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Recent Trend of Precipitation and Crop Planning in Rajshahi Region of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out for investigation and analysis of long-term (45 years) monthly rainfall data of Rajshahi from 1975 to 2019 for better selection of crops and agricultural technology in this region of Bangladesh. The rainfall trend was determined using parametric and non-parametric method. Probability analysis of rainfall was performed for estimation of dry, wet, and average year rainfall. The results revealed negative trend of yearly rainfall, but it is statistically insignificant. By non-parametric method, 'no trend' was observed for yearly rainfall. Increasing trend of monthly rainfall during March and May and decreasing trend in other months were observed. The rainfall deficit period continued from November to March, and in some instant up to April (rainfall<PET).Total deficit for dry, wet, and average year were found as 488.2 mm, 405.7mm and 426.1mm respectively. By adopting low water-demanding cropping patterns during the deficit period, the withdrawal of groundwater can be minimized.

Keywords: Rainfall deficit; crop planning; probability of rainfall; Raifall trend.

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1. INTRODUCTION

Rainfall is the most important factor that determines the agricultural production in Bangladesh. The variability of rainfall and the pattern of extreme high or low precipitation are very important factor for the agriculture as well as the economy of our country [1]. Like other part of the Bangladesh, the economy of Rajshahi Division is also largely dependent on rain-fed agriculture. So, the changes of rainfall pattern may largely impact the agricultural economy of the region [2]. The climate of Rajshahi Division is generally marked with a typically tropical monsoon climate characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations [3]. In terms of rainfall, a variation within 10 percent in a year is marked as normal which exhibit a mild economic impact while a variation greater than 10 percent may exhibit an adverse impact to the economy and normal life style of the people [4]. In dry western region of Rajshahi, where the annual rainfall is about 1,600 mm (63. in), most parts of the country receive at least 2,300 mm (90.6 in) of rainfall per year. Because of its location just south of the foothills of the Himalayas, where monsoon winds turn west and northwest [1]. Agricultural practice in Bangladesh has developed over the centuries to accommodate and take advantage of monsoon rainfall. Any change in total rainfall or its pattern will disrupt current agricultural practices and alternate cropping pattern may be needed to accommodate such change. Therefore, it is important to investigate whether there has been any discernible change in the behavior of rainfall. Information on variability of monthly rainfall is required in many areas of water resource management and engineering design, selecting areas for profitable rain fed farming and developing possible means for rainwater harvesting during monsoon season [5]. It may also help in identification of appropriate crops and cropping sequences that can match the water-availability duration and ensure increased and stabilized crop production [6-8]. Therefore, it is essential to find out whether there are changes in rainfall patterns or not, so that information can be used for adjusting the planning and management of irrigation project, supplying drinking water, planning of fishery extension department and other water resources related issues and movements. Thus, climatologically studies can provide basic information in the deliberation and adoption of agricultural technologies. In this paper, some investigations and analysis were carried out with long-term (45 years) rainfall data to predict rainfall trend and probabilities which is supportive for better selection of crop at Rajshahi region of Bangladesh.

2. MATERIALS AND METHODS

2.1 Study Area

Monthly rainfall data of Rajshahi from 1975 to 2019 were collected from Bangladesh Meteorological Department. Trends of yearly rainfall and monthly rainfall were investigated by non-parametric as well regression (slope) method.

2.2 Non-parametric Test

Trends were examined by 'Spearman's Rho' test [9]. The advantage of the non-parametric test is that it does not depend on absolute values of data and is equally applicable for linear and non-linear trends. These tests are distribution free, i.e. they do not require any assumption to be made about population following normal or any other distribution. As the test uses relative values, missing data is not a problem.

The test statistic ***T*** of 'Spearman's Rho' test is given by:

$$T = \sum_{i=1}^{n} [R(X_i) - R(Y_i)]^2 \quad (1)$$

WhereX_i is the value of rainfall (or temperature) corresponding to the year Y_i, $R(X_i)$ is the rank of rainfall (or temperature) X_i, and $R(Y_i)$ is the rank of the year Y_i. For n greater than 30, the quantiles of $T$is approximated by (Conover, 1980):

$$w_p \cong \frac{1}{6} n(n^2 - 1) + x_p \frac{1}{6} \frac{n(n^2 - 1)}{\sqrt{n-1}} \quad . \quad (2)$$

Where,x_p is the pth quantile of a standard normal random variable. Upper quintile was estimated from the equation:

$$w_{1-p} = \frac{1}{3} n(n^2 - 1) - w_p \quad \text{..... .(3)}$$

In all cases, the two tailed test was done at levelα = 0.05.

2.3 Regression Test (Slope Test)

Trend was also examined by testing the significance of slope of the linear regression line. For this purpose, climatic variables were plotted (Y-axis) against the relative year values (year rank, i.e. for 1975 to 2019, relative year values are 1 to 45). The slope of the plot represents the trend. The slope was then subjected to *t*-test for significance at 5 % level.

