ANALYSIS ON THE CLIMATE OF LASHIO TOWNSHIP: THE CASE OF RAINFALL FLUCTUATION AND ITS TREND

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Abstract

The climate of Lashio is classified as irregular because of large inter-yearly variations in the climatic elements, especially the amount of rainfall. According to Koppen's climatic classification system, the climate of Lashio is Cwa climate (Humid Subtropical Climate) depending on the amount of average temperature and total rainfall. Annual variability in rainfall is markedly significant and monthly rainfall also varies from year to year. This paper explores annual and monthly of rainfall in Lashio over the period between 1980 and 2019. This study has displayed the existence of trends in annual and monthly rainfall, however in which months are decreasing trends and in which months are increasing trends. Decline in rainfall in the months might have serious agricultural implications because most agricultural activities in this area rely on rainfall of this period. The declining in the annual rainfall may lead to the lowering of the water table. This study will be of assistance to better inform farmers as well as agricultural decision makers, also study of temporal fluctuation and trends of rainfall may be used to characterize the climate of the area.

Key points: climate, temperature, rainfall, fluctuation, and trend

Introduction

Climate is perhaps the most important component of the environmental system. It influences man in diverse ways. Man, in turn influences climate through his various activities. The influence of climate on man and his activities may be benevolent or malevolent. Human health, energy and comfort are affected more by climate than by any other element of the natural environment whereas the activities of man in certain locations and over a period of time may lead to increasing maladjustment of man to his climatic environment. In the study of climate for a given area, it is essential to analyse how the climatic controls effect upon the climatic elements (i.e. temperature, precipitation, air pressure and wind) and variation patterns of these elements and types of climate. Thus, rainfall is one of the key climatic variables that affect both the spatial and temporal patterns of water availability. Water has become a prime concern for any development and planning including food production. So, rainfall is very crucial for the economic development of Lashio Township as the integral percentage of the people get involved in rain fed agriculture (crop and plantation). The distribution pattern of rainfall in Lashio Township is most uneven and varies considerably from year to year. In order to have a reliable estimate of rainfall fluctuation, it is necessary to analyze the recent and expected future trend of annual and seasonal total rainfall. Knowing the variations in the general rainfall pattern is valid to understand rainfall variations. Thus there is the need to study the short term structure of rainfall characteristics especially in the study area being a fairly new state (40 years) with recent development affecting rainfall and being affected by rainfall. Keeping above points in mind the study is carried out for Lashio Township, Northern Shan State.

Study Area

The study area covers the Lasiho Township. Lashio Township is located in the Northern Shan State lies on the Mandalay-Muse motor road. It is located between latitude 22° 35' 53" N and 23° 4' 27" N and between longitude 97° 31' 10" E and 98° 22' 48" E. The area of Lashio Township is 2,628.63 square kilometers. Rugged, mountainous and moderately to steeply sloping area nearly

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the whole region and narrow alluvial plain on the central lowland area and western lowland area and southern lowland area generally characterize the topography of the township. Comprising some parts of the alluvial plain is a flat tract of land. However, the majority of the places are an undulating and rolling topography. The location of the outer north side cordillera with N-S stretching is on the northern edge of the township with elevation of about 2,169.7 metres.

Objectives

The main aim of this study is to analysis the rainfall trends and variability over Lashio. In order to achieve main aim, the following specific objectives were conducted;

- to study the general climatic condition of Lashio
- to determine monthly and annual rainfall variability
- to analyze the temporal pattern of rainfall for modals
- to investigate statistical and graphical rainfall trends

Data and Methodology

The required data and information to examine the climate of Lashio and its rainfall variability and trend were collected from the Department of Meteorology and Hydrology (DMH), Lashio Township, Shan State and the Department of Geography, Lashio University. To present quantitatively the variation pattern of climatic elements in Lashio, the techniques of descriptive statistics (i.e. Average, Standard Deviation, and Coefficient of Variation) are applied.

