Analysis of Rainfall Data for Selected Areas in Myanmar

San San Myint[1], Aye Aye Thant[2]
[1]*Associate Professor, Department of Civil Engineering, Technological University (Mandalay)*
[2] *Associate Professor, Department of Civil Engineering, Mandalay Technological University*

***Abstract* –This paper presents about analysis of rainfall data. Rainfall analysis is prerequisite for designing efficient storm water management system. In this paper, Mawlaik, Hakha, and Homalinare selected as the study areas. Rainfall data of the study areas are collected from Department of Meteorology and Hydrology in Myanmar. Thus, annual rainfall, climate change analysis and probability analysis for one day maximum rainfall are performed. The moving average, semi average method and probability analysis by Weibull formula are adopted. Moving average method is used to identify the long term trend lines and, 3 and 5 year moving average trend lines are generated. Semi average method is adopted to obtain the straight line trends.From the result of annual rainfall analysis, maximum annual rainfall, minimum annual rainfall and average annual rainfall are obtained for each study area. According to the probability analysis for one day maximum rainfall using Weibull formula, probability of one day maximum rainfall occurrence for selected areas are obtained.**

***Keywords*– rainfall analysis, annual rainfall, Climate change, probability analysis**

I. INTRODUCTION

Inadequate hydrologic data and the need for proper planning of water resources development have forced engineers to analyze available data more critically. This is particularly so in developing countries. Analysis of rainfall and determination of annual maximum daily rainfall would enhance the management of water resources applications as well as the effective utilization of water resources. Probability and frequency analysis of rainfall data enables us to determine the expected rainfall at various chances. Such information can also be used to prevent floods and droughts, and applied to planning and designing of water resources related to engineering such as reservoir design, flood control work, soil and water conservation planning. The primary source of water for agricultural production for most of the world is rainfall and it is useful for forecasting the floods to downstream towns and villages. Much of the information about the rainfall climatology of any region or a basin is mostly based on monthly, seasonal and annual rainfall data that are derived from daily rainfall recorded at individual stations. And, quantifying and adapting to them is one way to reduce urban vulnerability. Analysis of time series (eg; rainfall data series) is helpful to understand the past behavior and to predict the future behavior. Analysis of the past behavior enables to forecast the future. Therefore, rainfall data are analysed to evaluate trend (the trend is the long-term movement of a time series and any increase or decrease in the values of a variable occurring over a period of several years gives a trend) and temporal pattern of water availability.

II. METHODOLOGY

Methodology used in this paper is illustrated with the following flow chart shown in Figure 1.

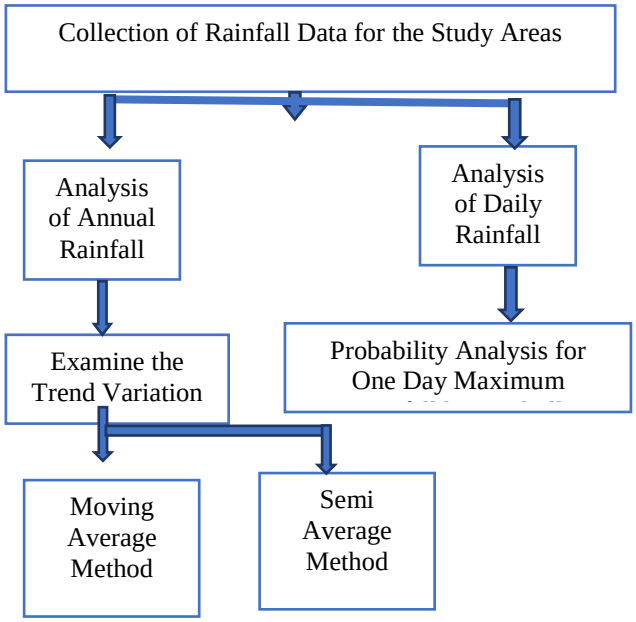

FIGURE 1. METHODOLOGY FOR RAINFALL DATA ANALYSIS

III. RAINFALL ANALYSIS

The main important source of water for any area is rain. And, rainfall is the major contribution to the water balance and thus it is the water resources of an area. Thus, rainfall is really beneficial for people on the earth. And, rainfall trend is very crucial for the economic development and hydrological planning for the country [3].Changes in the hydrologic cycle due to increase in greenhouse gages cause variations in intensity, duration, frequency of rainfall events and rainfall pattern changes because of the climate changes. Changes in rainfall pattern are likely to lead to severe water shortage and/or flooding in which the flood can cause waterlogging,

landslides, degradation of water quality, crops/food shortage, property damage and potential loss of life. Rainfall data of Mawlaik, Hakha, and Homalin are collected for 25 years record (1981-2005) for performing rainfall analysis.

