. The Pearson's Product Moment Correlation Coefficient and Pentad Sub-periodic Frequency of Significance at $\alpha= 0.05$ also proved that millet and sorghum were positively correlated and appreciably significant to rainfall while maize was negative and insignificant except during the 3rd period (2006-2010). The findings of this study concluded that millet and sorghum yields in the area have been economically appreciable and effectively able to cope with irregularities in rainfall attributes as low as 850 mm within the period. The study recommends that the research institutes should produce better adapted varieties of millet and other grains and government should subsidize the seeds to the farmers. Furthermore, there should be adequate provision for fertilizers, irrigation, weather forecasting and other agricultural technological infrastructure, modern knowledge on climate change adaptation and strengthening of the extension services.

Keywords: Annual Rainfall; Grain Crops Yield; Gusau Station; Trend Analysis; Variability.

1.0 INTRODUCTION

There is a large uncertainty with respect to climate change predictions and impacts on future water availability and quality especially in Sub-Saharan Africa including Nigeria. Global warming is projected to cause an intensification of present climatic and hydrological variability in Northern Nigeria and may cause extreme events – such as tropical storms, floods and drought to increase in frequency and intensity (IPCC, 2007). Rainfall variability refers to variations in the mean state and other statistics of the rainfall pattern in a given area beyond that of individual weather events. Rainfall Variability in Northern Nigeria is caused by different mechanisms of rainfall producing systems such as the Inter-tropical Discontinuity (ITD) movement, Tropical Easterly Jets (TEJ) and Bio-geophysical Feedback mechanisms (BFM). Nigeria receives rainfall from the southwest trade wind, which invades the country from the Gulf of Guinea coastline, i.e. the Tropical Atlantic Ocean. This moist airstream is overlain by the northeast trades, which originate from above the Saharan desert and are thereby dry and dust-laden. The zone of contact of the two air masses at the surface is a zone of moisture discontinuity (ITD) zone. The ITD advances inland as far as 22 – 25°N in August and at the margin of the Sahara i.e. considerably beyond Nigeria's northern border (Adejuwon and Odekunle, 2004; Ayansin, 2008). It does not retreat equatorward beyond latitude 4°N during the "Harmattan" dry season (Adefolalu, 1983). The TEJ is part of the Indian summer monsoon system, and it extends from the Indian Ocean over Africa in the Northern Hemisphere summer months, generally, at a height of around 12 to 15km. the West-East axis of the TEJ is located between 4 to 10°N. TEJ reinforces aridity over the extreme Northern part of the country but causes a belt of above average rainfall in the central part. Undoubtedly, reduced rainfall combined with human activities has influenced Bio-geophysical Feedback Mechanisms (BFM) which has invariably served to reinforce drought conditions over the Northern part of Nigeria.

Awosika *et al.* (1992) stressed that one undisputable cause of famine in the Guinea and Sudan Savannah of Nigeria is the failure of crops resulting from insufficient or untimely

rainfall. Either a deficiency or a surplus of rain can cause crop failure and in turn affect crop yields, as has been the case during the drought of 1968-1973 and 1973-1983 in northern Nigeria. Maurya *et al.* (1995) also affirmed that the low, erratic rainfall and high rate of evapotranspiration for the period of 1984-1991 in Sokoto state increased the duration of water deficit period in the year, which severely affected agricultural production. Sawa (2010) opined that semi-arid areas especially the Sudan-Sahel zone of northern Nigeria have suffered from inter-annual climatic variability, droughts and desertification since the 1960s, worsened by the expected decrease in rainfall trends within the range of 30-40 percent per decade.

Trends in rainfall are thus, vital in assessing the productivity index of grain crops and the crops' adaptive mechanism in relation to drought when subjected to periodic moisture stress (Jones *et al.*, 1981; Ashley, 1993). Parry *et al.* (2004) observed that the global average crop yield in several countries for wheat, rice, maize and soybean as at 2004 amounted to 10.9 tonnes per hectare (t/ha) of land. The study showed that 73 per cent of countries produced 2.1 t/ha of wheat, 48 per cent produced 3.0 t/ha of rice, 3.5 t/ha of maize produced in 71 per cent of the countries while 96 per cent produced 2.3 t/ha; which was not sufficient enough due to climate change and variability. Awoyemi, *et al.* (1986), Sowunmi and Akintola (2010) also estimated that millet, sorghum and maize accounts for over 60-70 percent of the cereal production in most semi-arid areas of Nigeria but they depend entirely on rainfall for moisture supply which is most at times irregular and unpredictable. The Federal Ministry of Environment (2003) also opined that most grain crops were part of Carbon four (C4) crops common in Nigeria either functioning above or below-optimal conditions with relative increases in carbon dioxide (CO₂) levels in the atmosphere. The study stressed that expected changes in crop development and phenology due to climate change can cause shortening or lengthening of the crop cycle that could lead to increases or decreases in productivity and could also affect nutritional value, taste and storage quality of the crops while increases in CO₂ can lower

crop water requirements by reducing transpiration per unit leaf area.