Analysis and Discussion

The General Climatic Condition of Lashio

Lashio is situated on the northern part of the Eastern Shan Plateau. As Lashio lies in the Humid Subtropical Climate Zone of Myanmar, most of the land surface has elevations over 762 smetres above sea level; and although there are no big forests, Lashio generally has a Humid Subtropical Climate due to geographical location. The yearly average mean temperature is 22.04° C. In examining the conditions of temperature during the 40-year period from 1980 to 2019, it is found that the yearly average maximum temperature is 29.86° C; the yearly average minimum temperature is 14.22° F and the yearly average mean of temperature is 22.04° C. In studying the temperature conditions during the year, January is the coldest month with the average mean temperature of 15.22° C, the average maximum temperature and average minimum temperature of January is 26.22° C and the 4.23° C respectively. The hottest month is April with the average mean temperature of 23.80° C, the average maximum temperature and average minimum temperature of April is 33.66° C and the 13.93° C respectively. See Table (1). According to the data of rainfall records obtained from the Meteorological and Hydrology Department of Lashio Station, during the 40-year period from 1980 to 2019, the yearly average rainfall of Lashio is 107.34 mm. Within a year the average number of rainy days is 184 days. The conditions of the relative humidity of Lashio differ from one season to another. Even during a day, the relative humidity of the morning session is not the same as the evening session. In observing the conditions of the relative humidity of Lashio during the period 1980-2019, September is the highest relative humidity and April has the least relative humidity. Wind and atmospheric pressure are related weather phenomena. Winds blow from high to low pressure systems. The average hourly wind speed in Lashio experiences mild seasonal variation over the course of the year. The windier part of the year is from December to May. The windiest month of the year is March with an average hourly wind speed of 2.9 miles per hour. In Lashio, the average percentage of the sky covered by clouds experiences extremes

seasonal variation over the course of the year. The clear part of the year in Lashio begins around ending October and lasts ending around April. On February, the clearest day of the year, the sky is clear. The cloudier part of the year begins around April and lasts ending October. On July, the cloudiest day of the year, nearly the sky is overcast or mostly cloudy. According to the Koppen's climatic classification system, Lashio has Humid Subtropical Climate (Cwa). Temperature and rainfall conditions of Lashio are shown in Table (1).

Table 1 Average Monthly Rainfall and Temperature of Lashio (1980-2019)

	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
R.F (mm)	8.74	9.51	15.75	56.95	137.90	198.90	230.95	238.43	192.23	138.85	50.58	9.31
Max(˚C)	26.22	28.67	31.98	33.66	32.63	31.14	30.22	30.39	29.59	29.76	28.07	25.93
Mean(˚C)	15.22	16.97	20.27	23.80	25.45	26.14	25.86	26.16	24.96	23.59	19.90	16.17
Min (˚C)	4.23	5.26	8.56	13.93	18.28	21.14	21.48	21.92	20.33	17.42	11.73	6.40

Source: Meteorology and Hydrology Department, Lashio

Monthly Rainfall Variability of Lashio between 1980 and 2019

In Lashio, from May to October are the months with the most annual amount of rainfall. Generally, May, June, July, August, September and October are the months with the highest amount of rainfall in Lashio. Aprial and November are the months with moderate amount of rainfall in Lashio. January, February March and December are the months with the lowest amount of rainfall in Lashio. See in Table (2&3).

Among the total number of 40-year period, it is found that there are 24 years with rain and another 16 years without rainfall in January. The maximum rainfall was 55.12 mm and the range of rainfall was 55.12 mm. The mean of rainfall was 8.74 mm in January. The standard deviation of this month was 16.02 and the coefficient of variation was 183.26. The precipitation ratio of this month was 638.24.

In February, 21 years were no precipitation whereas 19 years with rain period. The maximum rainfall was 87.12 mm and the range of rainfall was 87.12 mm. The mean of rainfall was 9.51. The standard deviation of this month was 16.92 and the coefficient of variation was 177.87. The precipitation ratio of this month was 927.03.

The highest distribution of March was recorded at 78.23 mm. During 40-year period, 7 years had no precipitation and 37 years had rain. The mean of this month was 15.75 mm and the range of rainfall was 78.23 mm. The standard deviation of this month was 20.48 and the coefficient of variation was 130.02. The precipitation ratio of this month was 496.77.