A.Annual Rainfall Analysis

Annual rainfall data derived from the collected daily rainfall data are analysed by moving average method and semi average method and, the analysis also shows climate change analysis. Annual rainfall of Mawlaik, Hakha, and Homalinare illustrated in Figures 2 to 4.

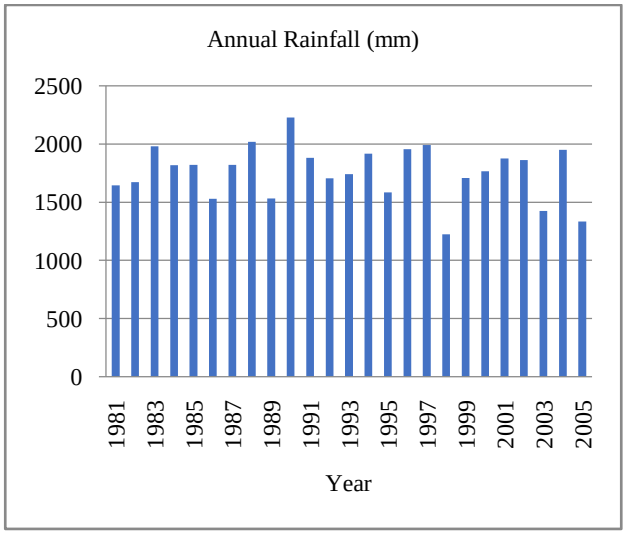

FIGURE 2.ANNUAL RAINFALL OF MAWLAIK (1981 – 2005)

Average annual rainfall of Mawlaik is 1759.16 mm. The minimum annual rainfall is 1225 mm that occurred in 1998 and the maximum annual rainfall is 2228 mm (in 1990).

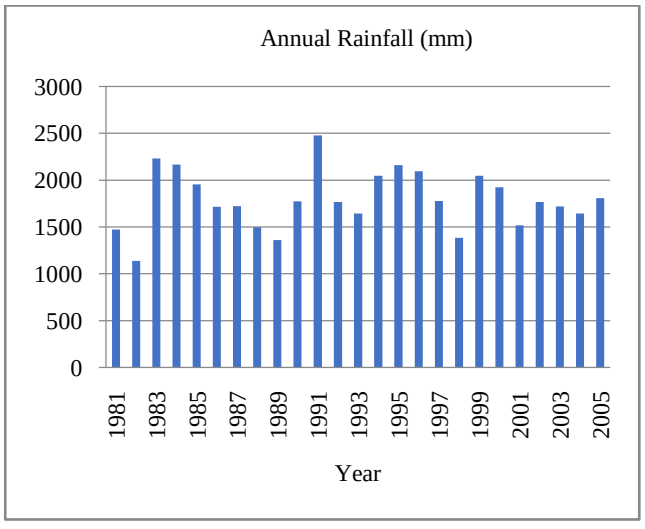

FIGURE 3.ANNUAL RAINFALL OF HAKHA (1981 – 2005)

It is observed that the average annual rainfall of Hakha is 1792.08 mm, the minimum annual rainfall is 1139 mm (in 1982) and the maximum annual rainfall is 2476 mm (in 1991).

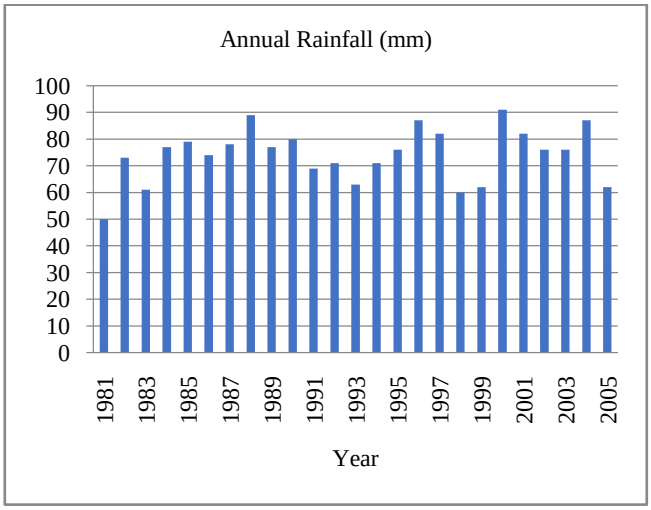

FIGURE 4.ANNUAL RAINFALL OF HOMALIN (1981 – 2005)

From above Figure 4, it is found that the average annual rainfall of Homalin is 74.12 mm, the minimum annual rainfall is 50 mm (in 1981) and the maximum annual rainfall is 91 mm (in 2000).

