International Journal of Agricultural Sciences ☞DOI:10.15740/HAS/IJAS/20.1/249-256
Volume 20 | Issue 1 | January, 2024 | 249-256 ■ ISSN : 0973-130X Visit us : *www.researchjournal.co.in*

RESEARCH PAPER

Study of changes in temporal distribution pattern of rainfall at Dapoli station in Konkan region of Maharashtra

S. S. Parab[1], S. S. Nagarkar* **and** B.L. Ayare[1]
Department of Agricultural Engineering, College of Agriculture, Dr. B.S.K.K.V., Dapoli (M.S.) India
(Email : palkarshweta23@gmail.com)

Abstract : Dapoli situated in the Konkan region of Maharashtra is having average annual rainfall of 3587 mm with average number of rainy days 75. The yield of major *Kharif* season crop rice is affected by the erratic behavior of rainfall. Present study is an attempt to study the rainfall variations at the Dapoli station which will be useful for forecasting the future temporal availability of water. Comprehensive statistical tools were used to investigate trends in averages and monthly rainfall over the station on decadal basis. Forty years (year 1972-2011) daily rainfall data for Dapoli station was used for the analysis. Results of study showed that, decadal mean rainfall depths of June and August were found decreasing and those for September was found increasing. Mean rainfall depth variations for July as well as annual total rainfall were found random. Seven years moving averages showed that, rainfall depths for the months of June, July and August were found decreasing and for month of September was found increasing. In annual rainfall graph a slight decline was observed.

Key Words : Rainfall distribution analysis, Trend analysis, Moving averages

View Point Article : Parab, S. S., Nagarkar, S. S. and Ayare, B.L. (2023). Study of changes in temporal distribution pattern of rainfall at Dapoli station in Konkan region of Maharashtra. *Internat. J. agric. Sci.*, **20** (1) : 249-256, **DOI:10.15740/HAS/IJAS/20.1/249-256.**

Article History : Received : 02.10.2023**; Revised :** 02.11.2023**; Accepted :** 04.12.2023

INTRODUCTION

Water is one of the most important factors influencing the agricultural production. In India precipitation is majorly in the forms of rainfall. The rainfall received is the important factor for determining the availability of water for agriculture and other usages. The changes in patterns of rainfall affects the availability of water as well as it increases the danger of increasing occurrences of draughts and floods. It is therefore very essential to study the trend of one of the most important climatic factors that is rainfall. The trend analysis of rainfall will be useful to construct the future scenarios of water availability.

A steady and regular movement in a time series through which values are on average either increasing or decreasing is termed a trend. The Indian monsoon rainfall as a whole does not show any significant trend, but over some specific areas of the country significant trends are observed. Significant increasing trend is observed in the annual rainfall for the meteorological sub division, Konkan and Goa is one of them (Guhathakurta and Rajeevan, 2006). The present study was undertaken

***Author for correspondence:**
[1]Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, Dr.B.S.K.K.V., Dapoli (M.S.) India

for Dapoli station which is situated between 17 26' N latitude and 73 45' E longitude.

Daily rainfall data for Dapoli station was converted to monthly rainfall by summing up for the entire study period. Determination of the existence of trend in monthly rainfall data series was done using the moving average method that provides a simple method for smoothing the past history data (Makridakis, 2003). Major objectives of the study were to check variations in the monthly and annual rainfall data from the mean monthly and annual rainfall and to detect and analyze the trend in the monthly and annual rainfall.

MATERIAL AND METHODS

The present study was undertaken for Dapoli, Dist. Ratnagiri (Maharashtra). It is situated between 17 26' N latitude and 73 45'E longitude. The daily rainfall data for Dapoli station for 40 years (1972-2011) was obtained from the Department of Agronomy, College of Agriculture, Dapoli.

Deviations monthly and annual rainfall :

Means of decadal monthly rainfall (June-September) and annual data for the entire study period (40 years) was calculated. The percentage departure of mean monthly and annual rainfall of these decadal periods from the mean rainfall for that particular month was studied.

Contribution of monthly decadal rainfall in annual rainfall :

Monthly per cent contributions of four monsoon months in annual total were calculated for each year. Average per cent contribution of each month for each decades was calculated.

Trend analysis :

The monthly and annual precipitation data can be considered as a single or univariate hydrological time series. The trend analysis to detect the presence of raising and falling trends in a monthly and annual rainfall series was performed using moving average method.

Moving average method :

Moving average provide a simple method for smoothing the past history data. (Makridakis, 2003). Simple moving average can be defined for any odd order. The appropriate order for simple moving average method will be selected to get smooth curve for trend.

A moving average of order k, where k is an odd integer is defined as an average consisting of an observation and m= (k−1) /2 points on the either side, so that,

$$T_t = \frac{1}{k} \sum_{j=-m}^{m} Y_{t+j} \quad (1)$$

where, k= number year for moving average.