In April, the average rainfall was 56.89 mm. The maximum and minimum rainfalls were recorded at 115.82 mm and 9.14 mm and the range of rainfall was 6.60 mm. It is found that the monthly rainfall for 20 years was less than the mean rainfall 56.9 mm and 20 years were more than the mean. The standard deviation of this month was 32.34 and the coefficient of variation was 56.79. The precipitation ratio of this month was 566.07.

In May, the average rainfall was 137.92 mm. The monthly rainfall of May for 23 years was less than the mean and only 17 years had more than the mean. The maximum and minimum rainfalls were recorded at 356.10 mm and 34.04 mm. The range of rainfall was 322.07 mm. The standard deviation of this month was 71.83 and the coefficient of variation was 52.09. The precipitation ratio of this month was 233.52.

In June, July and August, it is found that there are 22 years with less than the mean rainfall and only 18 years were more than the mean of rainfall in each month. The average rainfall was

198.88 mm, 251.46 mm and 238.51 mm respectively. The maximum rainfall of June, July and August was 459.23 mm, 411.99 mm and 391.92 mm respectively. The minimum rainfall of June, July and August was 64.00 mm, 103.89 mm and 302.26 mm respectively. The range of rainfall of these months was 395.22 mm, 308.10 mm and 89.66 mm respectively. The standard deviation of these months was 83.61, 77.40 and 69.53. The coefficient of variation in June was 42.04. The precipitation ratio of this month was 198.08. The coefficients of variation in July and August were 33.52 and 29.16. The precipitation ratio of these months was 133.44 and 138.31.

In September, the monthly rainfalls for 17 years were less than the mean and 23 years have more than the mean of rainfall. The maximum and minimum rainfalls of September were 322.83 mm and 56.90 mm. The range of rainfall was 265.94 mm. The standard deviation of this month was 66.95 and the coefficient of variation was 34.83. The precipitation ratio of this month was 138.31.

The highest distribution of October was recorded at 367.03 mm and the lowest distribution had no rain. During 40-year period, one year had no precipitation and 39 years had rain. The average mean of this month was 138.94 mm and the range of rainfall was 367.03 mm. The standard deviation of this month was 87.98 and the coefficient of variation was 63.30. The precipitation ratio of this month was 246.17.

In November, 5 years were no precipitation whereas 35 years with rain period. The maximum rainfall was 225.04 mm and the range of rainfall was 225.04 mm. The mean of rainfall was 48.26 mm. The standard deviation of this month was 51.24 and the coefficient of variation was 101.31. The precipitation ratio of this month was 445.23.

In December, it is found that there are 26 years with rain and another 14 years without rainfall. The maximum rainfall was 72.90 mm and the range of rainfall was 72.90 mm. The mean of rainfall was 1.78 mm. The standard deviation of this month was 14.11 and the coefficient of variation was 151.56. The precipitation ratio of this month was 775.68.

In analyzing rainfall data of Lashio, it is found that there are differences between maximum and minimum rainfall of over the series of expressed in terms of mean. This ratio may give the stability of rainfall with special relationship. Higher the ratio is higher in abnormality in rainfall and vice versa.

Table 2 Numbers of Monthly Rainfall Variation and Precipitation of Lashio

No.	Months	No. of years above of the mean	%	No. of years below of the mean	%	Precipitation Ratio
1.	January	29	72.5	11	27.5	638.24
2	February	28	70.0	12	30.0	927.03
3	March	27	67.5	13	32.5	496.77
4	April	20	50.0	20	50.0	566.07
5	May	23	57.5	17	43.5	233.52
6	June	22	55.0	18	45.0	198.08
7	July	22	55.0	18	45.0	133.44
8	August	22	55.0	18	45.0	138.31
9	September	17	42.5	23	57.5	138.31
10	October	21	52.5	19	47.5	246.17
11	November	24	60.5	16	39.5	445.23
12	December	28	70.0	12	30.0	775.68