B. Moving Average Method for Study Areas

To identify long-term trend line, annual rainfall of Mawlaik, Hakha, and Homalin are analysed for 3-year and 5-year by moving average method are illustrated in Figures 5 to 7 respectively.

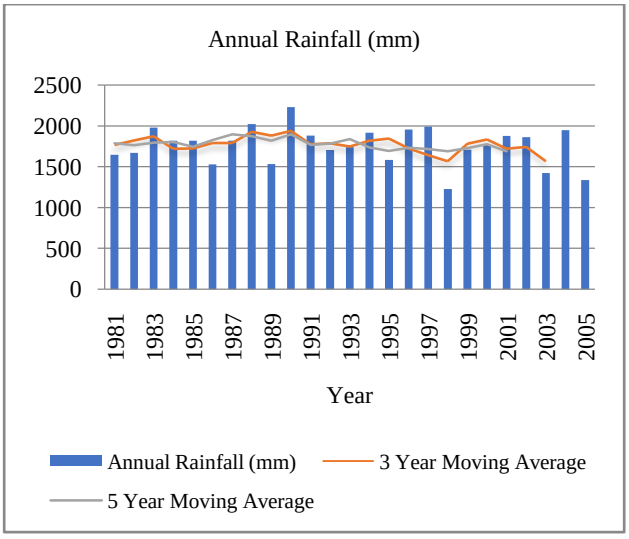

FIGURE 5.THREE AND FIVE YEAR MOVING AVERAGE FOR MAWLAIK

As for Figure 5, it is found that the real rainfall are fluctuating much more than 3-year moving trend line and 5-year moving trend line in the year 1983, 1990, 1994, 1996, 1997and 2004. In 5-year moving average, the trend line is more smoother compared with 3-year moving trend line. For

the years 1990, 1996, and 1997, real rainfall are significantly higher than those of both trends and thus these years are supposed as much-rainfall years. However, as for the years 1986, 1989 and 1998, real rainfall are much less than rainfall of both trends. Therefore, it is observed that these years are less-rainfall year. As for overall study period, it is said that annual rainfall of Mawlaik are variable.

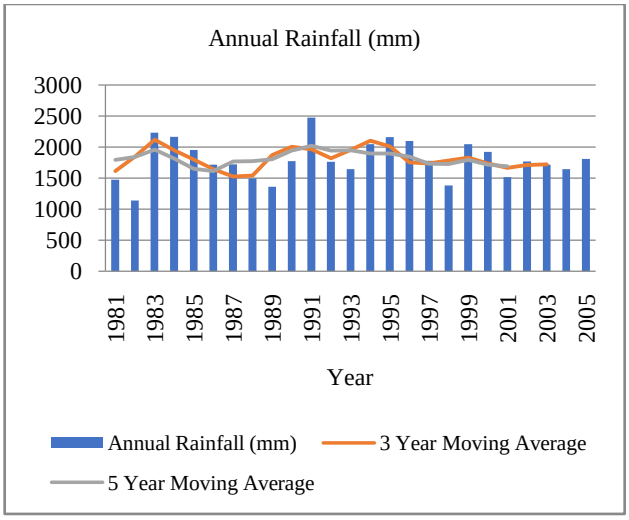

FIGURE 6.THREE AND FIVE YEAR MOVING AVERAGE FOR HAKHA

Figure 6 shows that the original data are fluctuating much more than 3-year moving trend line and 5-year moving trend line. Moreover, the 3-year moving trend line is more fluctuated than 5-year moving trend line. The original data are higher than both of 3-year and 5-year moving average trend lines in 1983, 1984, 1985, 1986, 1991, 1995, 1996, 1999, 2000 and 2002, however, it is predominant in 1991 than other years. But, in 1987 and 1988, 3-year moving trend line is lower dominantly than 5-year moving trend line. For Hakha, it can be said that annual rainfall during study period shows variability.