2.4 Probability Analysis

Weibull's ranking method was used to find the probability of a certain event. According to this method, yearly data were arranged in descending order for probabilities of exceedance. The probability, P, was calculated as follows:

$$P = \frac{m}{N+1} \quad \text{.....} \quad (4)$$

Where, N = number of records
m = rank number

The probabilities thus found were plotted on log-normal probability paper. The points were found to approximate a straight line which indicated in all cases that the distribution is approximately log-normal. Then year value at 80%, 50% and 20% probability (P80, P50,P20) was selected. The P80, P50,P20 represents the dry year, average year and wet year simultaneously. Monthly values of rainfall for the dry year were determined according to the following relationship (Amin et al., 2004):

$$P_{idry} = P_{iav} * \frac{P_{dry}}{P_{av}} \quad \text{.....} \quad ..(5)$$

Where, P_{iav} = average monthly rainfall for month i
P_{idry} = average rainfall dry year for month i
P_{av} = average yearly rainfall
P_{dry} = yearly rainfall at 80 % probability of exceedance

Deficit period was assessed from the graph of period of the year vs. rainfall and reference evapotranspiration (ET_0).

3. RESULTS AND DISCUSSION

3.1 Yearly Rainfall Trend

The rainfall trends revealed changes in rainfall of Rajshahi over the time period from 1975-2019. The analysis of rainfall data reveals that the average annual rainfall in Rajshahi during this period was 1447.1 mm. The highest amount of annual rainfall was recorded as 2241mm in the year of 1981, while the lowest amount of annual rainfall was 792 mm in the year of 2010. The total amount of annual rainfalls was higher than 2000 mm in the years of 1981 and 1997 in Rajshahi (Fig.1). Fig. 1 depicts that the amount of total annual rainfall is negatively correlated with time, which is statistically insignificant.

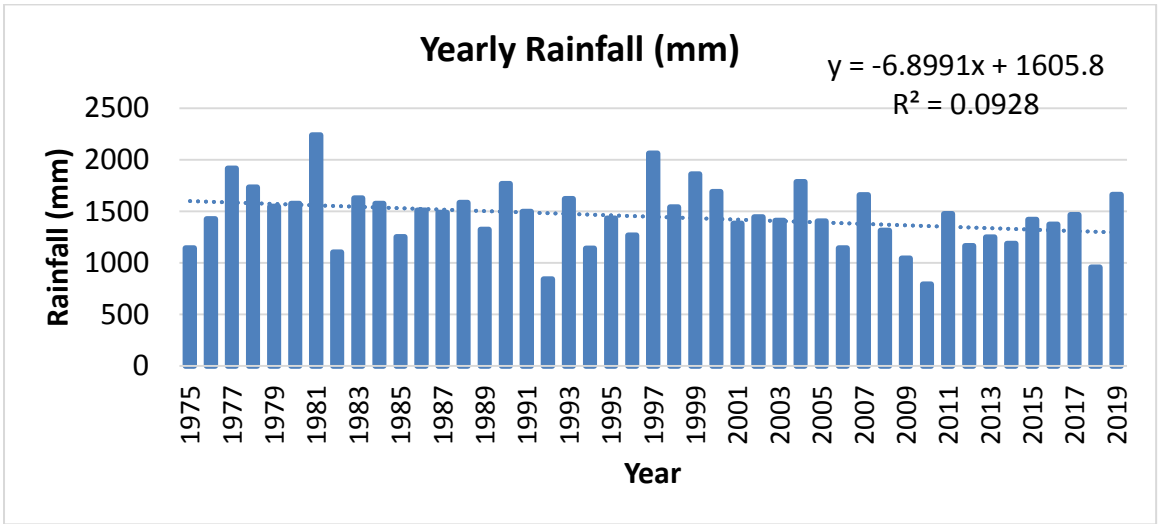

Fig. 1. Pattern of yearly rainfall at Rajshahi (1975-2019)

3.2 Monthly Trend of Mean Rainfall

From the Monthly pattern of mean rainfall graph it's revealed that the lowest amount of rainfall occurred during winter season say November, December, January, and February and the highest during rainy monsoon seasons say June, July, August, and September (Fig. 2).

3.3 Statistical Summary of Monthly Rainfall

Table 1 shows the distribution of mean monthly rainfall of Rajshahi during 1975-2019. The other statistical parameters such as mean, median standard deviation, skewness and kurtosis were calculated to analyze the monthly data. Data revealed that maximum rainfall was occurred in the month of July.

3.4 Seasonal Rainfall in Rajshahi

Fig. 3 shows that 72.1% annual rainfall occurs during the rainy monsoon months of June-September, while 16.3% annual rainfall occurs in the pre-monsoon months of March-May, 9.5 % annual rainfall in post-moonsoon months October- December and 2.2% annual rainfall was recorded in dry winter(December-February)periods.