Source: Meteorology and Hydrology Department, Lashio

Table 3 Monthly Standard Deviation and Coefficient of Variation of Lashio

No.	Months	Average (mm)	Std	CV
1	January	8.74	16.02	183.26
2	February	9.51	16.92	177.87
3	March	15.75	20.48	130.02
4	April	56.95	32.34	56.79
5	May	137.90	71.83	52.09
6	June	198.90	83.61	42.04
7	July	230.95	77.40	33.52
8	August	238.43	69.53	29.16
9	September	192.23	66.95	34.83
10	October	138.85	87.98	63.36
11	November	50.58	51.24	101.31
12	December	9.31	14.11	151.56

Source: Meteorology and Hydrology Department, Lashio

Annual Rainfall Variability of Lashio between 1980 and 2019

As Lashio is situated on the highland region, it receives more rain than the surrounding areas. According to the rainfall data from 1980 to 2019, the average total annual rainfall of Lashio is 1288.29 mm. See in Table (1& 4).

The temporal distribution of rainfall over the study region was investigated. The pattern of ombrothermic diagram for individual year is unstable varying from unimodal type to bimodal, trimodal and multimodal types. During 40-year period, there are 11 years with unimodal, 20 years in bimodal, 7 years with trimodal and 2 years with multimodal. Nearly all unimodal patterns have much

rain in July (1980, 1994, 1996, 1997, 1998, 2004, 2005, 2012, 2013, 2014 and 2015) but 1997 and 2004 receive much rainfall in September. Although some years have bimodal pattern, rainfall is evenly distributed during the rainy season. In trimodal and multimodal patterns, the rainfall is relatively distributed evenly throughout the rainy season.

During the period of 1980 to 2019, the total annual average rainfall is about 50.72 inches. In some of the years like 1982,1988, 1990, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2002, 2003, 2005, 2007, 2009, 2010, 2011, 2012, 2014, 2015 and 2019 are under the average total rainfall and the rest years (19 years) were above the average total annual rainfall. Among these years, some of the years -1986 and 2008 are very slightly increased with the average total rainfall of 107.35 mm, but some of the years like 1980, 1981, 1983, 1984, 1985, 1986, 1987, 1989, 1991, 1995, 2000, 2001, 2004, 2006, 2008, 2013, 2016, 2017 and 2018 significantly increased with amounted over 107.35 mm. See fig (1).

During the 40-year period, the average annual rainfall for the period from 1980 to 2019 in Lashio was 107.35 mm with the standard deviation of 91.97 and coefficient of variation was 85.67%. During 40 year period, the highest coefficient of variation (125.87%) was 1012 and the lowest coefficient of variation (70.19%) was 2019. Thus, the range of the two extremes amounted to 55.68%. During the 40-year period, the average total rainfall of Lashio is very fluctuation. Therefore, it is noted that the rainfall receiving in Lashio is fluctuation. See table (4).