In the driest parts of the world, millet is favoured in agriculture due to its productivity and short growing season under dry, high temperature conditions. Millet is a *C4* crop which means that it has good water efficiency and utilizes high temperatures and is therefore a summer crop. A *C4* plant uses a different enzyme in photosynthesis to *C3* plants and this is why it improves water efficiency. It produces a 4-carbon rather than 3-carbon hence the name *C4* (and *C3*). Carbon dioxide is fixed twice in *C4* plants whereas only once in *C3* plants. The Pearl, Finger and Ripe head of Proso millets are fondly produced. India is the world's largest producer of millets. In the 1970s, all of the millet crops harvested in India were used as food staple. In 2009, Nigeria was the world's second largest producer of millet with other sub-Saharan African countries such as Niger, Mali, Burkina Faso, Senegal, Chad, Sudan, Uganda and Ethiopia following suit and contributing to over 50% of the world's 10 top millet exporters. In 2010, the average yield of millet crops worldwide was 0.83 tonnes per hectare (FAO, 2010).

In the case of Sorghum, FAO (2010) also reported that the United States of America (USA) was the top producer of Sweet Sorghum otherwise known as Guinea corn in 2008 with a harvest of 12 million tonnes while Nigeria was next with 9.3 million tonnes. In 2009, USA still topped with 9.7 million tonnes and the next four major producers in decreasing quantities were India, Nigeria, Sudan and Ethiopia. The world harvested 55.6 million tonnes of Sorghum in 2010 and the

1.1 The Study Area

The study area; Zamfara state is located in the Sudano-Sahelian region of the savannah. Rainfall distribution combined with human activities has influenced Biogeophysical Feedback Mechanisms (BFM) reinforcing climate change and variability impacts on crops over the Northern part of Nigeria; however, its impacts are yet to be noticed on grain yield in Zamfara state. Thus, the objective of this research will be to: (i)

world average annual yield for the 2010 sorghum crop was 1.37 tonnes per hectare. Sorghum requires an average temperature of at least 25°C to produce maximum grain yields in a given year.

In Nigeria, Maize is a major cereal crop for livestock feed and human consumption. Despite its widespread use across the country however, maize consumed in Nigeria is the normal maize. Unlike other West African countries such as Ghana, the adoption and cultivation of Quality Protein Maize (QPM) is still low in Nigeria (Jaliya, *et al.*, 2008). In the Sudano-Sahelian region of Nigeria, Maize grows and matures between 90 – 120 days. The annual mean minimum rainfall for the crop is 900 mm and above. The maize yield requirement in these regions is about 1.5 to 2.5 tonnes per hectare. It grows best on well-drained sandy loam to loamy soil with good water holding capacity. Varieties include the open pollinated ones such as *Sammaz 9*, *Sammaz 10*, *Sammaz 17* and the hybrid varieties *V* (Maurya *et al.*, 1995). Mohammed, *et al.*, (2014) assessed the performance of quality protein maize varieties in two ecological zones of Nigeria (Samaru, Kaduna state and Kadawa, Kano state) and the study showed that the analysis of 100-seed weight of maize yield influenced by rainfall produced a far superior performance in Samaru than in Kadawa and *Sammaz 17* and *Flint Q* were recommended in terms of crop yield. The current study a comparison in trend analysis of annual rainfall variability on grain yield pattern in Gusau Station, Zamfara State, Nigeria.

determine annual rainfall trends in Zamfara state from 1971 to 2010 (40 years); (ii) determine the trends in millet, sorghum and maize pattern in the state from 1996 to 2010 (15 years); (iii) determine any significant relationship between the annual rainfall data to that of grain yield data in the state from 1996 to 2010 (15 years) (iv) adopting useful recommendations for grain farmers in order to minimize climatic variability incidences and boost grain yield in the future in case of any decline.