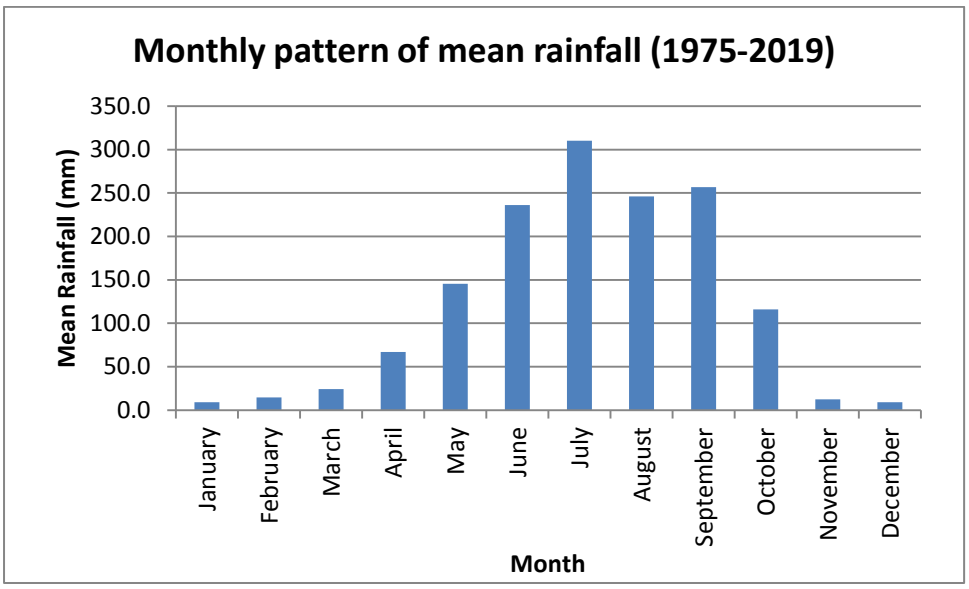

Fig. 2. Pattern of Monthly mean rainfall (1975-2019) of Rajshahi of Bangladesh

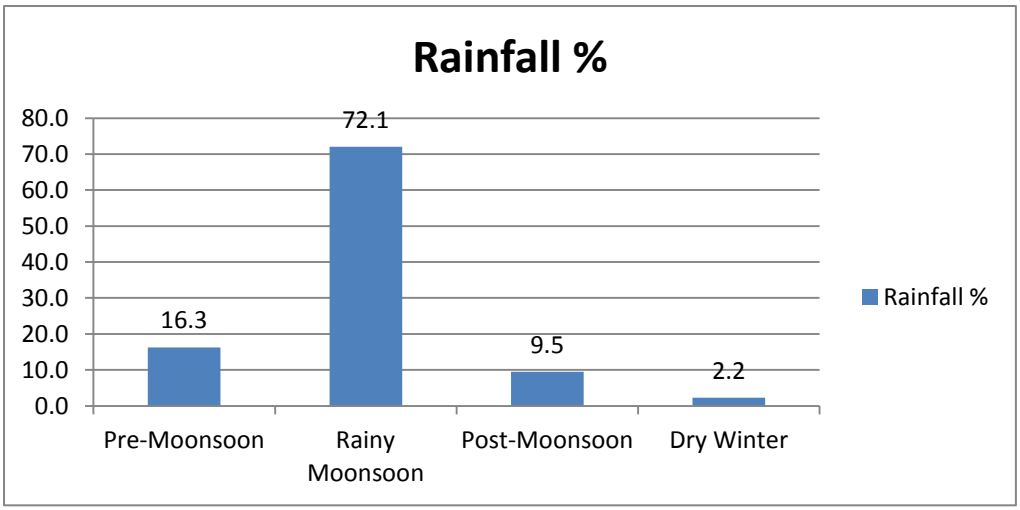

Fig. 3. Percentage of seasonal rainfall in Rajshahi

Table 1. Statistical summary of monthly rainfall data of Rajshahi

Year	January	February	March	April	May	June	July	August	September	October	November	December
Mean	9.0	14.6	24.2	67.0	145.5	236.2	310.2	246.2	256.6	116.0	12.6	9.0
Median	3	10	12	55	144	232	301	238	238	112	3	0
STDEV	14.6	15.3	26.0	56.9	67.4	120.8	136.8	101.1	129.1	81.3	20.7	20.5
Max	71	49	104	240	301	543	763	505	644	358	101	92
Min	0	0	0	0	13	46	94	84	66	0	0	0
Variance	214.4	233.6	674.6	3233.8	4537.5	14594.6	18727.6	10228.8	16676.2	6602.5	430.2	420.7
Kurtosis	7.1	-0.4	0.8	1.7	-0.2	0.3	1.5	0.1	0.8	0.7	6.9	10.6
Skewness	2.5	0.9	1.2	1.3	0.2	0.7	0.7	0.7	0.9	0.8	2.4	3.2
Sum	407	659	1088	3013	6547	10628	13960	11077	11546	5220	568	406

3.5 Seasonal Rainfall trend Analysis

The rainfall data for 45 years (1975-2019) were again analyzed to study the seasonal rainfall variation and trend within the country (Fig. 4) .It is seen from analysis that the rainfall occurred maximum in monsoon season and minimum in winter. It is also observed that the variation in rainfall is also found maximum in monsoon.A trend analysis over Bangladesh during the last 45 years (1975-2019) shows an increasing trend for all seasons (Fig. 4). For monsoon season, the linear trend line is in increasing trend.

