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TREND ANALYSIS OF MONTHLY AND ANNUAL RAINFALL PROFILE IN KATSINA AND ITS ENVIRONS

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ABSTRACT
This study aimed at examining the trend analysis of monthly and annual rainfall profile in Katsina and its environs. The specific objective was to determine the monthly and annual trends in rainfall for the area. Rainfall data from 1971 to 2010 was sourced from the archive of the Nigerian Meteorological Agency (NiMets) Katsina Airport. The data was used to characterize rainfall trends for monthly and annual total which are the determinants of rainy season using Microsoft excel tool (2016) and SPSS 23.0 version. The 5-year running mean showed that below average rainfall was experienced from the early 1970s up to 2000. Findings also showed that above average rainfall is being experienced from the year 2000 afterward. Findings further indicated that there was a significant decrease in rainfall amount in the month of June, little change in the month of July and substantial increase in the months of August and September. The study concludes that there is an apparent increase in rainfall amounts in recent years. The study recommends that there is need to improve information delivery and foster the use of climate information to inform decision making, using seasonal climate forecasts to inform farmers and other stakeholders to avoid surprises by taking right decisions. Additional functioning synoptic weather stations should be provided to complement the existing ones in the study area with distance from each other not more than 100km to conform with WMO standard. This will enhance network of data collection and accurate seasonal rainfall prediction.

Keywords: Trend, Monthly, Annual Rainfall, Profile, Katsina

INTRODUCTION

Rainfall is a climate parameter of great importance that affects the entire human way of life. This also covers every facet of the ecological system, flora and fauna inclusive and in shaping the partial and temporal variations of agriculture in tropics (Isma'il and Oke, 2012). Northern Nigeria is perhaps characterized by two distinct seasons- the wet season (April- October) and the dry season (November –March), (Anyadike, 1993). The start of the rain is abrupt but is usually proceeded by a succession of isolated showers of uncertain intensities with intervening dry period of varying duration (Ati, 2002). The pattern of rainfall is highly variable in spatial and temporal dimensions with inter-annual variability of between 15 and 20% which often results in climate hazards, especially floods and severe droughts with devastating effects on livelihood systems (Adebayo and Oruonye, 2013).

There are many researches conducted in various parts of Nigeria on trends in annual rainfall amounts such as (Adefolalu, (1986); Oladipo (1989) and Olaniran (1990, 1992) showed down ward trends. The result of Olaniran (1992) showed that there has been a progressive early retreat of rainfall over the whole country spanning up to a half a century now and consistent with this pattern there has also been a significant decline of rainfall frequency i.e. the number of rainy days in September and October which, respectively, coincide with the end of the rainy season in the northern and southern parts of the country. Furthermore, the combined effect of these declines was found to lead to a significant decrease in annual rain days over the whole country.

Evidence from meteorological parameters showed that changes are occurring in the amount, intensity, frequency and types of rainfall. Pronounced long- term trends from 1900 to 2005 had been observed in rainfall amount in some places: significantly-wetter in Eastern North and South America, northern Europe and northern and central Asia but drier in the Sahel, southern Africa, the Mediterranean and southern Asia. Wide spread increase in heavy precipitation event have been observed, even in places where total amount has decreased. These changes are associated with increased water vapour in the atmosphere arisen from the warming of the world oceans especially, at lower latitudes (Trenberth *et al.*, 2007).

Recent researches such as (Ati 2006; Abaje, 2010, Abaje, *et al.* 2012 and 2016*)* revealed that recent trends of annual rainfall have been that of high intensity from the year 2000 to date. The above reviews have pointed out the importance of rainfall and the needs for continuing monitoring of its characteristics from time to time. It is in view of the above that this research aimed at analyzing the trends of rainfall in Katsina and its environs. As a result, the following objectives were set out to:

- Determine the monthly and annual trends in rainfall for the area over the study period (1971-2010) using Microsoft excel tool (2013).
- Determine the amount and rate of changes in rainfall per year over the study period (1971-2010)

