ESTIMATION OF RAINFALL IN BANGLADESH BY USING SOUTHERN OSCILLATION INDEX

Masud Rana[1], Sultana Shafee[2], Samarendra Karmakar[3]

Abstract:

Attempts have been made to construct linear relationship between monthly, seasonal and annual rainfall over Bangladesh with the southern oscillation index (SOI). Monthly rainfall at 24 stations over Bangladesh during the period 1981-2004 have been used for the determination of correlation coefficients between monthly rainfall and the southern oscillation index (SOI) of the same month, previous one-month, previous two-month and previous three-month. Correlation between seasonal and annual rainfall at 24 stations over Bangladesh with southern oscillation index (SOI) has also been studied. Regression equations corresponding to the significant correlation coefficients have been obtained through scatter diagram.

Key words: Correlation, Southern Oscillation Index (SOI) and rainfall.

Introduction:

Bangladesh is situated in the active monsoon region of the world. It is deltaic land with total area of about 1, 47,570 sq. km (DOE, 2002). The river area is 9399 sq. kms and the forest area is 22584 sq. Kms. The coastal line of the Bay of Bengal is 712 km to the south of the country. It is an agro-based country. About 80% of the total population is involved if agriculture as a profession. Rice, jute, tea, sugarcane etc are main agriculture products in Bangladesh. Due to the increasing pressure of population together with limitations of natural resources it has become very urgent to ensure the maximum production of food. The production of various types of crops especially rice is extremely dependent on the amount of the adequate rainfall timely and adequate rainfall i.e. neither too little nor too much is needed for successful agriculture. Crops may fail as a result of either drought or floods.

About 80% of the annual rainfall over Bangladesh occurs during the Southwest monsoon. Remaining 20% rainfall occurs during pre-monsoon and post-monsoon periods. During these times (pre-monsoon and post-monsoon period) rainfall is associated with local thunderstorms, nor' westers, tornadoes, cyclone etc. Winter remains mainly dry except for a few occasions when western disturbances pass over the region, conjugate with easterly waves and yield light to moderate rain.

Debnath (1995) et al. studied the rainfall characteristics and probabilistic rainfall extremes in Bangladesh during the post-monsoon and early winter season. Using monthly rainfall data of 21 stations of Bangladesh for the post-monsoon and early winter period (October-December) for 30 years (1961-1990), the probabilistic rainfall extremes for three different time scales, namely (a) in l year out of 4 years, (b) in 1 year

[1] Department of Physics, Mohipur Hazi Mohsin Govt. College, panchbibi, joypurhat,Bangladesh.
[2] Department of Physics, University of Dhaka,Bangladesh.
[3] Bangladesh Meteorological Department, Dhaka, Bangladesh.

out of 10 years and (c) in 1 year out of 25 years had been computed. The mean rainfall decreases sharply from October to November and slowly from November to December. The gradients of mean monthly rainfall are maximum over the northeastern and southwestern parts of Bangladesh during these periods. The general shape of the probabilistic rainfall extreme curves seems to indicate a belt of minimum high rainfall approximately between latitudes 23°N and 24°N.

Rahman (1995) studied the scales and values of several regional meteorological parameters over Bangladesh for a year of normal precipitation (1993) and those for a year of reduced rainfall (drought) year (1994) and compared to detect any difference. Daily rainfall and Rawinsonde data and meteorological charts from Bangladesh meteorological department were used in their work. The flood/drought index as calculated from the mean precipitation of June-July showed 1994 to be a drought year. Mean monthly positions of the axes of upper air anticyclones at 100 hPa and 200 hPa levels seemed to indicate an increase in rainfall with a southward shift of the axes and reduced rainfall with a northward shift. The vertical axes of the anticyclone showed a tilt towards southwest. A prominence of easterly wind was also found to be associated with increased rainfall and vice versa.

Sabbir (1996) et al. studied the variations of rainfall over Bangladesh and found the correlation with El Nino/Southern Oscillation (ENSO). They utilized data of forty-three years (1951-1992) for four stations namely Jessore, Dhaka, Barisal and Sylhet for their studies. The yearly rainfall shows a distinct negative (decreasing) tendency with the occurrence of ENSO. The seasonal rainfall analysis shows a somewhat better correlation.

Data used:

Daily Rainfall of 14 stations (Fig. 1) namely Dhaka, Mymensingh, Faridpur, Chittagong, Comilla, Feni, Cox's Bazar, Dinajpur, Rajshahi, Bogra, Rangpur, Rangamati, Khulna, Jessore, Barisal, Bhola, Ishurdi, Khepupara, Madaripur, M.Court, Patuakhali, Satkhira, Sylhet, & Srimangal under six divisions of Bangladesh during the period 1981-2004 have been taken from Storm Warning Centre (SWC), Dhaka of Bangladesh Meteorological Department (BMD) for in-depth studies. The stations have been selected in such a way as to represent all geographical and climatological variation.