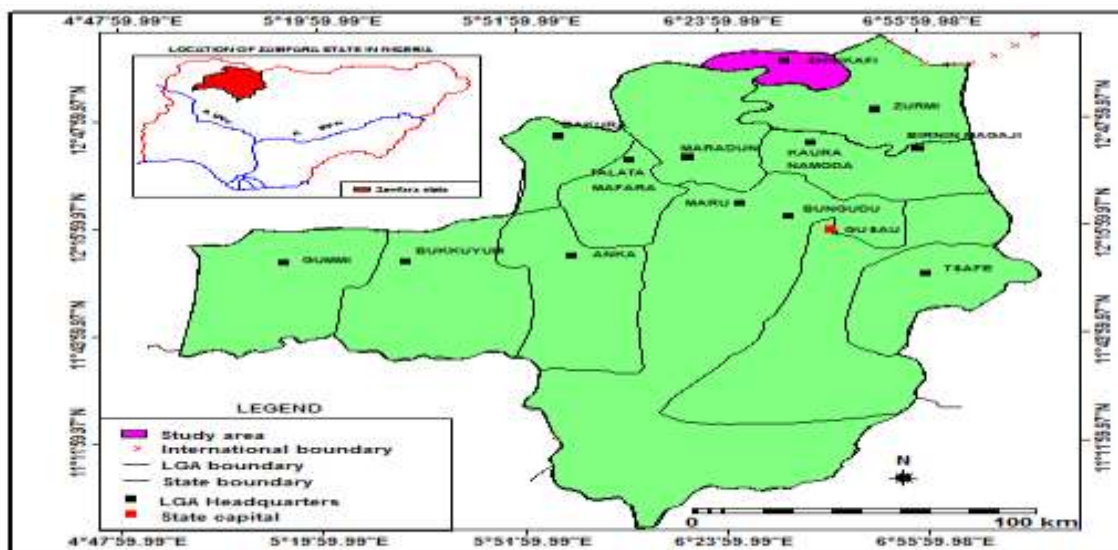


FIGURE 1: LOCATION OF STUDY AREA
Source : Administrative Map of Zamfara State, 2010

Zamfara state (Figure 1) covers a total area of 39,762 square kilometres (Zamfara Agricultural Rural Development Authority, 2008).

The Meteorological station at Gusau station (Zamfara state) number 1206.14 is located on latitude $12^{\circ} 10' N$ of the Equator and on longitude $06^{\circ} 42' E$ of the Greenwich meridian. Its altitude is about 461 metres and its year of establishment was in 1942 (Nigerian Meteorological Agency, Abuja). The Nigerian Meteorological Services Department, Oshodi had confirmed that the station's data are reliable enough for climatic researches of this type due to its ability to record daily climatic readings. There is also a long and continuous

period of daily rainfall records for the station, and there was no relocation of the station since its establishment in 1942; thus this station is deemed fit to be used in this study (Sawa, 2010).

The study area has a tropical continental climate of the AW type, characterized by distinct wet (April – October) and dry (November – March) seasons governed by the movement of the Intertropical Discontinuity (ITD) (Sawa, 2010).

2.0 MATERIALS AND METHODS

Annual rainfall records for 15 years (1996 – 2010) for the Gusau station was obtained from the Nigerian Meteorological Services Department, Oshodi, Lagos. The standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) as propounded by Brazel and Balling (1986), were both used in testing for the normality of the annual rainfall series during the specified periods. If the absolute value, Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at 95% confidence level.

The long-term mean of annual rainfall totals from 1996 to 2010 was obtained by dividing

the annual rainfall amounts by the number of years. The five-year and ten-year running means were also obtained by dividing the consecutive pentad and decadal totals by the number of years.

Grain yield data for Millet, Sorghum and Maize (kilogram of maize grain per area of land in hectares) produced by the state for 15 years (1996 – 2010) were obtained from the Zamfara State Agricultural Development Project (ZADP). The yield data obtained was derived from kilogram per land hectare from 1996-2010.

3.0 RESULTS AND DISCUSSION

3.1 Normality Test

The annual rainfall series for Gusau station of Zamfara state was subjected to the normality test using the Coefficients of Skewness (Z_1) and Kurtosis (Z_2) as described by Brazel and Balling (1986) as explained in Table 1.1. The

coefficient of Skewness (Z_1) was 0.781 while that of Kurtosis (Z_2) was 0.096. This indicated that the rainfall series from 1996-2010 had no significant deviation above the normal curve (1.96) at 95% confidence level. Hence the rainfall data was normally distributed.

Table 1.1: Summarized General Statistics of Annual Rainfall for Gusau station, Zamfara state (1996-2010)

Total Amount(mm)	Long-term Mean(mm)	SD (mm)	CV (%)	Max (mm)	Min (mm)	Range (mm)	Z_1	Z_2
14875.08	991.67	302.44	30.50	1597.5	548.66	1048.84	0.781	0.096

Source: Data Analysis for Gusau station, Zamfara state (2012).