Table 4 Yearly Standard Deviation and Coefficient of Variation of Lashio

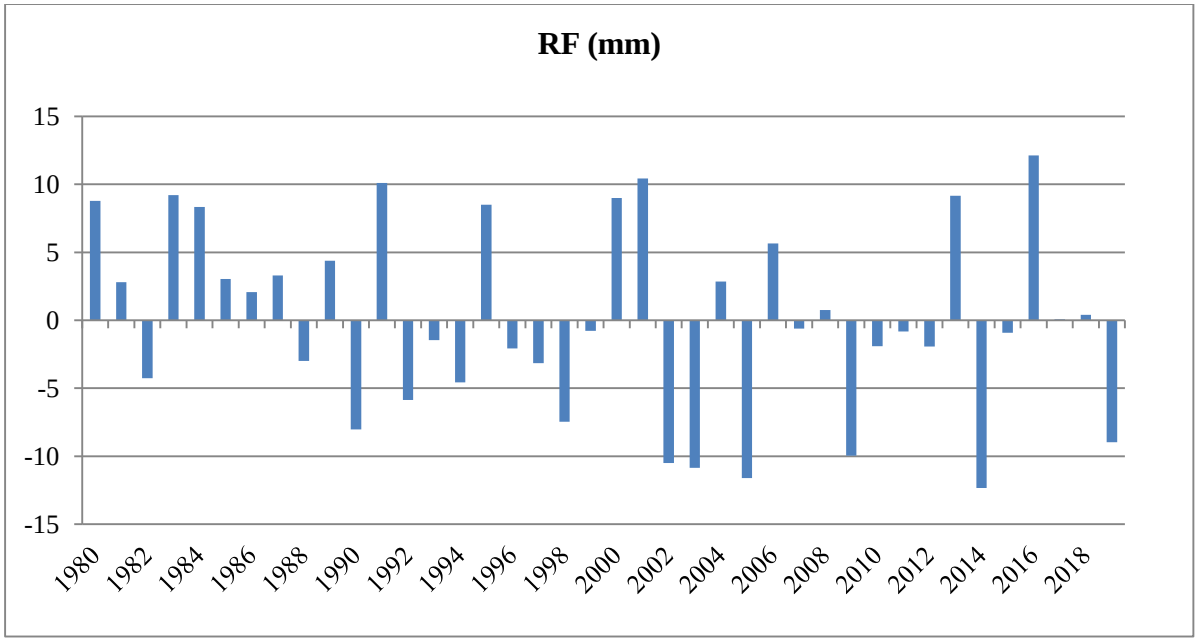
Year	Rainfall(mm)	Std	CV		Year	Rainfall(mm)	Std	CV
1980	1511.05	138.57	110.05		2000	1516.63	118.71	93.93
1981	1359.15	101.27	89.41		2001	1552.96	146.29	113.04
1982	1179.83	117.79	119.80		2002	1021.84	87.74	103.04
1983	1522.22	94.55	74.54		2003	1012.95	94.16	111.54
1984	1500.12	130.20	104.15		2004	1360.42	109.43	96.53
1985	1365.50	112.78	99.11		2005	993.90	94.41	113.99
1986	1341.12	129.35	115.74		2006	1432.05	114.50	95.94
1987	1371.85	123.64	108.15		2007	1273.05	110.46	104.12
1988	1212.60	82.38	81.52		2008	1307.34	96.46	88.54
1989	1399.29	125.29	107.45		2009	1035.30	89.26	103.46
1990	1084.58	86.77	96.01		2010	1240.03	98.06	94.90
1991	1544.57	118.68	92.20		2011	1267.46	97.89	92.68
1992	1139.70	95.52	100.58		2012	1239.01	129.96	125.87
1993	1250.95	98.55	94.54		2013	1520.95	142.35	112.31
1994	1172.21	86.39	88.44		2014	975.11	99.88	122.91
1995	1504.19	118.75	94.73		2015	1265.17	127.58	121.00
1996	1235.46	98.91	96.07		2016	1595.88	123.17	92.62
1997	1208.28	112.88	112.11		2017	1290.32	83.53	77.69
1998	1098.80	82.44	90.03		2018	1298.70	100.29	92.67
1999	1268.48	96.40	91.20		2019	1060.70	62.04	70.19