Monthly-accumulated rainfall of six divisions from January, 1981 through December, 2004 and Southern Oscillation Index (SOI) of the same period of time have been collected from SWC, Dhaka and Bureau of Meteorology (BOM), Australia through internet respectively. Monthly normal rainfall of 24 stations of Bangladesh was also collected from SWC, Dhaka.

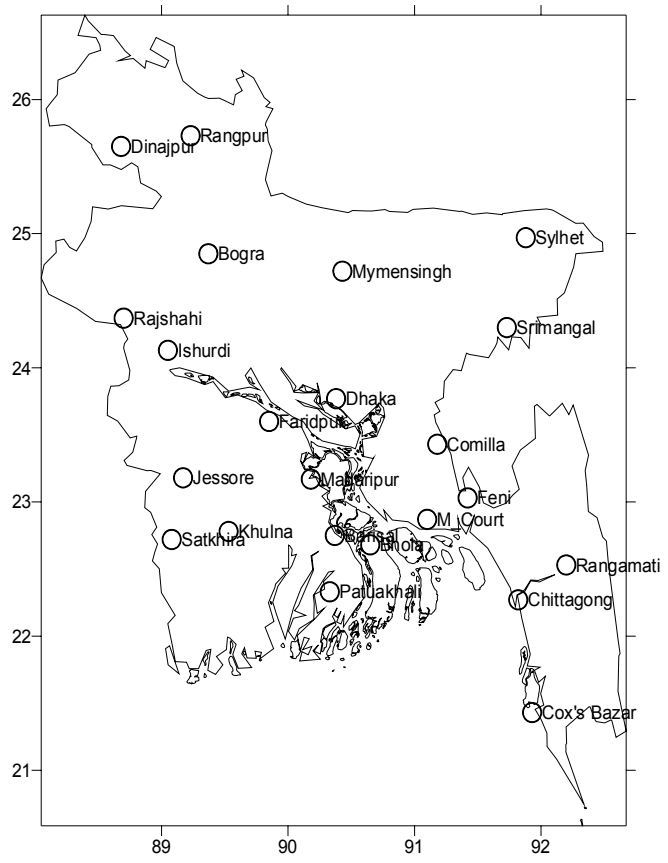

Figure 1: Location of 24 Meteorological stations of Bangladesh under study

Theoretical background:

Southern Oscillation Index (SOI):

The Southern Oscillation (SO) is generally associated with the work and publications of Walker on the Indian Monsoon in the early 1920's. Walker characterized the Southern Oscillation (SO) as follows- "When pressure is high in the Pacific Ocean, it tends to be low in the Indian Ocean from Africa to Australia. These conditions are associated with low temperatures in both areas and rainfall varies in the opposite directions to pressure". The alternation in the sign of the pressure anomaly across the tropical oceans has often been described as pressure "Sea-Saw." Southern Oscillation Index (SOI) is the air pressure: Sea-Saw" between Tahiti and Darwin. It is the difference of pressure anomaly of Darwin (120 S, 1310 E) from Tahiti (170 S, 1500 W).

There are a few different methods to calculate the SOI. The method used by the Australian Bureau of Meteorology is the Troup SOI which is the standardized anomaly of the Mean Sea Level Pressure difference between Tahiti and Darwin. It is calculated as follows:

$$SOI = 10 \times \frac{(P_{diff} - P_{diffav})}{SD(P_{diff})}$$

where

Pdiff = (average Tahiti MSLP for the month) - (average Darwin MSLP) for the month),

Pdiffav = long term average of Pdiff for the month in question, and

SD(Pdiff) = long term standard deviation of Pdiff for the month in question.

The multiplication by 10 is a convention. Using this convention, the SOI ranges from about –35 to about 35 and the value of the SOI can be quoted as a whole number. The SOI is usually computed on a monthly basis, with values over longer periods such a year being sometimes used.

Correlation Coefficients between rainfall and southern oscillation index:

Correlation coefficients between monthly rainfall of 15 stations and the country and the southern oscillation index (SOI) of the same months were calculated. Correlation coefficients between monthly-accumulated rainfall and SOI of the previous month were also calculated. Correlation coefficients between monthly rainfall and Southern Oscillation Index (SOI) of the previous one month, previous two month and previous three month were also calculated. Regression equations were set up between monthly rainfalls of six divisions and the country and SOI, in those cases where correlation coefficients were near about 0.4 or more. Graphical relation was derived between rainfall and SOI. Monthly rainfall and SOI of the same month, previous one month, previous two month and previous three month were also plotted against time for the six divisions and the other.

Monthly rainfall deviation and SOI of the same month, previous one month, previous two month and previous three month were also plotted against time for the six divisions and the other.

Results and Discussion:

The spatial distribution or correlation coefficients and trends of monthly, seasonal and annual rainfall over Bangladesh have been studied and discussed critically.

Correlation between monthly rainfall and SOI:

The correlation coefficient between monthly rainfall and SOI of the same month is given in Table 1 which shows that monthly rainfall at Dhaka in February is moderately correlated with February SOI having correlation coefficient of r = -0.53. This correlation coefficient is statistically significant at 99% level of significance.