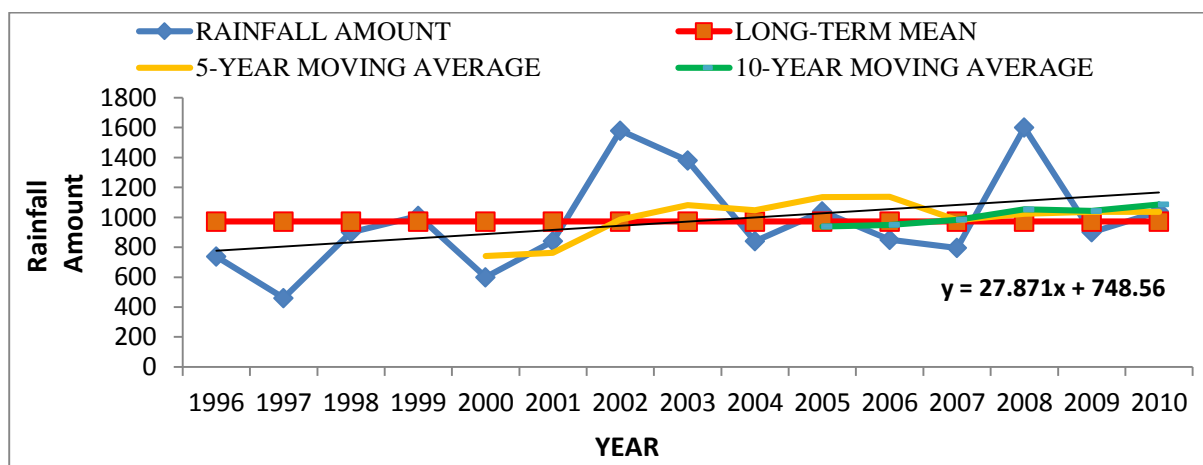
3.2 Long-term Statistics of Annual Rainfall Amount

The Standard Deviation, **SD** (302.44) decreased below the Long-term mean (991.67) depicting a much rather deviation from the mean and tendency of being trendy in pattern. The Coefficient of Variation, **CV** recorded a percentage of 30% which was appreciable.

period, the 5-year and 10-year running means as presented was used to filter and smoothen the rainfall series. The rainfall trend based on the 5-year moving average was below the long-term mean from the early periods of the millennium to 2002, after which it slightly increased above normal till the end of the period. Trends in 10-year running mean also showed a slightly normal rainfall amount with the long-term mean between 2005 and 2007 after which, it began to increase above normal till the end of the period.

3.3 Trends in Annual Rainfall Pattern

Figure 1.2 shows annual rainfall from 1996-2010 plotted against the periods. To further specify the character of the rainfall during the



Source: Data Analysis for Gusau station, Zamfara state (2012).

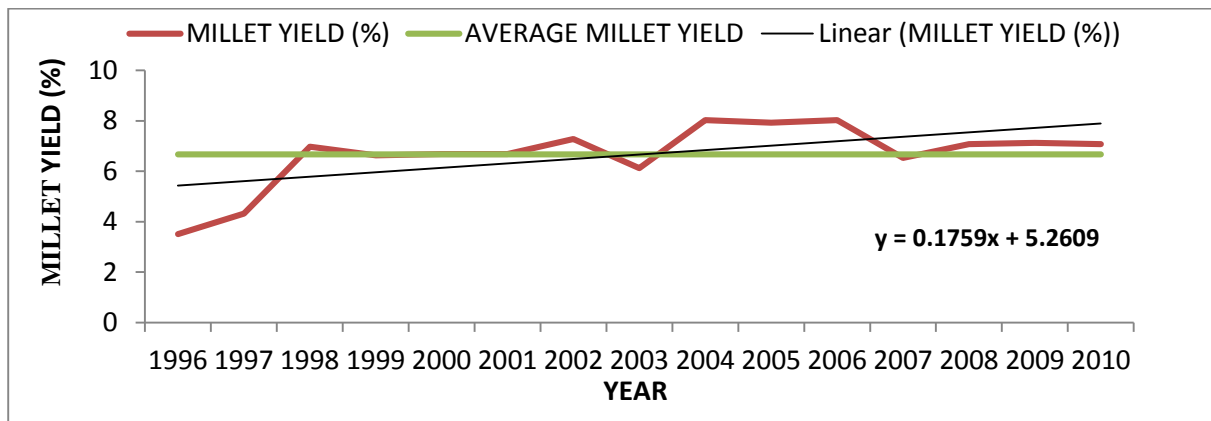
Figure 1.2 – Trends in Annual Rainfall in Gusau station, Zamfara state (1996-2010).