3.6 Trend of Yearly Rainfall by Non-parametric Test (Rho-test)

From non-parametric test (Rho-test), the trend of yearly rainfall is non-significant for this location. From regression analysis, the slope of regression line of yearly rainfall (Fig.5a) isnegative.

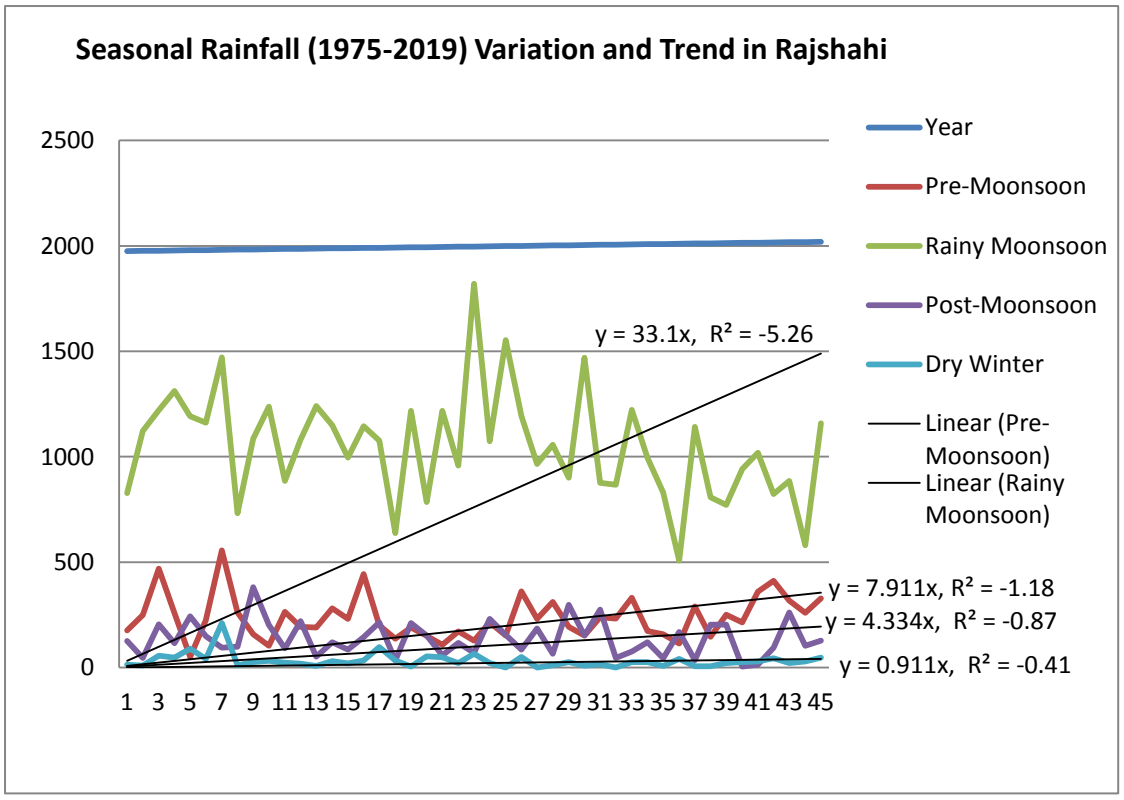

Fig. 4. Seasonal rainfall variation and trend of Rajshahi for years 1975-2019

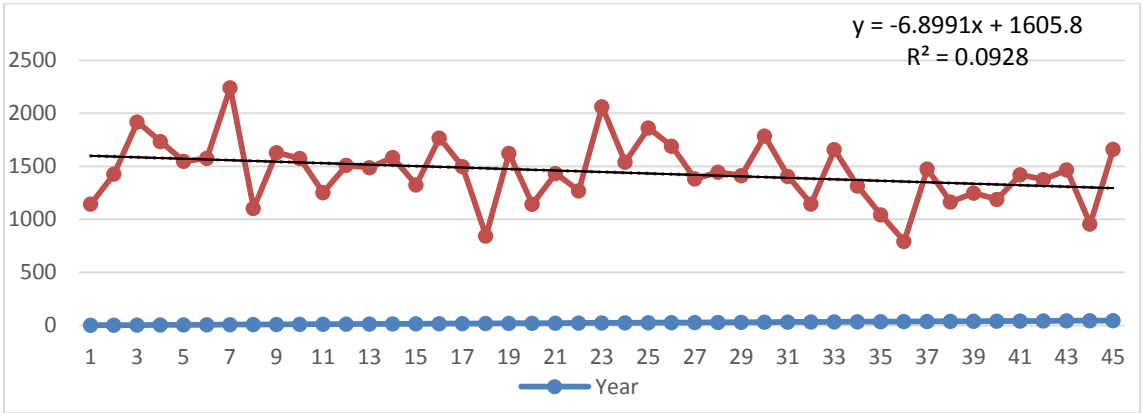

Fig. 5(a). Pattern of Yearly rainfall at Rajshahi

3.7 Monthly Rainfall Trend

From non-parametric test (Rho-test), the trend of monthly rainfall was depicted (Fig 5b, 5c). From the test "no trend" was found in every month except December. Positive trend was found in December and yearly trend. (Table 2).