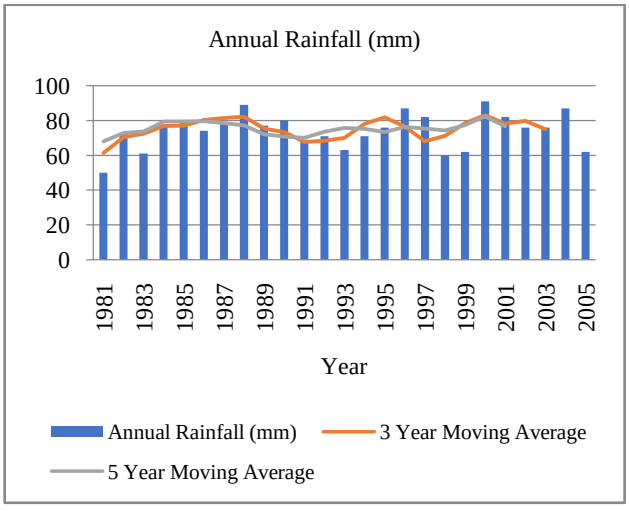

FIGURE 7. THREE AND FIVE YEAR MOVING AVERAGE FOR HOMALIN

Figure 7 indicates that the real rainfall are fluctuating much more than 3-year moving trend line and 5-year moving trend line in the year 1988, 1990, 1996, 1997, 2000 and 2004. The most serious consequence of smoothing is the shift of peaks and troughs in the smoothed curve relative to the original data. In 5-year moving average, the trend line is smoother compared with 3-year moving trend line. However, as for the years 1983, 1993, 1998, 1999 and 2005, real rainfall are much less than rainfall of both trends. Therefore, it is observed that these years are less-rainfall year. As for overall study period, it is said that annual rainfall of Homalin are variable.

C. Semi Average Method for Study Areas

Semi average rainfall of Mawlaik, Hakha, and Homalin, are determined to obtain the straight line trend and the results are illustrated in Figures 8 to 10 respectively.

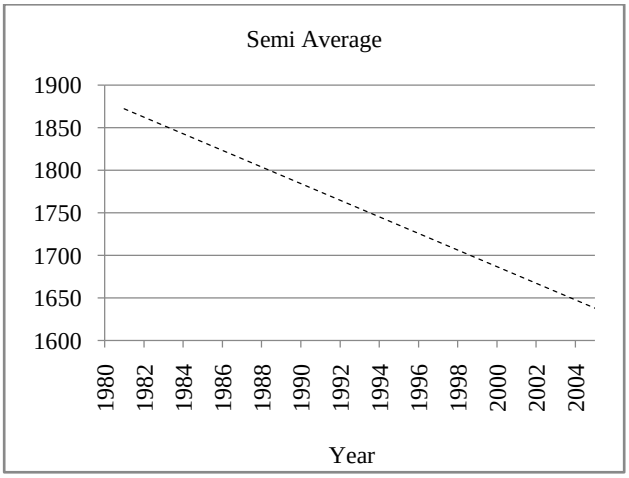

FIGURE 8.SEMI AVERAGE FORMAWLAIK

As from Figure 8, the trend line for Mawlaik is obtained by joining the two points (1803.83 mm and 1716 mm). The trend line is decreasing line during the study period of 25 years (1981-2005) and so annual rainfall of Mawlaik decrease.

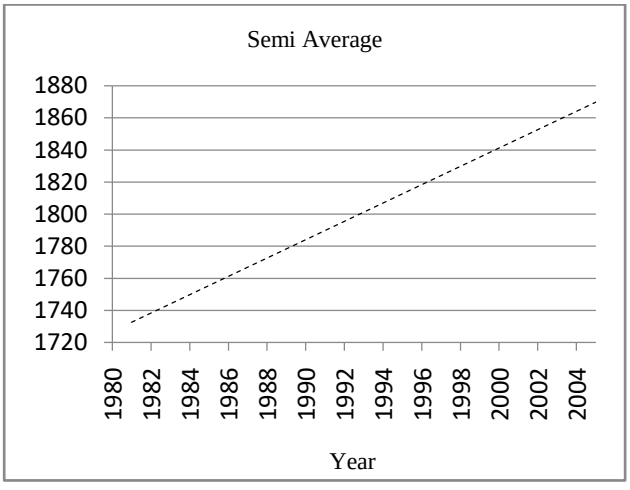

FIGURE 9.SEMI AVERAGE FORHAKHA

In Figure 9, two points (1772.58 mm and 1824.08 mm) are plotted corresponding to their middle years. By joining these points, trend line is found as increasing line during the study period of 25 years (1981-2005) and thus annual rainfall of Hakhaincreases.

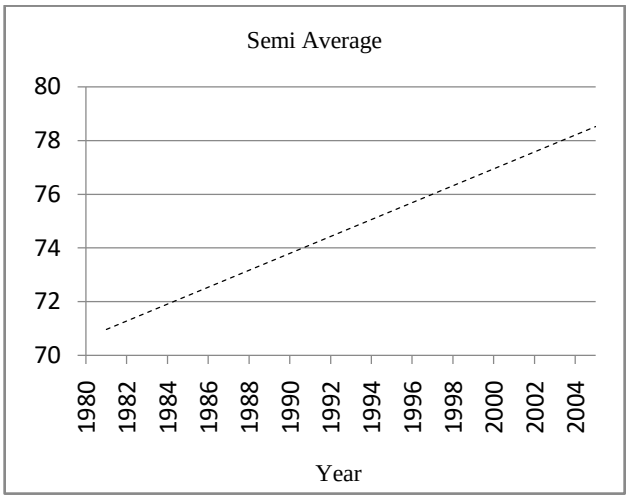

FIGURE 10.SEMI AVERAGE FORHOMALIN

In Figure 10, two points (73.17 mm and 76 mm) are plotted corresponding to their middle years. By joining these points, the trend line is observed as increasing trend. Annual rainfall for Homalin increases during the study period of 1981-2005.