3.4 Trends in Millet Yield Pattern

Figure 1.3 shows that the percentage of millet yield was below the average normal yield of 6.7% in 1996 but steadily began to rise in 1997 recorded near normal and above normal increases between 1998 and 2002 and between 2004 till the end of the period. This further

illustrates that comparing the annual rainfall amounts as shown in Figure 1.2 with millet yield pattern in the figure below, there were corresponding tendencies of increases in millet yield

($y=0.1759x + 5.2609$) even when annual rainfall was below 900 mm. Millet also thrived very well with increases in rainfall amount.



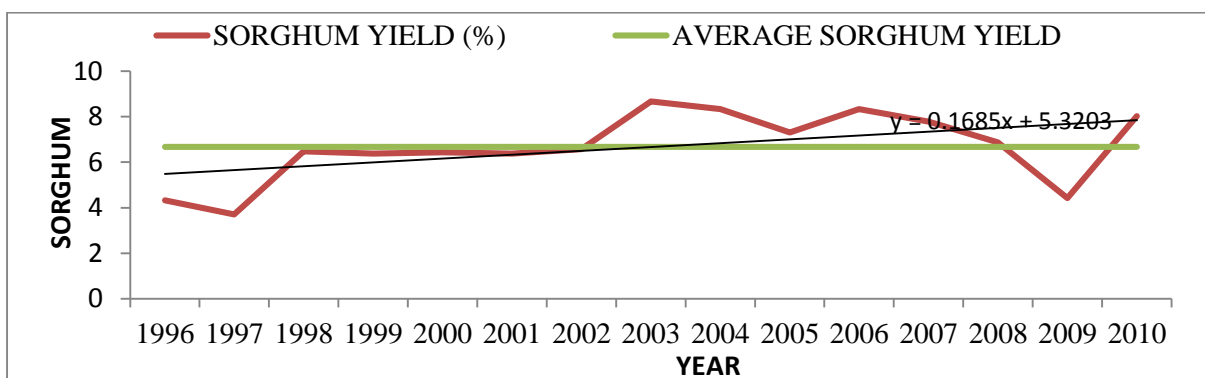
Source: Data Analysis for Gusau station, Zamfara state (2012).

Figure 1.3 – Trends in Millet yield pattern for Gusau station, Zamfara state (1996-2010).

3.5 Trends in Sorghum Yield Pattern

In the case of sorghum (Figure 1.4), the yield was below normal in 1996 and steadily increased in 1997 until it became near normal between 1998 and 2002. Yield pattern then rose above normal between 2003 and 2008, sharply dropped in 2009 and rose above

normal in 2010. The trend line equation shows that sorghum production has tendencies of increasing in future provided that rainfall attributes increasingly normalize. The figure illustrates that sorghum also did very well even when rainfall was below 900 mm because production was still significant between 1997 and 2001.



Source: Data Analysis for Gusau station, Zamfara state (2012).

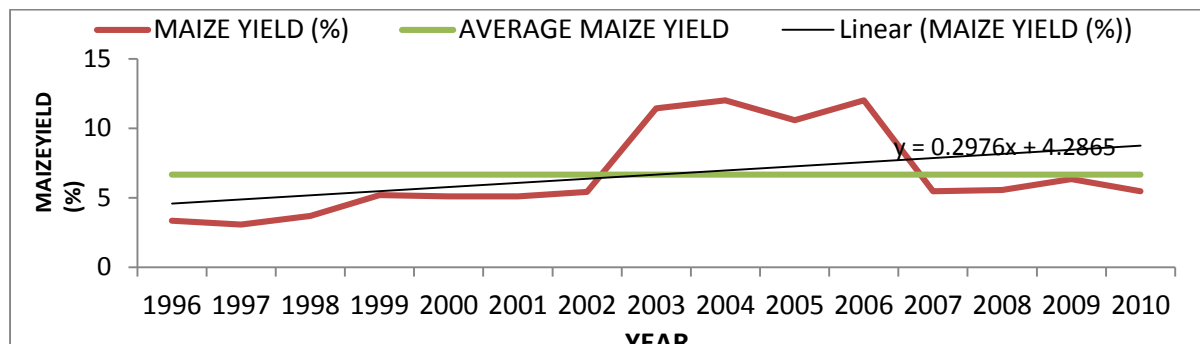
Figure 1.4 – Trends in Sorghum yield pattern for Gusau station, Zamfara state (1996-2010).