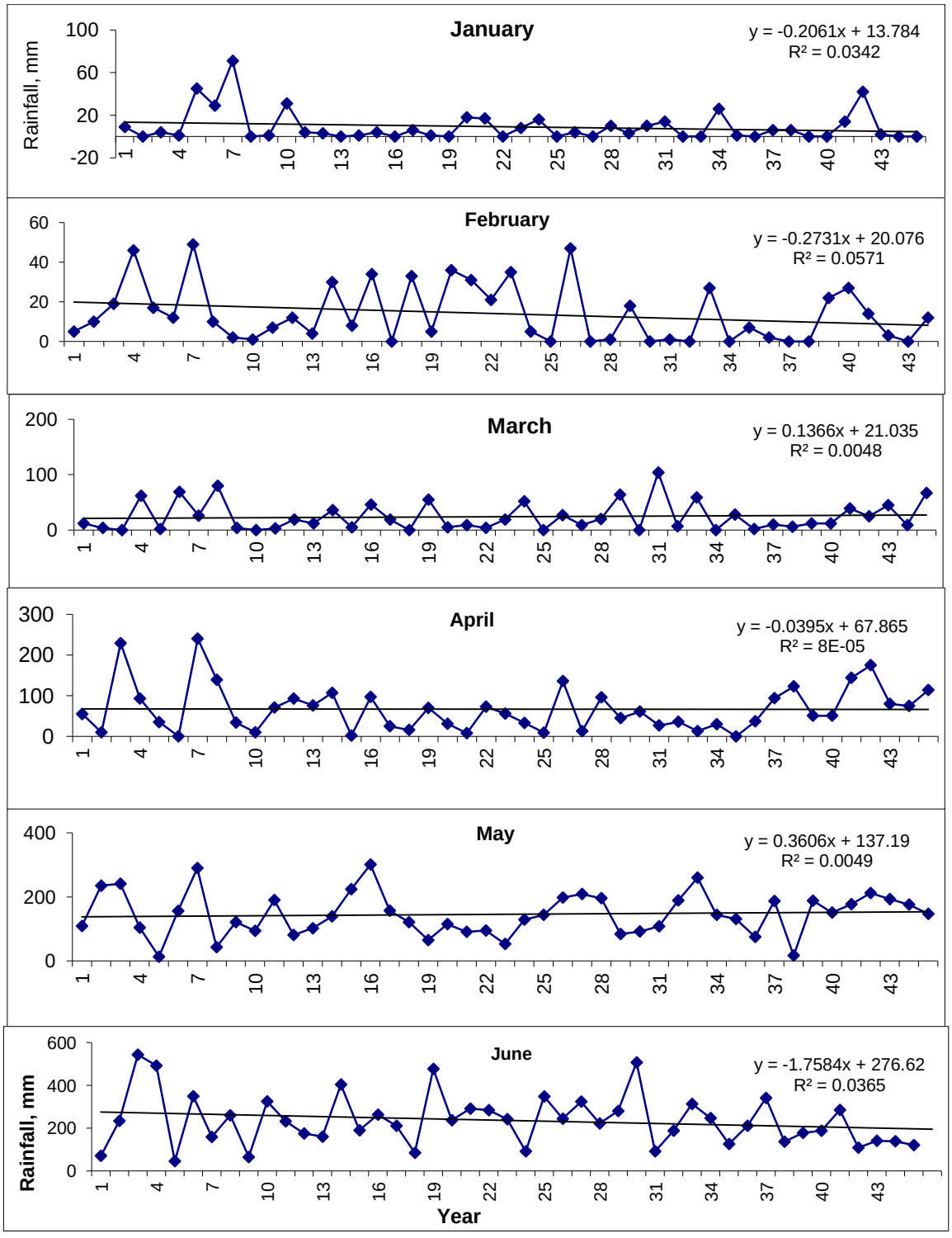

Fig. 5(b). Pattern of monthly rainfall at Rajshahi (Jan. - June)