Monthly rainfall at Madaripur in March is moderately correlated with SOI in March. The correlation coefficient is r = -0.56, which is statistically significant at 99% level. In February and October, the correlation coefficients are –0.40 and 0.43 respectively. These correlation coefficients are also significant at 95% level of significance.

At Barisal the monthly rainfall in February and March are moderately correlated with SOI in February and March respectively, having correlation coefficients of –0.43 and –0.44 respectively and the coefficients are statistically significant at 95% level.

The monthly rainfall at Bogra in May and July has moderate correlation with SOI in May and July. The correlation coefficients in these months are 0.41 and 0.40 respectively, which are statistically significant at 95% level of significance.

In February, September and October, monthly rainfall at Cox's Bazar is moderately correlated with the SOI of same months, having correlation coefficients –0.41, -0.40 and 0.44 respectively, which are found to be significant at 95% level of significance.

The monthly rainfall at Faridpur in May is moderately correlated with SOI in May. The correlation coefficient (0.43) is also statistically significant at 95% level.

Correlation between rainfall in January and October at Khulna and SOI of the same months indicated that the correlation coefficients in January and October are –0.63 and 0.56 respectively. These correlation coefficients are statistically significant at 99% level of significance. In February and March the correlation coefficients are –0.40 and –0.49 respectively and these correlation coefficients are also significant at 95% level of significance.

In April the monthly rainfall at M. Court is moderately correlated with SOI in April. The correlation coefficient is -0.50, which is statistically significant at 99% level of significance.

Table 1: **Correlation co-efficient between monthly rainfall (mm) of different stations and SOI of the same month (1981-2004)**

Division/ Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Dhaka	-0.16	-0.53**	0.0.63**	0.25	-0.14	-0.21
Madaripur	-0.11	-0.40*	-0.56**	0.14	0.10	-0.11
Barisal	-0.29	-0.43*	-0.44*	-0.22	0.17	0.09
Khulna	-0.63**	-0.40*	-0.49*	-0.11	0.36	-0.12
M. Court	-0.15	-0.38	-0.36	-0.50**	0.17	0.12
Mymensingh	-0.19	-0.16	-0.20	0.08	0.11	-0.54**
Rangpur	-0.41*	-0.15	-.035	0.31	0.58**	-0.35
Sylhet	-0.01	-0.04	-0.54**	0.12	0.29	-0.40*
Rajshahi	0.01	0.05	-0.15	0.13	0.48*	-0.24
Faridpur	-0.29	-0.36	-0.30	0.15	0.43*	-0.19
Cox's Bazar	-0.20	-0.41*	0.12	-0.24	-0.04	-0.05

Bhola	-0.15	-0.40*	-0.36	-0.21	0.17	0.11
Bogra	-0.06	-0.12	0.01	0.07	0.41*	-0.16
Chittagong	-0.08	0.32	-0.17	-0.08	0.06	0.23
Srimagal	-0.01	0.13	0.10	-0.20	0.06	-0.09

Division/ Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Dhaka	0.018	0.19	-0.005	-0.14	-0.01	-0.17
Madaripur	0.12	0.07	0.23	0.43*	-0.01	-.20
Barisal	0.33	-0.02	-0.04	0.32	0.10	0.05
Khulna	-0.03	-0.09	-0.25	0.56**	0.11	0.05
M. Court	-0.07	0.10	-0.12	0.24	0.11	0.09
Mymensingh	0.36	0.02	-0.23	0.22	.15	-0.35
Rangpur	-0.04	0.28	-0.03	0.29	0.09	-0.07
Sylhet	-0.02	0.40*	-0.04	0.29	0.22	-0.01
Rajshahi	0.07	-0.01	0.05	0.35	-0.02	-0.15
Faridpur	0.16	0.17	-0.09	0.30	0.01	-0.12
Cox's Bazar	-0.18	0.13	-0.40*	0.44*	0.04	0.29
Bhola	-0.06	-0.22	0.01	0.38	0.12	0.14
Bogra	0.40*	-0.05	0.05	0.34	0.31	-0.19
Chittagong	0.09	0.08	-0.27	0.38	-0.01	0.36
Srimagal	0.09	0.04	-0.28	0.39	0.38	-0.31

** Significant at 99% level. * Significant at 95% level.

The monthly rainfall in July at Mymensingh is moderately correlated with July SOI, having correlation coefficient –0.54. This correlation coefficient is statistically significant at 99% level of significance.

At Rajshahi the monthly rainfall in May is moderately correlated with the same month SOI. The correlation coefficient is 0.48, which is statistically significance at 95% level of significance.

In January and May at Rangpur, the monthly rainfall are correlated with the SOI in January and May having correlation coefficients –0.41 and 0.58 respectively. These correlation coefficients are found to be statistically significant.

The rainfall at Sylhet in March is correlated with SOI in March. The coefficient of correlation is –0.54, being significant at 99% level of significance.