D. Climate Change Analysis for Study Areas

In order to examine the rainfall pattern, average rainfall of the study areas are plotted for every 5 year and 10 year interval.Figures 11 to 16 illustrate 5 and 10 year average rainfall for the corresponding study areas.

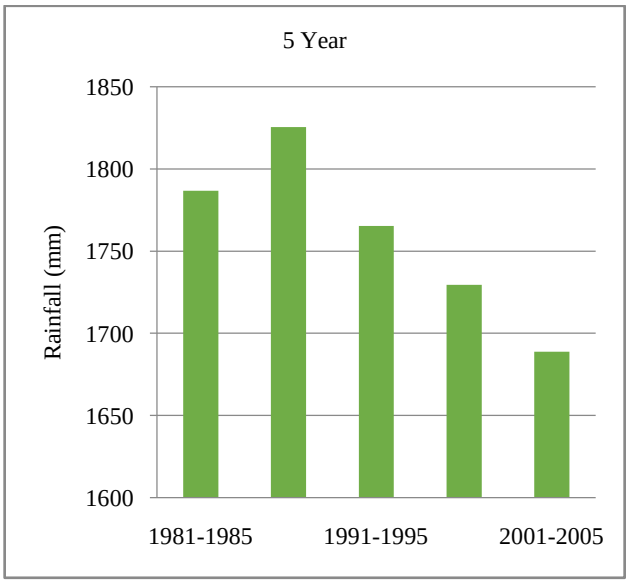

FIGURE 11.FIVE YEAR AVERAGE ANNUAL RAINFALL FORMAWLAIK

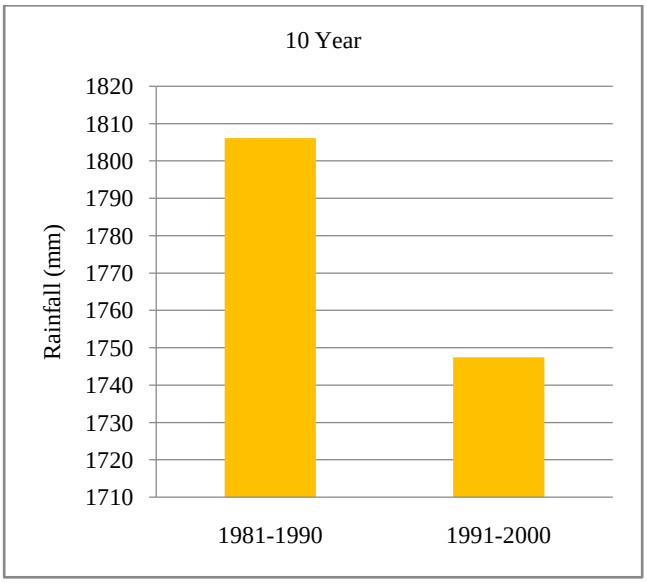

FIGURE 12.TEN YEAR AVERAGE ANNUAL RAINFALL FORMAWLAIK

For every five year interval during the study period, rainfall of Mawlaik for the first two period (1981-1985 and 1986-1990) isincreases and rainfall of the last three period (1991-1995, 1996-2000 and 2001-2005) decreases continuously. Rainfall of the second 5 year (1986-1990) is 1825.4 mm which is the largest value. For every 10 year interval, rainfall of first decade (1981-1990) is 1806.1 mm which is the maximum value. Rainfall in the second decade (1991-2000) reduces dominantly. As 5 year average annual rainfall show decreasing, monsoon of Mawlaik is decrease generally.