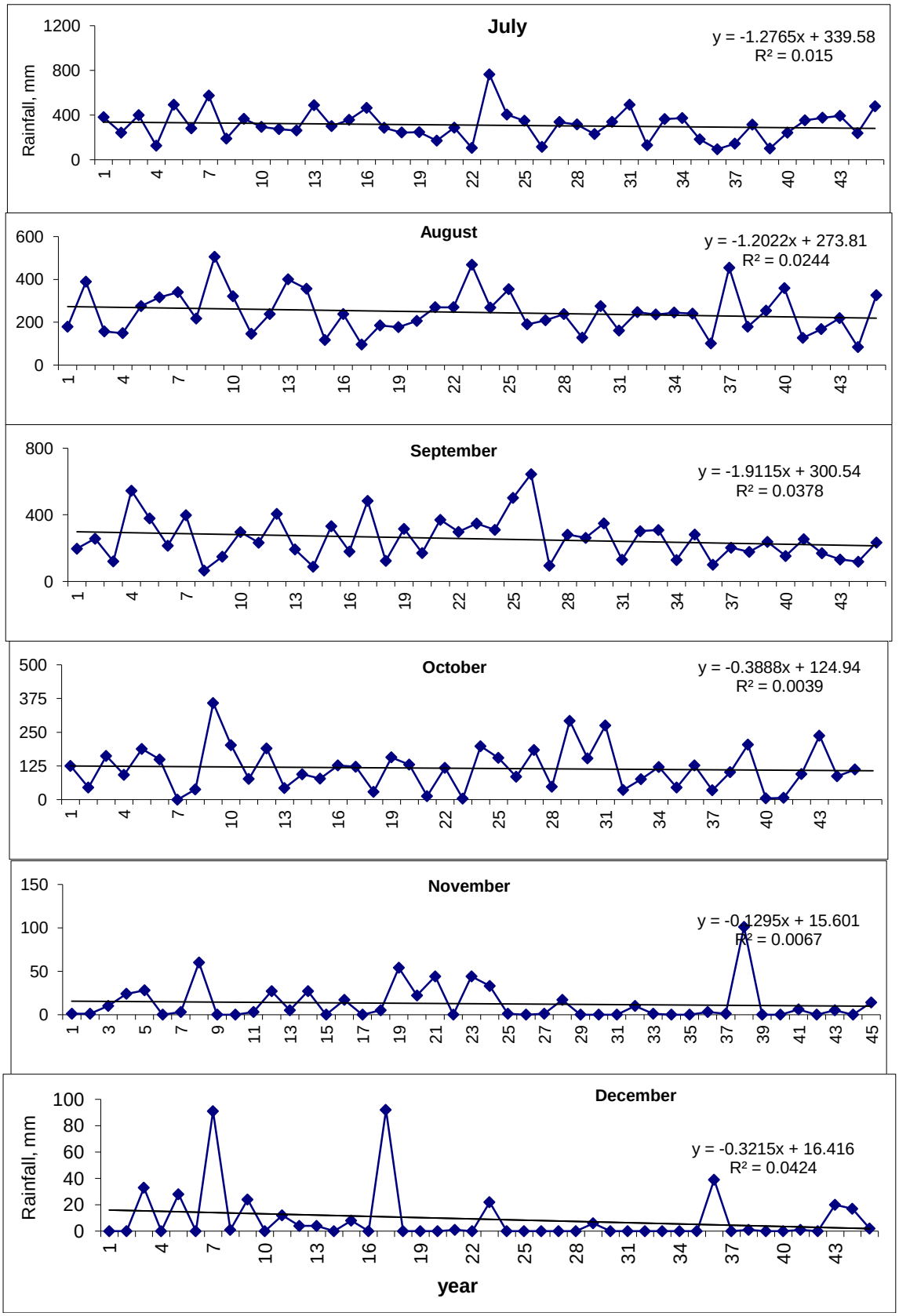

Fig. 5(c). Pattern of monthly rainfall at Rajshahi (July - Dec.)

3.8 Trend of Monthly Rainfall by Slope of Regression Equation

Monthly rainfall trends of Rajshahi are found from the slope of regression equation. Among the months positive trend are found in March and May and negative trends are found in others month. The calculated value of the monthly and yearly rainfall trend found insignificant.

3.9 Results of Probability Analysis of Rainfall

The dry, wet, and average year monthly rainfall and ET_0 values (calculated through ETo calculator software by FAO) were depicted in Fig. 6a, 6b and 6c. The months from November to March, and in some instant up to April is deficit period (rainfall<ET_0) for all cases. Total deficit for dry, wet, and average year were found as 488.2 mm, 405.7mm and 426.1mm respectively (Table 5).

Bangladesh has got primarily three cropping seasons, namely, Kharif-1 (April– July), when 'Aus' rice is the major crop; Kharif-2 (July-October), when 'Aman' rice is the main crop; and Rabi (December-April), when Boro rice and most of the winter vegetables are grown. The cropping pattern of different regions of the country is based on rice. The major Kharif-1 and Kharif-2 crops during April to October of different locations of the country are rice, and there is no problem of water except special years, when dry spell continued for long time affecting crop growth. For Aus and Aman rice, rainfall ranged from suitable to marginally suitable, which indicate the need of supplemental irrigation. For Boro rice, rainfall is actually unsuitable; which indicates that Boro rice cannot be cultivated as rainfed crop [10].