The Study Area

The study area (Katsina, Kaita, and Jibia LGAs) is bounded by Niger Republic to the north, Zamfara State to the West, Batsari, Batagarawa and Rimi LGAs to the South and Mashi LGA to the East. It is located between latitude $12^0\,59^1$ North and longitude 7^036^1 East. It has a total land mass of 142 Km^2 (See Figure 1). Katsina state can be classified into two climatic zones: The tropical continental and semi-continental. The north of Katsina state (from around Kankiya to the extreme North-East has total rainfall figure ranging from 600 – 700mm per annum. Generally, rainfalls vary considerably according to months and seasons. There are: Cool dry (Hamattan) season from December to February, a hot dry season from March to May, a warm wet season from June to September, less marked season after rains during the months of October to November characterized by decreasing rainfall and gradual lowering temperature (Online Nigeria [O.N], 2003).

Katsina and its environs are drained by many rivers. The major rivers that originate in or traverse the state include: the Koza, Jibiya; Sabke, Tagwai and Gada systems in the northern half of the state (all the following either north or North-West ward). The sandy 'drift' deposits of Katsina are coarse, resulting in light sandy soils of buff or reddish colours of low medium fertility. These soils are easily worked and well suited to crops such as millet and groundnut which are less demanding in their water requirement than Cotton, Maize and Guinea corn (O.N, 2003).

Katsina and its environs, belong to the Sudan Savannah Zone in the northern half of the state. The vegetation consists of trees that grow long tap roots and thick barks that make it possible to withstand the long dry season and bush fires.