3.6 Trends in Maize Yield Pattern

Figure 1.5 shows a fluctuating pattern in maize yield as compared to the average yield of 6.67. Although significant yield was recorded

between 2003 and 2006, production remained below normal from 1996 to 2002 and from 2007 to 2010. This indicates that if annual rainfall did not increase, maize yield will be grossly affected and vice versa. However, the

positive trend line equation ($y = 0.2976x + 4.2865$) showed that there were tendencies for increases in maize production in the future provided rainfall amounts increased.



Source: Data Analysis for Gusau station, Zamfara state (2012).

Figure 1.5– Trends in Maize yield pattern for Gusau station, Zamfara state (1996-2010).

3.7 Crop-Climate Relationship Test

The Pearson’s Product moment Correlation coefficient (r) was used to determine any relationship between grain yields for millet, sorghum and maize (Kilogram per hectares) and annual rainfall (centimetres) from 1996 to 2010. Oladipo (1993a) opined that the

independent variable (X) is annual rainfall since its total amount, intensity, duration, variability, reliability and its spatial and temporal distribution influences the quality and quantity of grain yield (Y) phenomena especially in the tropical regions where the prevailing economic activity is simply agro-based.

3.8 Rainfall-Millet Relationship and Significance

Year	Millet yield (Y) ('00) (kg/hectares)	Annual Rainfall (X)(cm)	X - x	Y - y	(X - x) (Y - y)	(X - x) ²	(Y - y) ²
1996	*7.00	*4.60	-5.69	-6.28	+35.73	32.38	39.44
1997	8.60	9.00	-1.29	-4.68	+6.04	1.66	21.90
1998	*13.90	*10.10	-0.19	+0.62	-0.12	0.04	0.38
1999	13.20	6.00	-4.29	-0.08	+0.34	18.40	0.01
2000	13.30	8.40	-1.89	+0.02	-0.04	3.57	0.00
2001	*13.30	*15.80	+5.51	+0.02	+0.11	30.36	0.00
2002	*14.50	*13.80	+3.51	+1.22	+4.28	12.32	1.49
2003	12.20	8.40	-1.89	-1.08	+2.04	3.57	1.17
2004	*16.00	*10.40	+0.11	+2.72	+0.30	0.01	7.40
2005	15.80	8.50	-1.79	+2.52	-4.51	3.20	6.35
2006	16.00	7.95	-2.34	+2.72	-6.37	5.48	7.40
2007	*13.00	*16.00	+5.71	-0.28	-1.60	32.60	0.08
2008	14.10	9.00	-1.29	+0.82	-1.06	1.66	0.67
2009	*14.20	*10.40	+0.11	+0.92	+0.10	0.01	0.85
2010	*14.10	*16.00	+5.71	+0.82	+4.68	32.60	0.67
Total	199.20	154.35			+39.92	177.86	87.81

* Significant at alpha = 95% confidence level, **Source:** Analysis using Microsoft Excel (2015).

$$\begin{aligned} \sum X &= 154.35 \\ \sum Y &= 199.20 \\ x &= \frac{\sum X}{n} = \frac{154.35}{15} = 10.29 \\ y &= \frac{\sum Y}{n} = \frac{199.20}{15} = 13.28 \\ \sum (X - x)(Y - y) &= +39.92 \\ \sum (X - x)^2 &= 177.86 \\ \sum (Y - y)^2 &= 87.81 \\ r &= \frac{+39.92}{\sqrt{177.86 \times 87.81}} = +0.319 \end{aligned}$$

The Pearson's Product Moment Correlation coefficient (*r*) indicates that there was a positive relationship though not perfect between millet yield and annual rainfall from 1996 to 2010. About 87% of annual rainfall from 1996 to 2010 was above 750mm and 93% of millet yield was averagely recorded above 750 kilogram per hectare of arable land. The only years where there was a decline in yield was in 1996 due to decline in rainfall amount. Generally, there was a 53% (8 out of 15 corresponding values) significant pattern in millet yield owing to the outcome of rainfall at alpha = 0.05 level of significance. A breakdown of the Pentad frequency years is recorded in Table 1.3.

Table 1.3: Pentad Sub-periodic Frequency and Percentage in Significance Level of Millet Yield at alpha = 0.05

Pentad Years	Frequency	Percentage
1996 – 2000 (1 st Period)	2	25.0
2001 – 2005 (2 nd Period)	3	37.5
2006 – 2010 (3 rd Period)	3	37.5
TOTAL	8	100

Source: Authors' analysis (2015)

From the above Table, there were significant increases in millet yield owing in the 2nd Period (2001 – 2005) and 3rd Period (2006 – 2010) owing to increases in annual rainfall in the later periods of the data. It also revealed that Millet is drought-resistant crop since it could still thrive within the 1st Period (1996 – 2000).