Generally water deficit occurs during pre monsoon period. Increase pre-monsoon precipitation can reduce the groundwater irrigation demand in Boro rice field which shares almost 70% of total rice production of Bangladesh. Therefore, it may help to decrease the pressure on groundwater resources in north western Bangladesh where declining groundwater level is a major problem due to the overexploitation of groundwater for irrigation [11]. The rainfall in monsoon period shows surplus rainfall for all years (wet, average and dry year).

Table 2. Trend of monthly rainfall at Rajshahi from Rho-test

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trend	0	0	0	0	0	0	0	0	0	0	0	+

Note: The '+' sign indicates positive trend, '-' sign indicates negative trend and '0'indicates notrend

Table 3. Regression equation and slope of monthly rainfall

Months	Slope Equation	R^2 from graph	Calculated t
January	y = -0.206x + 13.78	0.034	-0.00016
February	y = -0.273x + 20.07	0.057	-0.00012
March	y = 0.136x + 21.03	0.004	0.00006
April	y = -0.039x + 67.86	0.00008	-0.00001
May	y = 0.360x + 137.1	0.004	0.00006
June	y = -1.758x + 276.6	0.036	-0.00017
July	y = -1.276x + 339.5	0.015	-0.00011
August	y = -1.202x + 273.8	0.024	-0.00014
September	y = -1.911x + 300.5	0.037	-0.00017
October	y = -0.388x + 124.9	0.003	-0.00005
November	y = -0.129x + 15.60	0.006	-0.00007
December	y = -0.321x + 16.41	0.042	-0.00018
Yearly	y = -6.899x + 1605	0.092	-0.00028

Table 4. Trend of monthly rainfall at Rajshahi from slope of regression equation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trend	-	-	+	-	+	-	-	-	-	-	-	-

Note: The '+' sign indicates positive trend and '-' sign indicates negative trend