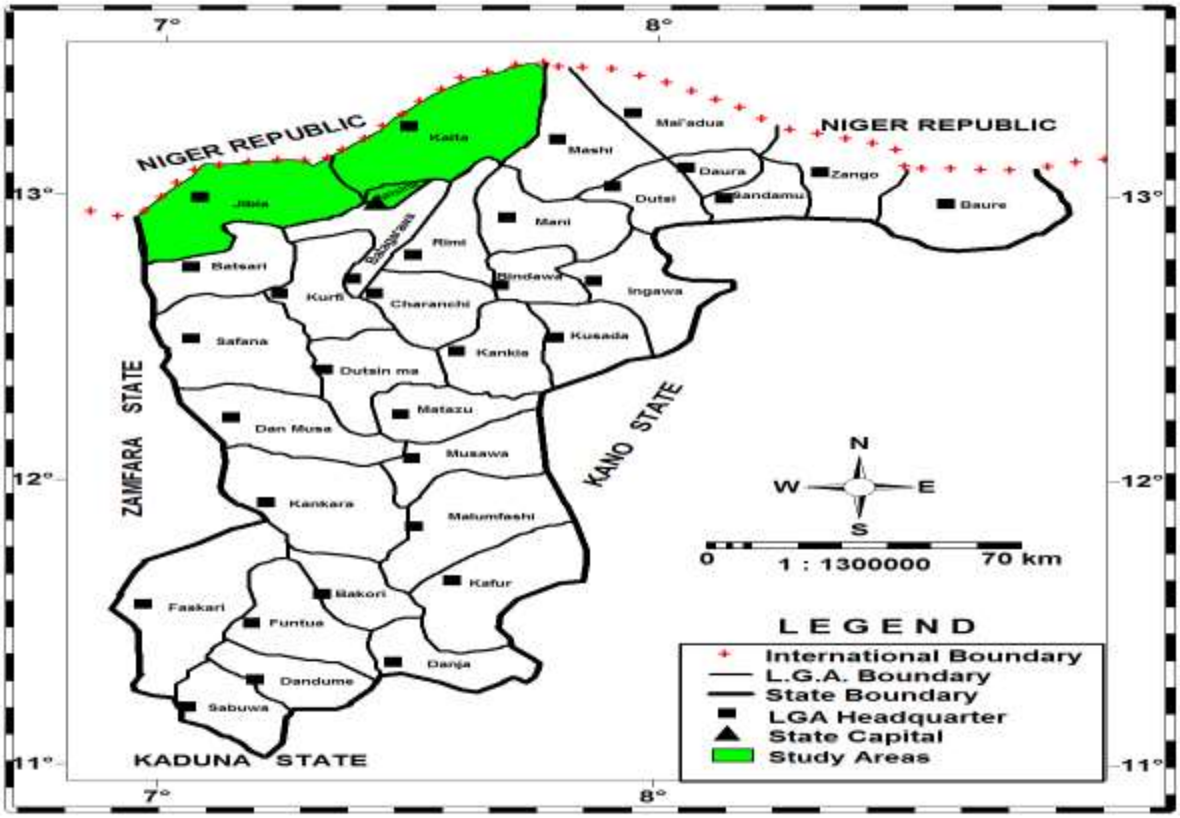


Fig. 1. Map of Katsina State Showing Study Area
Source: Adapted from Administrative Map of Katsina State, 2020

MATERIALS AND METHODS

The Rainfall data for the period 1971 to 2010 used for this research was obtained from the archive of Nigerian Meteorological Agency (NiMet) Katsina (Umaru Musa Airport Katsina, Station No.1307.4). The station was chosen to represent the entire study area because of the following reasons: (1) it is the only synoptic station in the study area and (2) it has no significant missing records during the study period. The data obtained was used to characterize rainfall trends for monthly and annual totals which are the determinants of rainy season. Linear trend lines and trend line equations of the monthly and mean annual rainfall for the area were plotted graphically against the years of records for easy identification of the rate of increases or decreases in the average values between the beginning and the end of the series using Microsoft excel tool (2016) and SPSS 23.0 version.

The long-term average rainfall was determined as:

$$\bar{x} = \sum \frac{(x_i)}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:

$\bar{x}$ = Long-term mean monthly and annual rainfall

x = Annual rainfall for each year

n= Number of years on records

To further specify the trends, linear regression was used to determine the linear trends of the rainfall for the station and amount/ rate of increase or decrease in rainfall were estimated using Microsoft excel tool (2016). Linear regression is represented with a formula:

$$y = a + bx \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

3

Where:

a the intercept of the regression is a line on the y-axis, b is the slope of the regression line. The value of a and b can be obtained from the following equations:

$$a = \frac{\sum y - b(\sum x)}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

RESULTS AND DISCUSSION

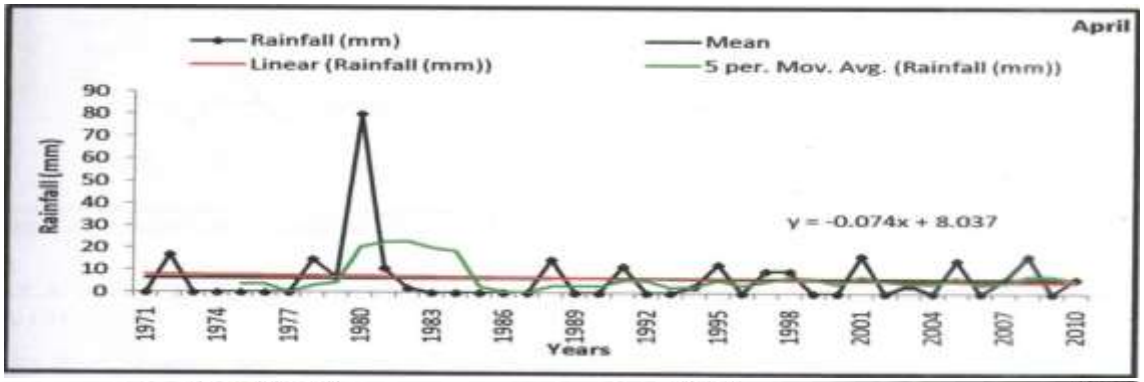
Rainfall Characteristics and Trends for Monthly and Annual Rainfall