Correlation between monthly rainfall and SOI of previous one month:

The correlation coefficient between monthly rainfall and SOI of the previous month are given in Table 2. The monthly rainfall at Barisal in February and November are moderately correlated with these previous months of SOI having correlation coefficient of r = -0.42 and r = 0.42 respectively. These correlation coefficients are statistically significant at 95% level of significance.

Monthly rainfall at Bhola in February and November are moderately correlated with SOI in January and October. These correlation coefficients are -0.45 and 0.43 respectively, which are statistically significant at 95% level.

At Bogra the monthly rainfall in May is moderately correlated with SOI in April having correlation coefficient of 0.45. This correlation coefficient is statistically significant at 95% level.

The monthly rainfall at Chittagong in February has moderate correlation with SOI in January. The correlation coefficient in this month is -0.51, which is statistically significant at 99% level of significance. In October, the correlation coefficient is 0.46. This correlation coefficient is also significant at 95% level of significance.

In January, March and October, monthly rainfall at Khulna is moderately correlated with the SOI of Previous months, having correlation coefficients –0.45, -0.43 and 0.41 respectively. These correlation coefficients are found to be significant at 95% level of significance. The correlation coefficient in February of this station with SOI in January is moderately correlated. The correlation coefficient is found to be –0.60, which is statistically significant at 99% level of significance.

The monthly rainfall at M.Court in March is moderately correlated with SOI in February having correlation coefficient of –0.46. This correlation coefficient is also statistically significant at 95% level.

The correlation coefficient between monthly rainfall in March and May at Faridpur and SOI of the previous months are moderate. The correlation coefficients are –0.41 and 0.41 respectively. These correlation coefficients are statistically significant at 95% level of significance.

In September the monthly rainfall at Cox's Bazar is moderately correlated with SOI in August. The correlation coefficient is -0.42, which is statistically significant at 95% level of significance.

The monthly rainfall in May at Rajshahi is moderately correlated with April SOI, having correlation coefficient 0.43. This correlation coefficient is statistically significant at 95% level of significance.

At Madaripur, the monthly rainfall in February is moderately correlated with the SOI of previous month. The correlation coefficient is -0.44. This correlation coefficient is statistically significance at 95% level.

In January the monthly rainfall at Rangpur is correlated with the SOI in December, having correlation coefficients –0.45 being significant at 95% level of significance. Also the correlation coefficient in March is moderately correlated with SOI in April.

The correlation coefficient is 0.54. This correlation coefficient is found to be statistically significant at 99% level of significance.

Table 2: Correlation coefficients between monthly rainfall of different stations and SOI of the previous one month (1981-2004)

Division/ Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Dhaka	-0.09	-0.24	0.09	0.30	-0.03	-0.16
Madaripur	-0.05	-0.44*	-0.53**	-0.11	0.13	-0.01
Barisal	-0.14	-0.42*	-0.37	-0.36	-0.10	-0.07
Khulna	-0.45*	-0.60**	-0.43*	-0.19	0.01	-0.13
M. Court	-0.11	-0.31	-0.46*	-0.32	0.33	-0.11
Mymensingh	-0.07	-0.02	-0.29	0.11	0.14	-0.35
Rangpur	-0.36	-0.02	-0.45*	0.12	0.54**	-0.37
Sylhet	0.13	-0.03	-0.49*	-0.01	0.28	-0.30
Rajshahi	0.04	0.05	-0.25	0.01	0.43*	0.12
Faridpur	-0.16	-0.37	-0.41*	-0.04	0.41*	-0.06
Cox's Bazar	-0.23	-0.26	0.11	-0.25	-0.25	0.05
Bhola	-0.01	-0.45*	-0.29	-0.39	0.19	0.14
Bogra	0.01	0.01	-0.12	-0.12	0.45*	0.31
Chittagong	0.08	-0.51**	-0.12	-0.24	0.12	-0.15
Srimangal	0.16	0.14	0.06	-0.08	0.33	-0.17

Division/ Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Dhaka	0.02	0.25	-0.07	-0.17	0.25	-0.15
Madaripur	0.22	-0.16	-0.26	0.25	0.36	-.24
Barisal	0.31	-0.25	-0.16	0.19	0.42*	-0.21
Khulna	-0.11	-0.29	-0.28	0.41*	0.34	-0.11
M. Court	-0.03	-0.20	-0.14	0.09	0.34	0.18
Mymensingh	0.22	-0.14	-0.18	0.03	0.34	0.21
Rangpur	-0.15	0.19	0.05	0.11	0.01	-0.17
Sylhet	0.01	0.29	-0.04	0.02	0.37	0.18
Rajshahi	-0.13	-0.09	0.15	0.21	-0.02	-0.09
Faridpur	0.15	-0.03	-0.11	0.17	0.27	-0.09
Cox's Bazar	-0.18	-0.17	-0.42*	0.31	0.05	0.14

Bhola	-0.01	-0.36	-0.07	0.15	0.43*	-0.06
Bogra	0.25	-0.08	0.18	0.14	0.34	-0.13
Chittagong	-0.08	0.06	-0.37	0.46*	0.01	0.07
Srimangal	-0.03	-0.27	-0.29	0.20	0.34	-0.25

** Significant at 99% level. * Significant at 95% level.

The rainfall at Sylhet in March is correlated with SOI in February. The coefficient of correlation is –0.49, being significant at 95% level of significance.