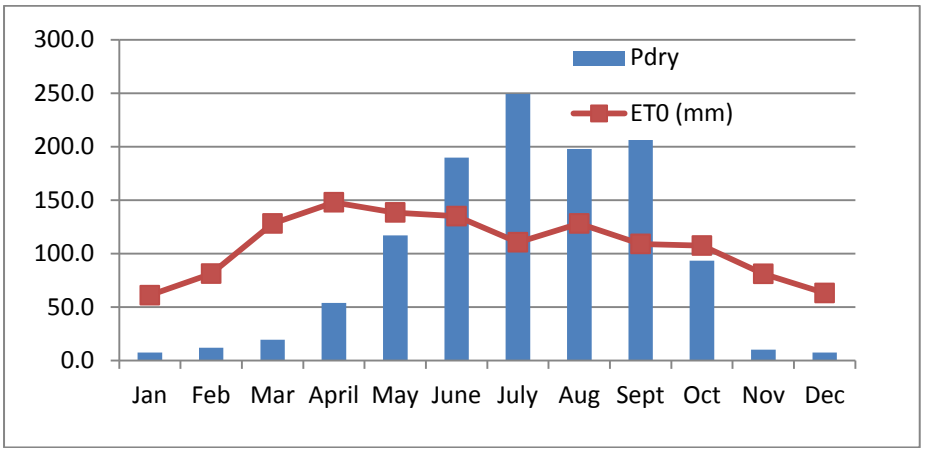

Fig. 6a. Water deficit or surplus in difference months in Dry year atRajshahi

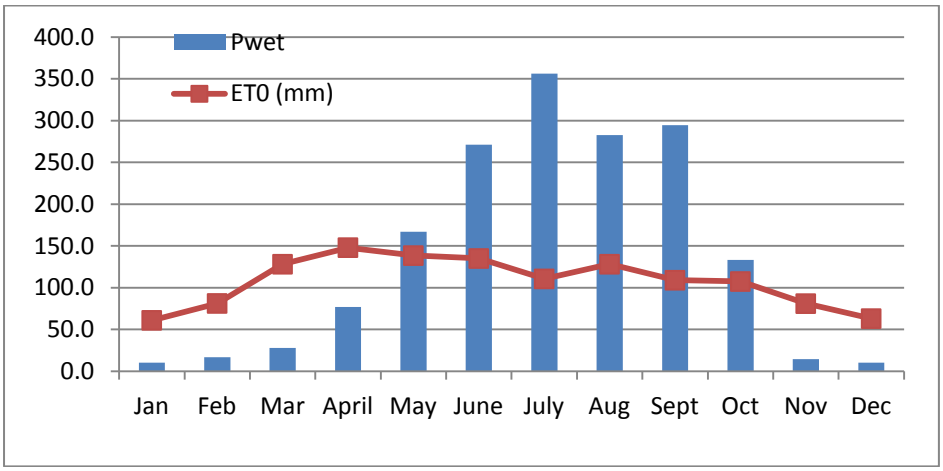

Fig. 6b. Water deficit or surplus in difference months in wet year at Rajshahi

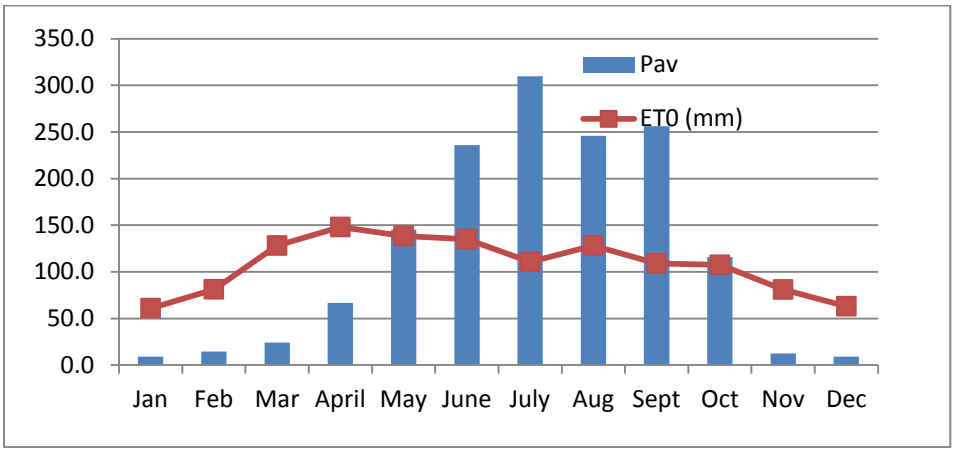

Fig. 6c. Water deficit or surplus in difference months in average year at Rajshahi

Rainfall is the most dominant climatic element. The dry winter seldom carries any rain bearing clouds in Rajshahi Division. Most of the rainfall occurs in the rainy monsoon season. It has been found that there is no typical trend in the rainfall variation in study areas. There are also mixed results of increasing and decreasing shift in both seasonal and annual rainfall.

Table 5. Monthly rainfall deficit/surplus at Rajshahi

Rainfall deficit/surplus	Month of the year												Total deficit
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Dry year	-53.7	-69.4	-108.7	-94.1	-21.4	54.9	138.9	69.8	97.3	-14.2	-70.8	-55.8	-488.2
Wet year	-50.6	-64.4	-100.4	-71.1	28.5	136.1	245.5	154.4	185.5	25.7	-66.5	-52.7	-405.7
Average Year	-51.9	-66.6	-104.0	-81.1	6.8	100.8	199.2	117.7	147.2	8.4	-68.4	-54.0	-426.1

Note: The '+' sign indicates rainfall surplus and '-' sign indicates rainfall deficit

4. CONCLUSIONS

The following conclusions can be made from the study:

- There is no significant trend in yearly rainfall at Rajshahi over 45year's data of rainfall analysis
- Monthly rainfall indicates a change in pattern of rainfall, although it is not significant.
- In Bangladesh, the period between May to October is surplus period (rainfall>ET0), and generally no problem with agricultural and other water-based activities. The months from November to March, and in some instant up to April is deficit period (rainfall<ET0).
- This dry spell continued for long time affecting crop growth and this accelerating the exploitation of groundwater for irrigation which can be minimized by practicing low water demanding cropping patterns.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Noorunnahar M, Hossain MA. Trend analysis of rainfall data in divisional meteorological stations of Bangladesh. Ann. Bangladesh Agric. 2019;23(1):49-61.
2. Shamsuzzoha M, Parvez A, Chowdhury AFMK. Analysis of Variability in Rainfall Patterns in Greater Rajshahi Division using GIS. J. Environ. Sci. & Natural Resources. 2014;7(2):141-149.
3. Islam T, Neelim A. Climate Change in Bangladesh: A Closer Look into Temperature and Rainfall Data. The University Press Limited, Dhaka; 2010.
4. Sivasami KS. Droughts and Rainfall Pattern in India, 1877–1999. Published online in Wiley Inter science; 2000. Available:www.interscience.wiley.com.
5. Schmidt GM, Smajstrla AG, Zazueta FS. Long-term variability of monthly total precipitation. Trans. ASAE. 1997;40(4): 1029 – 1039.
6. Shanker U, Agrawal KK, Gupta VK. Rainfall pattern and cropping strategy for Jabalpur region. Ind. J. Agril. Sci. 1992;62(1):58 – 59.
7. Chang JH. A climatological consideration of the transference of agricultural technology. Agri. Meteor. 1981;25: 1-13.
8. Quadir DA, Khan TMA, Hossain MA, Iqbal A. Study of climate variability and its impact on rice yield in Bangladesh. SAARC J. of Agri. 2003;1:69–83.
9. Conover WJ. Practical Nonparametric Statistics. John Wiley & Sons, Inc. 1980;252–260.
10. Amin MGM. Ali MH, Islam AKMR. Agro-climatic analysis for crop planning in Bangladesh. Bangladesh J. Agri. Engg. 2004;15(1& 2):31- 40.
11. Shahid S. Rainfall variability and the trends of wet and dry periods in Bangladesh, International Journal of Climatology. 2010;30(15):2299–2313.

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