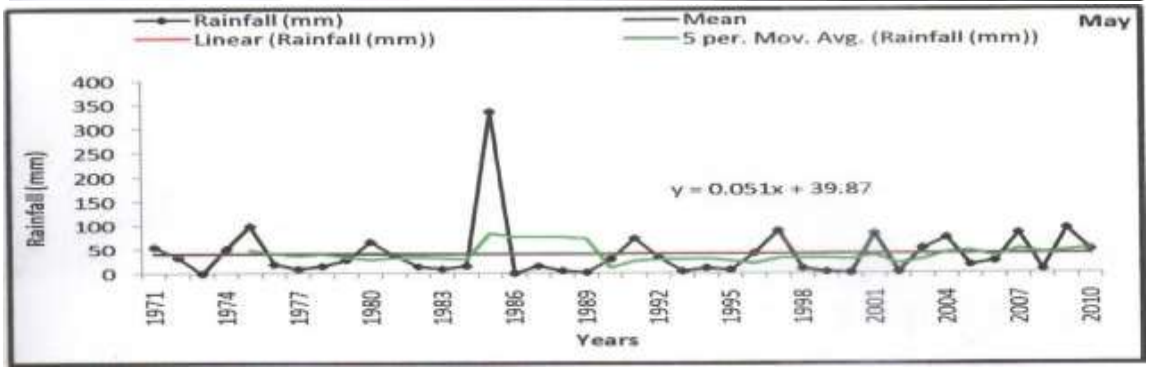
For meteorological purposes, the months of April to October were considered because they are said to be the months when more than 95% of the annual rainfall total is received in the study area (Anyadike, 1993).

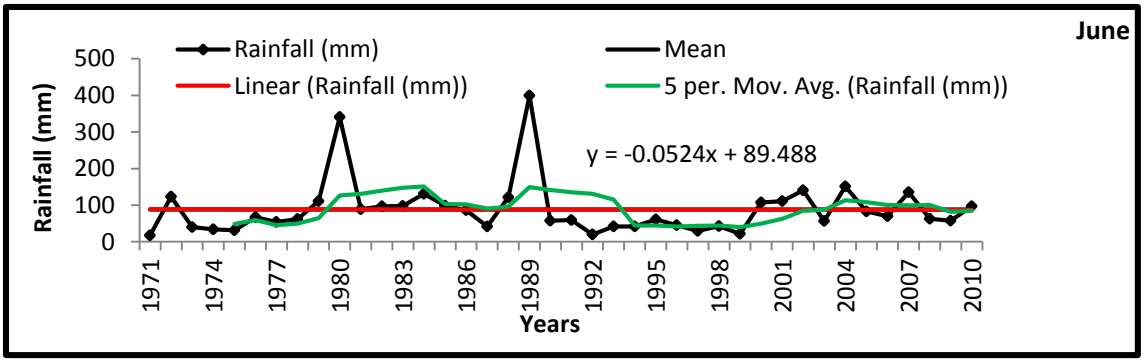
Table 1: General Statistics of Monthly Annual Rainfall for Katsina and its Environs

Statistics	Apr	May	June	July	Aug	Sep	Oct	Annual
$\bar{x}$	6.51	40.92	88.41	142.39	180.24	85.88	12.25	557.39
SD	13.43	56.65	74.99	62.45	71.61	45.53	19.59	154.17
CV	206.30	138.44	84.82	43.86	39.73	53.02	159.92	27.66
Z_1	4.418	3.859	2.842	1.135	0.145	1.061	1.911	0.157
Z_2	23.642	19.248	9.561	1.569	-1.107	0.769	3.137	-0.157