The correlation coefficients of other months at different stations are not found to be statistically significant with the previous month of SOI.

Correlation between monthly rainfall and SOI of previous two months:

The correlation coefficient between monthly rainfall and SOI of the previous two month are given in Table 3, which shows that monthly rainfall at Bhola in February is moderately correlated with these previous two month of SOI having correlation coefficient -0.40. These correlation coefficients are statistically significant at 95% Level of significance as indicated by Student's t-test.

At Dhaka the monthly rainfall in Jun is moderately correlated with SOI in April having correlation coefficient of 0.45. This correlation coefficient is statistically significant at 95% level of significance according to Student's t-test.

The monthly rainfall at Khulna in January has moderate correlation with SOI in November. The correlation coefficient in this month is -0.59, which is statistically significant at 99% level of significance. In February the correlation coefficient is 0.49. This correlation coefficient is also significant at 95% level of significance.

Table 3: **Correlation coefficients between monthly rainfall of different stations and SOI of previous two months (1981-2004)**

Division/Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Dhaka	-0.16	-0.39	0.10	0.14	-0.20	-0.46*
Madaripur	-0.15	-0.35	-0.27	0.05	-0.05	0.18
Barisal	-0.23	-0.39	-0.31	-0.16	-0.02	0.05
Khulna	-0.59**	-0.49*	-0.25	-0.07	0.24	0.04
M. Court	-0.24	-0.32	-0.31	-0.41*	0.07	0.16
Mymensingh	-0.12	-0.08	-0.16	0.10	0.01	-0.12
Rangpur	-0.53**	-0.09	-0.35	0.29	0.20	0.05
Sylhet	-0.01	-0.08	-0.49*	-0.14	-0.11	-0.08
Rajshahi	-0.08	0.02	0.04	0.08	0.02	0.11
Faridpur	-0.25	-0.28	-0.14	-0.13	0.33	-0.08
Cox's Bazar	-0.20	-0.34	0.01	-0.14	0.29	0.25

Bhola	-0.12	-0.40*	-0.23	-0.32	0.01	0.15
Bogra	-0.15	-0.15	-0.14	-0.05	0.13	0.02
Chittagong	-0.07	-0.37	-0.08	-0.33	0.14	0.16
Srimangal	0.06	0.07	0.11	0.05	0.25	0.05

Division/Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Dhaka	-0.29	0.38	-0.03	-0.12	0.06	-0.23
Madaripur	-0.21	0.22	-0.15	0.38	0.11	0.28
Barisal	-0.13	0.24	-0.04	0.17	0.23	0.12
Khulna	-0.27	-0.38	-0.04	0.31	0.16	-0.26
M. Court	-0.07	-0.16	-0.01	0.11	0.16	-0.11
Mymensingh	0.43*	-0.04	-0.05	0.08	0.24	0.16
Rangpur	-0.08	0.07	0.21	0.10	0.14	-0.15
Sylhet	0.24	0.33	0.07	0.08	0.27	0.03
Rajshahi	-0.14	-0.15	0.25	0.16	0.01	-0.21
Faridpur	0.17	0.19	-0.07	0.18	0.13	-0.23
Cox's Bazar	-0.31	-0.27	-0.37	0.11	0.05	0.13
Bhola	-0.24	-0.25	0.08	0.19	0.23	0.03
Bogra	0.23	-0.05	0.18	0.15	0.34	0.23
Chittagong	0.05	0.07	-0.21	0.29	0.01	0.15
Srimangal	0.18	-0.13	0.12	0.22	0.36	0.28

** Significant at 99% level. * Significant at 95% level.

In April monthly rainfall at M.Court is moderately correlated with the SOI of previous two months, having correlation coefficient –0.41. The statistical significance of this correlation coefficient has been studied with the help of Student's t-test and is found to be significant at 95% level of significance.

The monthly rainfall at Mymensingh in July is moderately correlated with the SOI in May, having correlation coefficient of 0.43. This correlation coefficient is also statistically significant at 95% level.

The coefficient of correlation between rainfall in January at Rangpur and SOI of the previous two month are moderate. The correlation coefficient is –0.53353. This correlation coefficient is statistically significant at 99% level of significance.

In March the monthly rainfall at Sylhet is moderately correlated with SOI in January. The correlation coefficient is -0.49, which is found to be statistically significant at 95% level of significance.

The correlation coefficients of other months at different stations are not found to be statistically significant with the previous month of SOI.