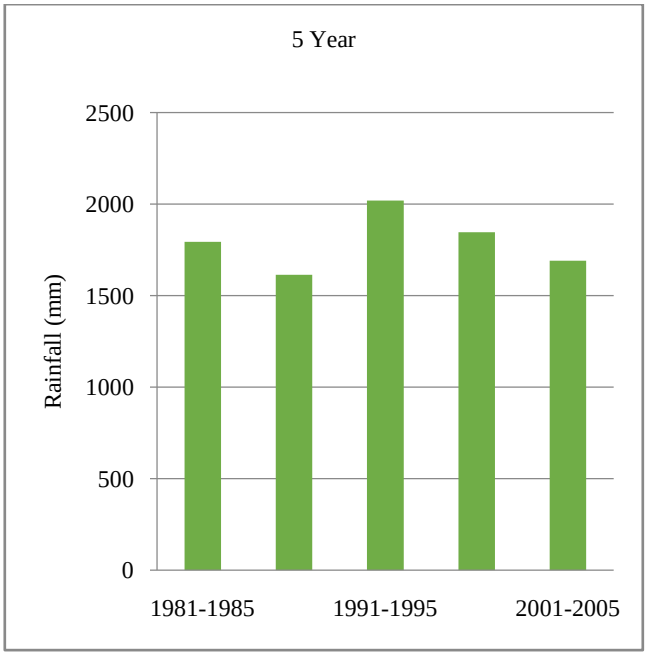

FIGURE 13.FIVE YEAR AVERAGE ANNUAL RAINFALL FORHAKHA

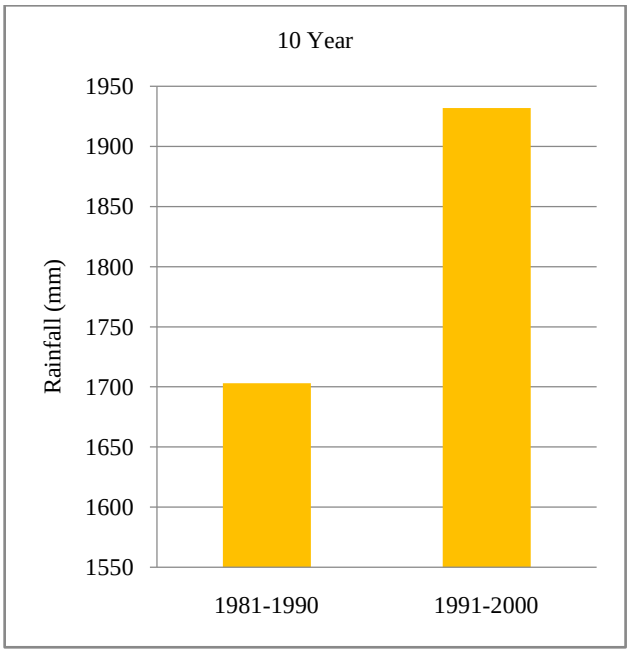

FIGURE 14.TEN YEAR AVERAGE ANNUAL RAINFALL FORHAKHA

As illustrated in Figures 13 and 14, for 5 year interval during the study period for Hakha, monsoon rainfall of first two and last two 5 year are decreases gradually. And, rainfall increases suddenly by 25% of the former at the middle 5-year which is the largest value. For 10 year interval, rainfall increases significantly. For Hakha, 5 year average rainfall flatuates and thus it is generally said that monsoon rain inHakaha unsteady.