Significant at 95% Confidence Level







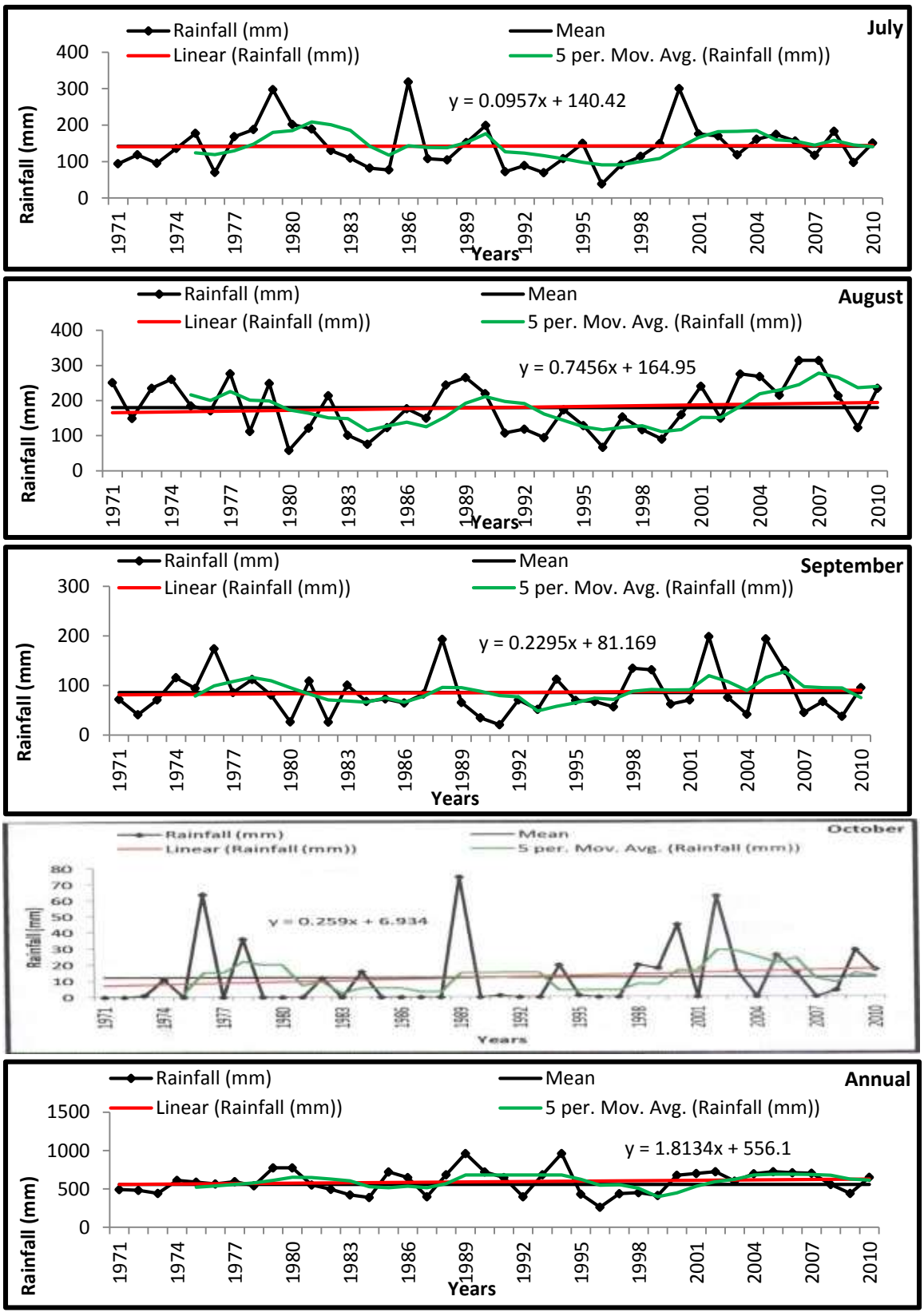


Fig. 2: Rainfall trends for (a) April, (b) May, (c) June, (d) July, (e) August, (f) September, (g) October, and (h) Annual total

The estimation of changes in the monthly rainfall expressed in mm for the period of study period showed that in the month of April, there was increase of approximately 2.80mm at the rate of 0.07mm year^{-1}. Compared with the long-term mean, it means that the April rainfall was decreasing at a rate of 1.08 % year^{-1}. The five-year running mean indicated values below the long-term mean from the beginning to the end of the 1979, with a sharp increase from 1980 – 1985. The value decreased below the long-term mean from 1986 until the end of the last decade.

For the month of May, there was an increase of approximately 2.00mm at the rate of 0.05mm year^{-1} which is about 0.12% year^{-1}. Thus, linear trend line did not indicate any significant increase, rather, the line passess through the long – term mean. The five-year running mean indicated values below the long-term mean from the beginning to the end of 1984 with a sudden increase from 1985 to the end of that decade. The value remains below long-term mean from 1990-2000 with a slight increase from 2004 to the end of the last decade.