Correlation between monthly rainfall and SOI of previous three months:

The correlation coefficient between monthly rainfall and SOI of the previous three months are given in Table 4, which shows that monthly rainfall at Dhaka in February is moderately correlated with these previous three months of SOI having correlation coefficient -0.49. This correlation coefficient is statistically significant at 95%.

At M.Court the monthly rainfall in October is moderately correlated with SOI in July, having correlation coefficient 0.41. This correlation coefficient is statistically significant at 95% level.

The monthly rainfall at Rajshahi in June has moderate correlation with SOI in March. The correlation coefficient in this month is 0.55, which is statistically significant at 99% level of significance.

In January, May, August and October, monthly rainfall at Khulna are moderately correlated with the SOI of Previous three month, having correlation coefficients –0.48, -0.42, -0.46 and 0.40 respectively, which are significant at 95% level of significance.

The coefficients of correlation between rainfall in January and March at Rangpur and SOI of the previous three month are moderate. These correlation coefficients are –0.42 and -0.44 respectively. These correlation coefficients are statistically significant at 95% level of significance.

In June the monthly rainfall at Srimangal is moderately correlated with SOI in March. The correlation coefficient is 0.41, which is statistically significant at 95% level of significance.

At Sylhet the monthly rainfall in March is moderately correlated with the previous three month of SOI. The correlation coefficient is -0.48. This correlation coefficient is statistically significance at 95% level of significance.

The correlation coefficients of other months at different stations are not found to be statistically significant with the previous three months of SOI.

Table 4: Correlation coefficients between monthly rainfall of different divisions and SOI of previous three month (1981-2004)

Stations/Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Dhaka	-0.18	-0.49*	0.12	0.36	-0.07	-0.29
Madaripur	-0.11	-0.14	-0.36	0.04	-0.13	0.21
Barisal	-0.21	-0.32	-0.18	0.01	-0.17	0.22
Khulna	-0.48*	-0.32	-0.24	0.13	-0.42*	0.19
M. Court	-0.12	-0.23	-0.33	-0.21	0.07	0.35

Mymensingh	-0.34	0.04	-0.16	0.11	-0.17	0.29
Rangpur	-0.42*	0.03	-0.44*	0.05	0.30	0.12
Sylhet	0.01	0.09	-0.48*	-0.03	0.13	0.02
Rajshahi	-0.07	0.02	-0.07	0.16	0.09	0.55**
Faridpur	-0.29	-0.37	-0.27	0.19	0.21	0.12
Cox's Bazar	-0.35	-0.24	0.02	-0.07	0.31	0.30
Bhola	-0.10	-0.31	-0.11	-0.60**	-0.05	0.27
Bogra	-0.24	-0.06	-0.02	0.01	-0.05	0.25
Chittagong	-0.03	-0.30	-0.12	-0.12	0.25	0.29
Srimangal	0.06	0.24	0.02	-0.27	0.30	0.41*

Stations/Month	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Dhaka	-0.01	0.23	-0.09	-0.10	0.05	-0.28
Madaripur	0.03	-0.21	-0.17	0.16	0.04	-0.38
Barisal	0.03	0.09	0.07	0.38	0.17	-0.11
Khulna	-0.04	-0.46*	0.09	0.40*	0.10	-0.13
M. Court	-0.18	0.01	-0.20	0.41*	0.14	-0.24
Mymensingh	0.01	-0.09	-0.04	0.14	0.15	-0.29
Rangpur	-0.09	0.01	0.09	0.15	0.10	-0.01
Sylhet	-0.33	0.37	-0.22	0.12	0.14	0.13
Rajshahi	-.26	-0.09	0.23	0.13	-0.08	-0.10
Faridpur	-0.16	-0.10	0.01	0.14	0.04	-0.18
Cox's Bazar	-0.19	-0.25	-0.31	0.25	0.15	-0.03
Bhola	-0.25	-0.27	-0.01	0.30	0.16	-0.08
Bogra	-0.16	-0.30	0.31	0.16	0.28	-0.16
Chittagong	-0.02	-0.14	-0.38	0.22	0.01	-0.02
Srimangal	-0.06	-0.13	-0.09	0.26	0.32	-0.39

** Significant at 99% level. * Significant at 95% level.

The scatter diagram of monthly rainfall with the SOI of same month, previous one month, previous two month and previous three month have been determined. Figs.1-3 are given as for example.