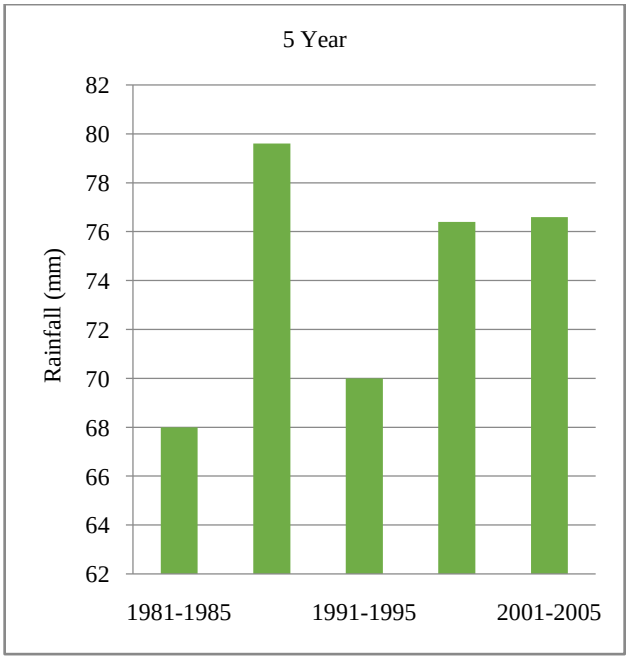

FIGURE 15.FIVE YEAR AVERAGE ANNUAL RAINFALL FORHOMALIN

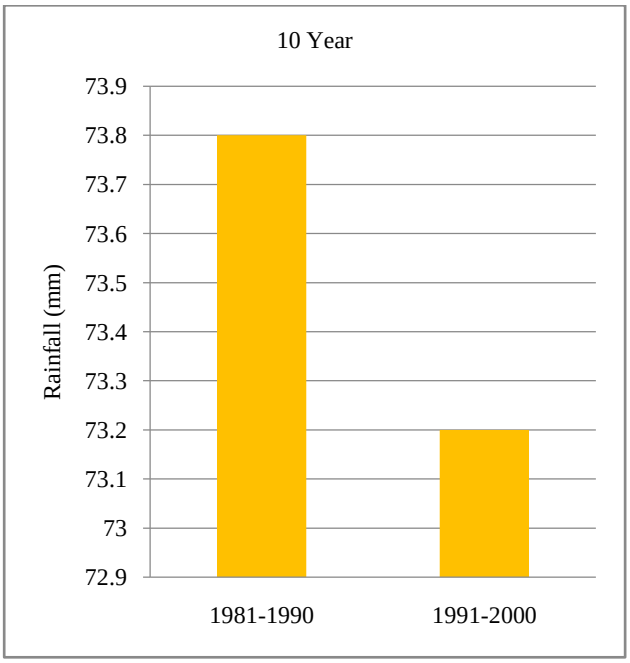

FIGURE 16.TEN YEAR AVERAGE ANNUAL RAINFALL FORHOMALIN

According to everyfive year interval during the study period in Figure 15, rainfall of Homalinfor second 5 year is increases suddenly with value of 79.6 maximum and the later 5 year (1991-1995) drop significantly. And the last two 5 year have the same rainfall amount.For every 10 year interval, rainfall of first decade (1981-1990) is 1806.1 mm which is the maximum value. Rainfall in the second decade (1991-2000) reduces dominantly.As 5 year average annual rainfall show variabilities, monsoon of Homalin is unusual and unsteady.

E. Probability Analysis for One Day Maximum Rainfall

From daily rainfall data, one day annual maximum rainfall for the study areas are analysed using Weibull formula of Equation (1) and (2) for probability analysis. The results for probability analysis during study period (1981-2015) are illustrated in Figures 17 and 19.

$$P = \frac{m}{N+1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where, P = the probability of occurrence of an extreme event

m = the rank of the observation

N = total number of years of record

Return Period, T = 1/P ……(2)

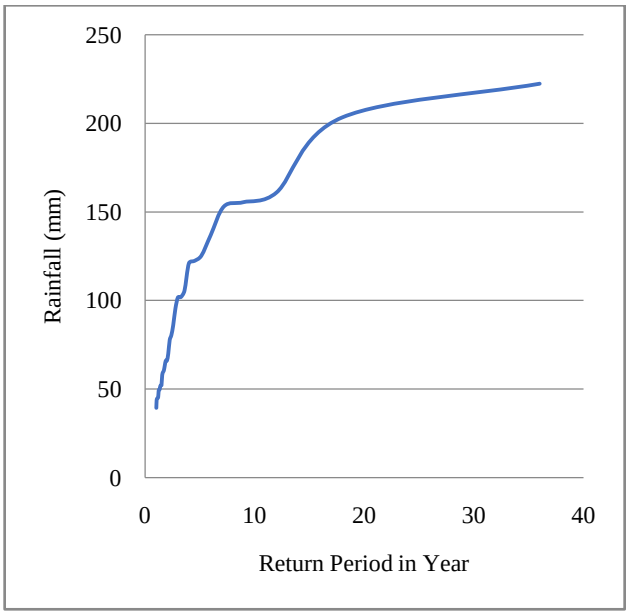

FIGURE 17.RETURN PERIOD FOR ONE DAY ANNUAL MAXIMUM RAINFALL FORMAWLAIK (1981-2015)

For Mawlaik, the maximum daily rainfall of 222.34 mm in 1985 is the rainfall which occurred once in 36 years. The maximum daily rainfall of 39.48 mm in 1993 is the rainfall that occurred once a year.

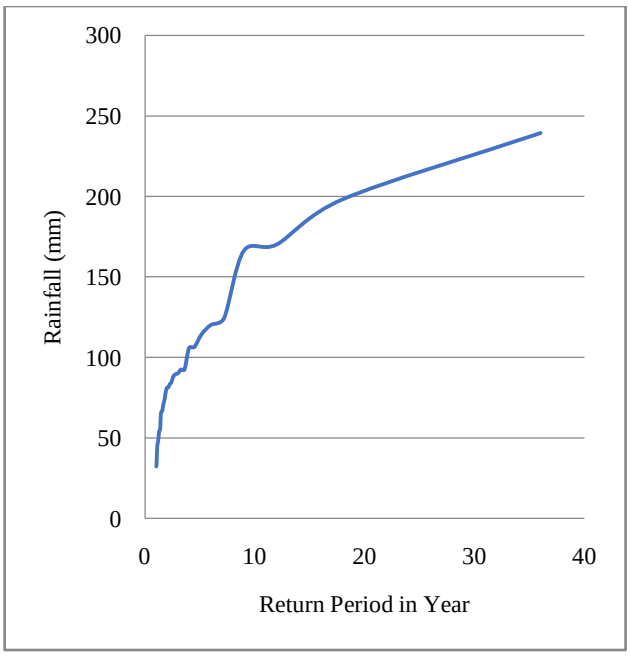

FIGURE 18.RETURN PERIOD FOR ONE DAY ANNUAL MAXIMUM RAINFALL FORHAKHA (1981-2015)