3.9 Rainfall-Sorghum relationship:

Table 1.4: Computation of Relationship between Annual Rainfall total and Sorghum yield

Year	Sorghum yield (Y) ('00) (kg/hectares)	Annual Rainfall (X)(cm)	X - x	Y - y	(X - x)(Y - y)	(X - x) ²	(Y - y) ²
1996	8.90	4.60	-5.69	-4.79	+27.26	32.38	22.94
1997	7.60	9.00	-1.29	-6.09	+7.86	1.66	37.09
1998	*13.30	*10.10	-0.19	-0.39	+0.07	0.04	0.15
1999	13.10	6.00	-4.29	-0.59	+2.53	18.40	0.35
2000	13.20	8.40	-1.89	-0.49	+0.93	3.57	0.24
2001	*13.10	*15.80	+5.51	-0.59	-3.25	30.36	0.35
2002	*13.50	*13.80	+3.51	-0.19	-0.67	12.32	0.04
2003	17.80	8.40	-1.89	+4.11	-7.77	3.57	16.89
2004	*17.10	*10.40	+0.11	+3.41	+0.38	0.01	11.63
2005	15.00	8.50	-1.79	+1.31	-2.35	3.20	1.72
2006	17.10	7.95	-2.34	+3.41	-7.98	5.48	11.63
2007	*16.00	*16.00	+5.71	+2.31	+13.19	32.60	5.34
2008	14.10	9.00	-1.29	+0.41	-0.53	1.66	0.17

2009	9.10	10.40	+0.11	-4.59	-0.51	0.01	21.07
2010	*16.50	*16.00	+5.71	+2.81	+16.05	32.60	7.90
Total	205.40	154.35			45.21	177.86	137.51

* Significant at alpha = 95% confidence level, **Source:** Analysis using Microsoft Excel (2015).

$$\begin{aligned} \sum X &= 154.35 \\ \sum Y &= 205.40 \\ x &= \frac{\sum X}{n} = \frac{154.35}{15} = 10.29 \\ y &= \frac{\sum Y}{n} = \frac{205.40}{15} = 13.69 \\ \sum (X - x)(Y - y) &= +45.21 \\ \sum (X - x)^2 &= 177.86 \\ \sum (Y - y)^2 &= 137.51 \\ r &= \frac{+45.21}{\sqrt{177.86 \times 137.51}} = +0.289 \end{aligned}$$

In the case of Sorghum yield, the Pearson's Product Moment Correlation coefficient (r) in Table 1.4 indicates that there was a positive relationship though not also perfect, between the yield and annual rainfall from 1996 to 2010. About 93% of annual rainfall from 1996 to 2010 was above 600mm and 87% of sorghum yield was also recorded to be above 900 kilogram per hectare of arable land. However, only about 40% (6 out of 15 corresponding values) significant increase in annual rainfall amounts led to increases in Sorghum yields at alpha = 0.05 level of significance as seen in the Pentad sub-periodic frequency shown in Table 1.5.

Table 1.5: Pentad Sub-periodic Frequency and Percentage in Significance Level of Sorghum Yield at alpha = 0.05.

Pentad Years	Frequency	Percentage
1996 – 2000 (1 st Period)	1	16.7
2001 – 2005 (2 nd Period)	3	50.0
2006 – 2010 (3 rd Period)	2	33.3
TOTAL	6	100

Source: Authors' analysis (2015)

From the Table above, there was more increase in Sorghum yield in the 2nd Period (2001-2005) than in any other period due to the increases in rainfall amounts within the period. Sorghum yield was not pronounced in the 1st period, it still showed that the crop is drought-resistant.

3.10 Rainfall-Maize Relationship

Table 1.6: Computation of Relationship between Annual Rainfall total and Maize yield

Year	Maize yield (Y) ('00) (kg/hectares)	Annual Rainfall (X)(cm)	X - x	Y - y	(X - x)(Y - y)	(X - x) ²	(Y - y) ²
1996	7.00	4.60	-5.69	-6.85	+38.98	32.38	46.92
1997	6.40	9.00	-1.29	-7.45	+9.61	1.66	55.50
1998	7.70	10.10	-0.19	-6.15	+1.17	0.04	37.82
1999	10.80	6.00	-4.29	-3.05	+13.09	18.40	9.30
2000	10.60	8.40	-1.89	-3.25	+6.14	3.57	10.56
2001	*10.60	*15.80	+5.51	-3.25	-17.91	30.36	10.56
2002	*11.30	*13.80	+3.51	-2.55	-8.95	12.32	6.50
2003	23.80	8.40	-1.89	+9.95	-18.81	3.57	99.00
2004	25.00	10.40	+0.11	+11.15	+1.23	0.01	124.32
2005	22.00	8.50	-1.79	+8.15	-14.59	3.20	66.42