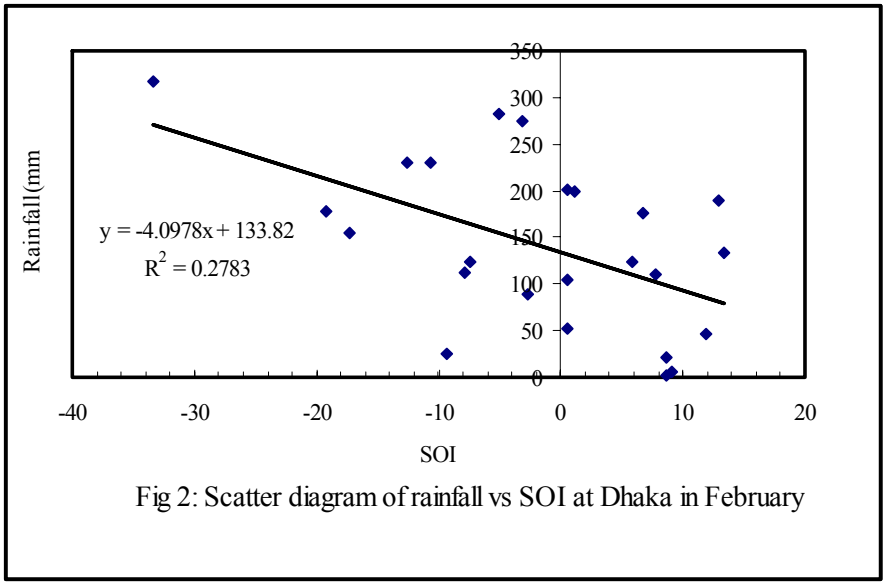

Fig 2: Scatter diagram of rainfall vs SOI at Dhaka in February

Figure 2

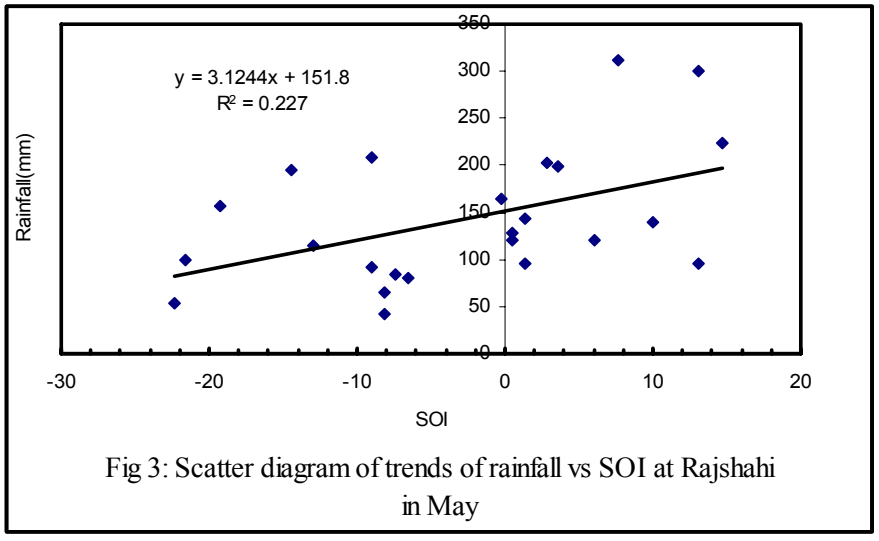

Fig 3: Scatter diagram of trends of rainfall vs SOI at Rajshahi in May

Figure 3

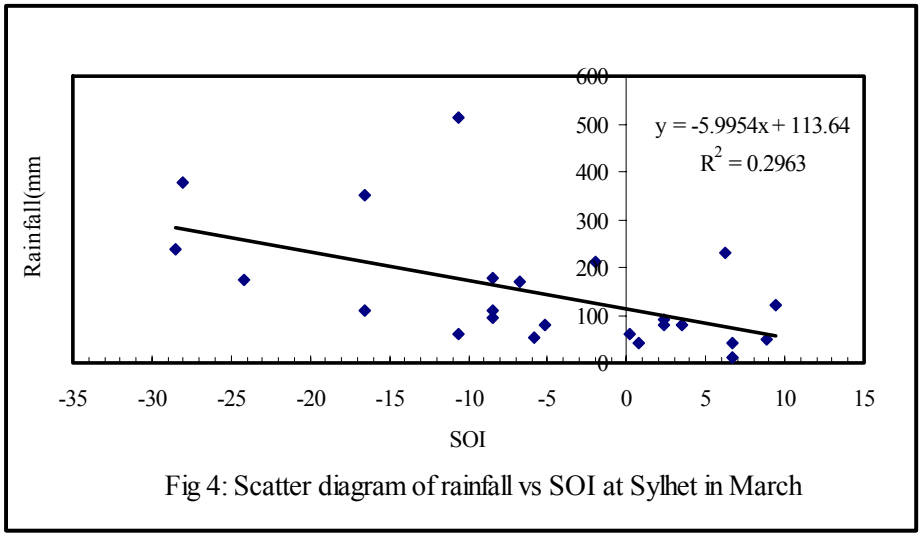

Fig 4: Scatter diagram of rainfall vs SOI at Sylhet in March

Figure 4

The regression equations of trend lines corresponding to the significant correlation in different months and at different stations are given in Table 5.