The month of June showed a decrease in rainfall of approximately 0.05mm year^{-1} which is about 0.06% year^{-1}. Thus, linear trend line did not indicate any significant decrease, rather, the line passess through the long –term mean. The five - year running mean indicated values below the long-term mean from the beginning to the end of the first decade with a sharp increase between 1980- 1984.The values decline between 1985-1988 with sudden increase between 1989- 1993. The value declined below the long- term mean between 1994 -2003 with slight increase from 2004 till end of that decade.

For the month of July, an increase of 4.00mm at the rate of 0.10mm year^{-1} which is about 0.03% year^{-1} in July was observed. Thus, linear trend line did not indicate any significant increase, rather, the line passess through the long –term mean. The five-year running mean indicated values below the long-term mean from the beginning with sharp increase between 1978- 1985. The value remained below the long- term mean until 1999. From then the value increased above the long- term mean until years of the last decade.

For the month of August , an increase of approximately 30.00mm at the rate of 0.75mm year^{-1} which is about 0.42% year^{-1} in August. The five-year running mean indicates values above long- term mean in the beginning to the end of the first decade. The value declined between 1980- 1989 with a sudden increase in between 1990-1992. Then the value decline until the beginning of 2000. The value then increase above the long -term mean till the end of the last decade.

For the month of September, an increase of approximately 9.20mm at the rate of 0.23mm year^{-1} which is about 0.27% year^{-1} in September. The five-year running mean indicated values above long-term mean at the beginning to the end of the first decade. The value decline below the long- term mean from early 1980 to the mid -1980s with sudden increase from 1986-1989. From then the value declined below the long- term mean till 1998. The value increased above the long- term mean until the end of the last decade.

For the month of October, an increase of approximately 10.40mm at the rate of 0.26mm year^{-1} was observed. The five-year running mean indicates values below the long-term mean at the beginning with increase in the mid- 1970 to early 1980s. From then, the value declined from the mid-1995 until early years of the last decade with sudden increase between 2001 - 2010.

However, comparing with the long-term mean totals, it is also clear that the monthly rainfall was increasing at the rate of 0.03% year^{-1} in July, 0.42% year^{-1} in August , 0.27% year^{-1} in September, and 0.32% in October.

Estimation of changes of the annual rainfall for the period of study indicates an increase of approximately 72.40 mm at the rate of 1.81mm year^{-1}. Compared with the long-term average total, it means that the annual rainfall was increasing at a rate of 0.32% year^{-1}. The five-year running mean indicated values below the long-term mean at the beginning with sudden increase towards the end of the first decade. Then the value decline below the long-term mean from 1982- 1987. From then the value increases above the long -term mean until mid- 1990. Then the value declined below the long- term mean until end 1990s. Since the beginning of the year 2000 the value increases above the long -term mean to the end of that decade.

The 5-year running mean, therefore, showed that below average rainfall was experienced from the early 1970s up to 2000. On the other hand, above average rainfall is being experienced from the year 2000 afterward. From the linear trend lines of the monthly and annual rainfall, there is a clear indication of an increase in rainfall amounts overtime. It is also clear from the results of the linear trend lines that the increase in the annual rainfall yield is predominantly as a result of the increase in August and September rainfall. These findings are in agreement with the observation made by Ati, Iguisi, and Afolayan (2007), Ati *et al.* (2008 and 2009), Abaje, Ishaya and Usman (2010), and Abaje, Ati and Iguisi (2012) that the Sudano-Sahelian Ecological Zone of Nigeria has been experiencing decreasing number of drought occurrences and consequently increasing wetness over the recent years.

CONCLUSION AND RECOMMENDATIONS

Based on the result of the linear trend analysis of the rainfall characteristics it's possible to generalized that there has been a change towards wetter condition in the study area over the recent years. Even if rainfall has come back to near-normal and food security improved in recent years, the study area remains an environmentally sensitive region and climate change is likely

to exacerbate repetition of drought circle where the immediate impact is felt is agricultural sector.

Based on the aforementioned findings the following recommendations are made:

i. There is the need to improve information delivery and foster the use of climate information to inform decision making, using seasonal climate forecasts to inform farmers to avoid surprises, and take right decisions in case of impending drought.
ii. Additional functioning synoptic weather stations should be provided to complement the existing ones in the study area with distance from each other not more than 100km so as to conform to WMO standard. This will enhance network of data collection and accurate seasonal rainfall prediction.