Source: Meteorology and Hydrology Department, Lashio

Rainfall Trend Analysis of Lashio

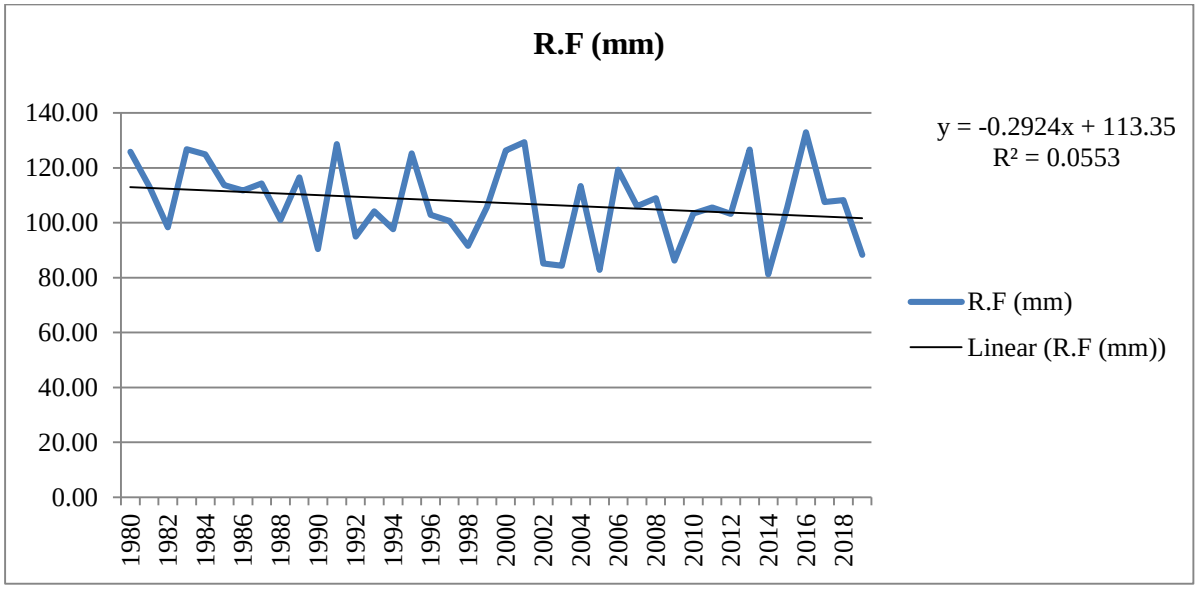
Trend line analysis is a useful tool to depict the changing pattern of time series data. Long term rainfall records are essential to study the climate of an area. Lashio is carried out first to understand the evolution of rainfall was how much increasing and decreasing during 40-year period.

The advantage of this method is that it provides quick visual observation of the presence trend in a given time series. Moreover the use of the graphical approach for trend analysis is simple. The visual method of determining trends from a graph is very subjective therefore statistical method can also be used. Statistical methods were used to test the statistical significance of the observed trends in a time series. The results of trends analysis from graphical method were categorized into two categories namely; increasing trends (positive) and decreasing trends (negative). The monthly analysis of rainfall data for Lashio station showed that there are increasing (positive) trends in January, March and July during the 40-year period from 1980 to 2019. However, the rest of the months- February, April, May, June, August, September, October, November and December depicted decreasing (negative) trends. To examine long term trend of rainfall for this study total annual rainfall records for the period from 1980 to 2019 is used. In summary result from all graphical methods showed decreasing (negative) trend given by the equation $y = -0.2924x + 113.35$, $R^2 = 0.0553$. See fig (2).



Source: Based on Table (4)

Figure 1 Annual Rainfall Abnormality of Lashio



Source: Based on Table (4)

Figure 2 Annual Rainfall Trend in Lashio Township

Conclusion

This study is undertaken to understand general climatic condition, rainfall variability and trend in Lashio Township. This paper analyzes the rainfall data of 40 years of Lashio which plays a significant agricultural and hydrological contribution in the over growth of Lashio Township. These will provide information on rainfall variability of the township and could be used as input for the local adaptation planning and to develop adaptation strategies for the study area.

The air we breathe is obtained from the atmosphere; the water we drink originated from precipitation and the food we eat has its origin in photosynthesis all of which attributes of climate. Climate and climatic variation exert a tremendous influence on society. The impact of climate and its variation may be positive or negative. The climate and society interface may be thought of in terms of adjustment that is the extent and ways in which society function in a harmonious relationship with its climate.

The climate of Lashio is marked by considerable inter-yearly fluctuations in precipitation. Such a study may be further detailed by analysing the daily data instead of monthly and yearly applying other climatic elements and pointing out the variation patterns by months and years which are most prone to variability those relatively or entirely free from it. This study indicates that there is variation in the climate of Lashio following rainfall variability and a lot of negative impacts have been created by this climatic phenomenon in the area. It is expected that the development planning for Lashio will be supported by studying the detailed patterns of variability in climatic elements. This study will be of assistance to better inform farmers as well as agricultural decision makers, also study of temporal fluctuation and trends of rainfall may be used to characterize climatology of the area.

Acknowledgements

We would like to express the deep gratitude to Dr. Kyaw Tun, Rector, Lashio University and Dr. San Yu Maw, Professor, Head of the Department of Geography, Lashio University for their kind permission of this research paper. We would also like to acknowledge those who academically and technically are involved in our research and those who co-operated in helping us in this study.

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