Table 5: **The regression equations of trend lines corresponding to the significant correlation in different months**

x = SOI of	Station	Y = Rainfall of	Regression equations with R2 values
Same month	Bhola	February	Y= -1.0986x +25.327; R2=0.1601
	Dhaka	February	Y= -4.0978x +133.82; R2=0.2783
	Khulna	February	Y= 1.0986x +35.011; R2=0.162
		October	Y= 4.9244x +153.13; R2=0.3177
	Mymensingh	June	Y= -9.2719x +355.75; R2=0.288
	Rangpur	January	Y= -0.6014x +4.388; R2=0.1697
		May	Y= 4.48x +283.05; R2=0.3333
	Sylhet	March	Y= -5.9954x +0.2963; R2=0.2963
	Barisal	February	Y= -1.0192x +24.838; R2=0.1864
		March	Y= -3.0026x +41.044; R2=0.1927
	Bogra	May	Y= 3.7276x +236.6; R2=0.1708
		July	Y= 6.2552x +402.35; R2=0.1623
	Cox's Bazar	February	Y= -0.9047x +18.566; R2=0.1646
		September	Y= -35.962x +523.92; R2=0.163
		October	Y= 6.0303x +242.63; R2=0.1927

	Faridpur	May	Y= 3.9177x +260.36; R2=0.1884
Previous month	Madaripur	February	Y= -0.9344x +24.661; R2=0.1936
	Barisal	February	Y= -0.9819x +25.176; R2=0.1778
		November	Y= 3.3471x +60.468; R2=0.174
	Bogra	May	Y= 3.1927x +243.46; R2=0.2064
	Faridpur	March	Y= -1.8909x +50.845; R2=0.1655
		May	Y= 2.9106x +265.21; R2=0.1713
	M.Court	March	Y= -3.2645x +73.451; R2=0.2107
	Rajshahi	May	Y= 2.2318x +155.19; R2=0.1908
	Bhola	February	Y= -1.2284x +25.448; R2=0.2058
		November	Y= 2.7682x +53.312; R2=0.1852
	Chittagong	February	Y= -1.287x +17.989; R2=0.2585
		October	Y= 7.7339x +231.69; R2=0.2103
	Khulna	February	Y= -2.4854x +34.354; R2=0.3574
Previous month		March	Y= -2.7444x +51.217; R^2=0.1827
		October	Y= 3.4671x +144.94; R^2=0.171
	Rangpur	March	Y= -1.1762x +25.944; R^2=0.2068
		May	Y= 3.2746x +288.31; R^2=0.2934
	Sylhet	March	Y= -5.2327x +137.96; R^2=0.2426
Previous two months	M.Court	April	Y= -3.9791x +153.35; R^2=0.166
	Bhola	February	Y= -1.3529x +24.553; R^2=0.1612
	Dhaka	June	Y= -3.8407x +277.93; R^2=0.2085
	Khulna	January	Y= -0.816x +9.7376; R^2=0.3452
		February	Y= -2.5782x +32.857; R^2=0.2483
	Rangpur	January	Y= -0.8038x +11.59; R^2=0.2847
	Mymensingh	July	Y= 7.5298x +501.68; R^2=0.1817
	Sylhet	March	Y= -5.2027x +139.46; R^2=0.2466
Previous three months	M.Court	October	Y= 6.3443x +201.47; R^2=0.1674
	Rajshahi	June	Y= 6.1183x +297.62; R^2=0.3072

	Khulna	January	Y= -0.7797x +8.3985; R^2=0.2351
		May	Y= -3.2002x +185.81; R^2=0.1797
		August	Y= -4.442x +291.93; R^2=0.2115
	Rangpur	January	Y= -0.7249x +10.335; R^2=0.1727
		March	Y= -1.3862x +25.238; R^2=0.1906
	Sylhet	March	Y= -6.2033x +134.74; R^2=0.2263

Conclusions:

On the basis of the present study, the following conclusions can be drawn:

i. The monthly rainfall over Bangladesh has moderate correlation with the SOI of the same month, previous month, previous two month and previous three month at some stations.

ii. The correlation coefficients of monthly rainfall with SOI of the same month are relatively higher for Barisal, Bhola, Bogra, Chittagong, Cox's Bazar, Faridpur, Madaripur, Khulna, M.Court, Rajshahi, Rangpur and Sylhet having maximum correlation coefficient -0.63 at Khulna.

iii. The correlation coefficients of monthly rainfall with SOI of the previous one month are relatively higher for Barisal, Bhola, Bogra, Chittagong, Cox's Bazar, Faridpur, Madaripur, Khulna, M.Court, Rajshahi, Rangpur and Sylhet having maximum correlation coefficient –0.60 at Khulna.

iv. The correlation coefficients of monthly rainfall with SOI of the previous two month are relatively higher for Bhola, Dhaka, Khulna, M.Court, Mymensingh, Rangpur and Sylhet having maximum correlation coefficient -0.59 at Khulna.

v. The correlation coefficients of monthly rainfall with SOI of the previous three month are relatively higher for Dhaka, Khulna, M.Court, Rajshahi, Rangpur, Srimongal, and Sylhet having maximum correlation coefficient 0.55 at Rajshahi.

vi. The regression equations may find applications in the prediction of monthly rainfall in Bangladesh.

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