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APPENDIX 1
RAINFALL DATA OF KATSINA

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1972	0	0	0	0	23.6	23.6	198.6	280.9	142.5	0.8	0	0
1973	0	0	0	0	55.9	16.5	94	250.2	71.9	0	0	0
1974	0	0	0	11.2	34	122	117.3	148.6	40.6	0	0	0
1975	0	0	0	0	0	39.9	94.7	235.2	70.6	0.5	0	0
1976	0	0	0	0	51.8	53.8	136.4	261.1	116.1	11.4	0	0
1977	0	0	0	0	79	11.2	176.8	183.4	93.7	0	0	0
1978	0	0	0	0	20.3	67.6	69.6	172.2	174.2	64.3	0	0
1979	0	0	0	0	10.2	54.2	168.3	276.8	87.5	0	0	0
1980	0	0	0	0.6	16.2	62.3	187.5	111.8	111.5	36.1	0	0
1981	0	0	0	7.2	30.2	111.1	297.2	249.3	81.4	0	0	0
1982	0	0	0	0	78.2	66.7	341.2	202.4	58.2	26.9	0	0
1983	0	0	0	11	37.5	88.5	188.6	122.3	109.1	0	0	0
1984	0	0	0	1.6	14.5	97.4	129.8	213.7	26.1	12.3	0	0
1985	0	0	0.1	0	0.4	98.3	109.4	101.1	101.2	0	0	0
1986	0	0	0	0	16.4	81.6	131.4	76.4	68.1	16.1	0	0
1987	0	0	11.2	0	33.7	77.2	98.8	121.3	73.1	0	0	0
1988	0	0	0	0	0.4	3.4	318.1	177.4	64.5	0	0	0
1989	0	0	0	0	16.2	41.5	107.5	149.7	83.4	0	0	0
1990	0	0	0	15.3	6.4	120.7	103.9	24.7	193.1	0	0	0
1991	0	0	0	0	2.9	79.8	152.1	266.3	66.4	74.8	0	0
1992	0	0	0	0	29.9	57.9	198.8	220.2	34.7	0	0	0
1993	0	0	10.8	12.2	73.5	58.8	71.5	109.7	21.1	1.4	0	0
1994	0	0	0	0	33.6	19.9	89.3	119.4	70.7	0.2	0	0
1995	0	0	0	0	4.5	42.3	69	94.5	51.7	0	0	0
1996	0	0	0	3.1	12.3	42.3	107.9	174.2	113.1	20.3	0	0
1997	0	0	0	10	30	70	80	120	80	10	0	0
1998	0	0	0	0	42.6	44.5	38.1	66.8	67.8	0	0	0
1999	0	0	7.2	9.5	89.5	30.4	91.1	153.7	113.1	8.3	0	0
2000	0	0	0	10.1	11.4	43.4	114.1	116.6	135.2	0.8	0	0
2001	0	0	0	0	4.2	22.4	149.2	89.8	26.9	18.4	0	0
2002	0	0	0	0	1.6	106.8	299.9	160.2	63.1	45	0	0
2003	0	0	0	16.9	83.9	110.8	176	240.9	70.6	0	0	0
2004	0	0	0	0	2.9	141.3	170.4	149.7	199.1	62.8	0	0
2005	0	0	4	52.8	57.2	151.9	199.4	180.6	96.5	1.8	0	0
2006	0	0	0	74.9	151.2	161.1	268.8	42	0	0	0	0
2007	0	0	0	14.8	18.4	83.2	173.7	216.1	194	26.4	0	0
2008	0	0	0	0	26.1	69.9	170.9	314.9	129.7	15	0	0
2009	0	0	0	6.2	84.9	135.2	117.4	314.9	45.5	0	0	0
2010	0	0	0	16.6	8.5	63.3	182.9	213.9	67.7	4.2	0	0

Source: NiMet ,Katsina (Umaru Musa Yar'aduwa Air Port, Katsina)