For Hakha, the maximum daily rainfall of 239 mm in 2009 is the rainfall which occurred once in 36 years. The maximum daily rainfall of 32 mm in 1992 is the rainfall that occurred once a year.

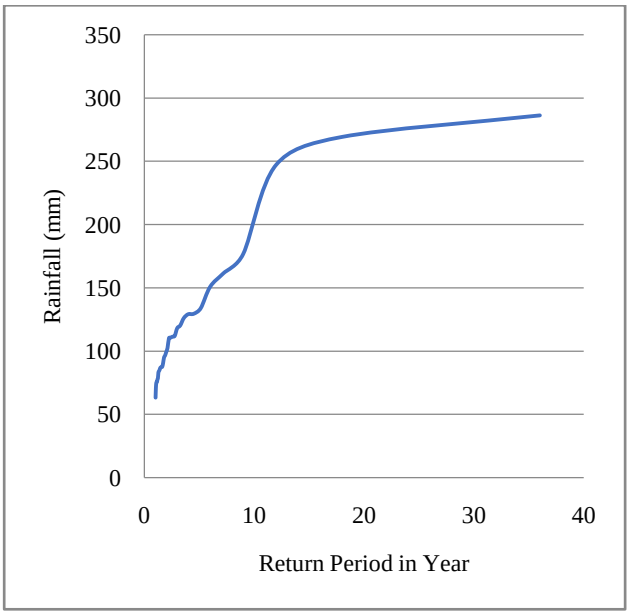

FIGURE 19.RETURN PERIOD FOR ONE DAY ANNUAL MAXIMUM RAINFALL FOR HOMALIN (1981-2015)

The maximum daily rainfall of 286 mm in 2010 is the rainfall which occurred once in 36 years. The maximum daily rainfall of 63 mm in 1985 is the rainfall that occurred once a year for Homalin.

IV. DISCUSSION AND CONCLUSION

In this paper, Mawlaik, Hakha and Homalin are selected as the study areas and rainfall data of the study areas are collected for study periods of 25 years from 1981 to 2005. Annual rainfall and daily rainfall of the study areas are analysed using moving average method, semi average method and climate change analysis for every 5 year and 10 year interval. Moving average method is used to identify the long term trend lines and, 3 and 5 year moving average trend lines are generated. Semi average method is adopted to obtain the straight line trends of the study areas and the middle year, 1993 is omitted because the number of data is odd. Then, probability analysis for one day maximum rainfall is performed using Weibull formula.

From the result of annual rainfall analysis, maximum annual rainfall of Mawlaik is 2228 mm which is occurred in 1990 and minimum annual rainfall of 1225 mm is occurred in 1998. And, average annual rainfall of Mawlaik is 1759.16 mm. Monsoon of Mawlaik is decrease since the 5 year and 10 year average rainfall values and straight line trend decrease along with the study period. For Hakha, the maximum annual rainfall is 2476 mm in 1991, minimum annual rainfall is1139 mm in 1982 and average annual rainfall is 1792.08 mm. As 5 year and 10 year average rainfall for climate change analysis fluctuate, it is generally said that monsoon rain of Hakhais likely to increases later period based on straight line trend and 10 year average annual rainfall. For Homalin, the maximum

annual rainfall is 91 mm in 2000, minimum annual rainfall is 50 mm in 1981 and average annual rainfall is 74.12 mm. As 5 year and 10 year average rainfall for climate change analysis fluctuate, it is generally said that monsoon rain of Homalin is lightly to decrease later period. The rainfall trend lines by moving average method fluctuate dominantly during study period in both Hakha and Homalin study areas. And, according to semi average method, it is found that the annual rainfall trend line for Mawlaik decreases when the trend line for Hakha and Homalin increase during the study period of 25 years.

According to the probability analysis for one day maximum rainfall using Weibull formula, once in 36 year occurrence of maximum daily rainfall for Mawlaik, Hakha and Homalin are 222.34 mm, 239 mm and 286 mm respectively and one day maximum rainfall occurred once a year for that study areas are 39.48 mm, 32 mm and 63 mm respectively.

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