2006	25.00	7.95	-2.34	+11.15	-26.09	5.48	124.32
2007	*11.40	*16.00	+5.71	-2.45	-13.99	32.60	6.00
2008	11.60	9.00	-1.29	-2.25	+2.90	1.66	5.06
2009	*13.20	*10.40	+0.11	-0.65	-0.07	0.01	0.42
2010	*11.40	*16.00	+5.71	-2.45	-13.99	32.60	6.00
Total	207.80	154.35			-41.28	177.86	608.70

* Significant at alpha = 95% confidence level
 Source: Analysis using Microsoft Excel (2015)

$$\sum X = 154.35$$

$$\sum Y = 207.80$$

$$x = \frac{\sum X}{n} = \frac{154.35}{15} = 10.29$$

$$y = \frac{\sum Y}{n} = \frac{207.80}{15} = 13.85$$

$$\sum (X - x)(Y - y) = -41.28$$

$$\sum (X - x)^2 = 177.86$$

$$\sum (Y - y)^2 = 608.70$$

$$r = \frac{-41.28}{\sqrt{177.86 \times 608.70}} = -0.126$$

$$r = -0.126$$

The Pearson’s Product Moment Correlation coefficient (*r*) in Table 1.6 indicates that there was a negative relationship though not perfect between maize yield and annual rainfall from 1996 to 2010. Even with the drop in rainfall amounts between 2003 and 2006, there was a rapid rise in maize yield. Yield also appeared

to drop when rainfall was high in amount in other years. This shows that an increase or decline in annual rainfall amount did not change the outcome of maize yield within the study periods because the level of significance at 0.05 was recorded to be 33% (5 out of 15 corresponding values) as seen in Table 1.7.

Table 1.7: Pentad Sub-periodic Frequency and Percentage in Significance Level of Maize Yield at alpha = 0.05

Pentad Years	Frequency	Percentage
1996 – 2000 (1 st Period)	0	00.0
2001 – 2005 (2 nd Period)	2	40.0
2006 – 2010 (3 rd Period)	3	60.0
TOTAL	5	100

Source: Authors’ analysis (2015)

The above table shows that there was practically no significant maize yield at alpha = 0.05 significance level within the 1st Period (1996 – 2000). However, there was a great

improvement in within the 3rd Period (2006-2010); thus disapproving the fact that Maize is a drought-resistant crop.

4.0 CONCLUSION AND RECOMMENDATIONS

It can be deduced from the trend analysis that:

1. Annual rainfall made meaningful increases only at the later periods of the 90s and beginning of the millennium otherwise other years were dry and drought years.
2. There was a positive correlation between annual rainfall amount with millet and

sorghum yields but a negative correlation for maize.

3. In addition, millet and sorghum yields significantly thrived well within the Pentad sub-periods including the 1st Period (1996-2000) but that was not the case for maize yield. It only thrived well within in the 3rd Period (2006-2010) when annual rainfall amounts increased significantly.

Based on the above facts, recommendations of this study are majorly adaptive in nature. Grain farmers should employ the following strategies such as;

1. Planting the best short duration of grain-seed variety in periods of drought especially for crops like maize which were neither influenced by increases nor decreases in rainfall pattern.
2. Application of organic manure such as cow dungs, bird droppings, green manure, farm wastes, compost and other decayed vegetative matter; and fertilizers made up of Nitrogen, Phosphate, Potassium, Potash and Calcium are all important to soil fertility and subsequently, quality crop yield in cases of drought.
3. Developing a more improved grain processing and storage facility is vital for maize grains and should be encouraged and provided for local farmers to reduce pest attacks on yield. Sorghum and Maize could be stored in cobs or shelled and kept in tightly closed silo or rhombus bags sprayed with acetylic dust or even dried

pepper. Store houses should also be sanitized. Storehouses should be properly sanitized thoroughly by spraying insecticides, well-ventilated with louvers, lightly painted and cracks on the wall mended to avoid grain pests attack.

4. Executing the best soil conservation practices for farming such as crop rotation, shifting cultivation, terracing, use of seed-dressing fungicides and insects' treatments which would help to reduce pests attack
5. Updating and monitoring continuous rainfall data will help improve maize productivity in terms of agricultural planning. Yearly budgetary planning in the agricultural sector should involve the services of professional experts from the agricultural research institutes, Nigerian Meteorological Agency etc.
6. Large scale irrigation development schemes should be developed to intensify agriculture especially for maize. Water for irrigation should be supplied from dams, boreholes and reservoirs.

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