Graphs of time verses rainfall depths obtained by performing moving average of order 7 years for monthly and annual rainfall were plotted for visual observation of trend.

RESULTS AND DISCUSSION

The daily rainfall data for 40 years periods (1972-2011) were analysed for four monsoon months June, July, August, September were constructed and time plot for annual and monthly rainfall were generated.

For monthly (June, July, August, September) and annual rainfall data series statistical parameter *viz.* mean, standard deviation, co-efficient of variation were calculated and result are presented in Table 1.

Deviations of monthly and annual rainfall from mean:

Numerical and per cent deviations of total rainfall depths for monthly (June-September) rainfall data and annual rainfall data from their respective means were computed for each decade. The results are presented in Table 2 to 6.

Contribution of monthly decadal rainfall in annual rainfall :

Deviations from mean per cent contribution of

Table 1: Statistical parameters (for the period of 1972-2011)

Sr. No.	Statistical parameters	Months (Rainfall Depth, mm)				Total rainfall (mm)
		June	July	August	September	
1.	Mean	914.76	1218.47	871.81	413.04	3582.16
2.	Standard deviation	362.15	345.57	375.16	245.99	804.93
3.	Co-efficient of variation	39.58	28.36	43.03	59.55	22.47

Table 2: Total rainfall deviations from mean on decadal basis

Decade	Mean rainfall (mm)	Deviation (mm)	Deviation (%)
2002-2011	3611.69	29.52	0.82
1992-2001	3493.38	-88.78	-2.47
1982-1991	3576.83	-5.33	-0.14
1972-1981	3646.76	64.59	1.80

Mean annual rainfall (1972-2011): 3582.16 mm

Table 3 : Deviations from mean for a month of June

Decade	Mean rainfall (mm)	June	
		Deviation (mm)	Deviation (%)
2002-2011	894.80	-19.96	-2.18
1992-2001	766.85	-147.9	-16.17
1982-1991	1000.73	85.96	9.39
1972-1981	996.68	81.91	8.95

Mean rainfall of June (1972-2011)**:** 914.76 mm

Table 4: Deviations from mean for a month of July

Decade	Mean rainfall (mm)	July	
		Deviation (mm)	Deviation (%)
2002-2011	1206.38	-12.10	-0.99
1992-2001	1262.52	44.04	3.61
1982-1991	1176.93	-41.54	-3.40
1972-1981	1228.08	9.60	0.78

Mean rainfall of July (1972-2011):1218.48 mm

Table 5: Deviations from mean for a month of August

Decade	Mean rainfall (mm)	August	
		Deviation (mm)	Deviation (%)
2002-2011	826.04	-45.77	-5.25
1992-2001	826.55	-45.26	-5.19
1982-1991	908.72	36.91	4.23
1972-1981	925.93	54.12	6.20

Mean rainfall of August (1972-2011): 871.81 mm

Table 6: Deviations from mean for a month of September

Decade	Mean rainfall (mm)	September	
		Deviation (mm)	Deviation (%)
2002-2011	546.16	133.11	32.22
1992-2001	439.25	26.20	6.34
1982-1991	312.72	-100.32	-24.28
1972-1981	354.04	-59.00	-14.28

Mean rainfall of September (1972-2011): 413.04 mm

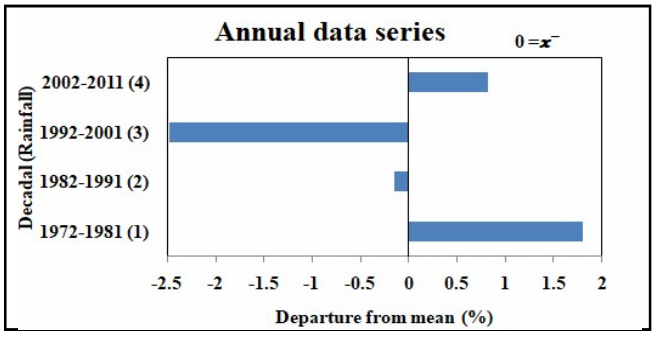

Fig. 1: Per cent deviation from mean rainfall for annual series

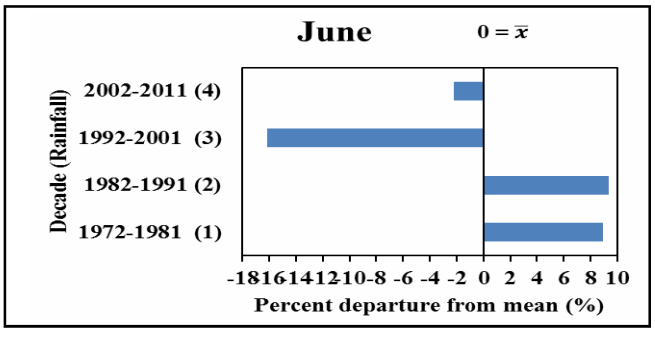

Fig. 2 : Per cent deviation of rainfall from mean for June

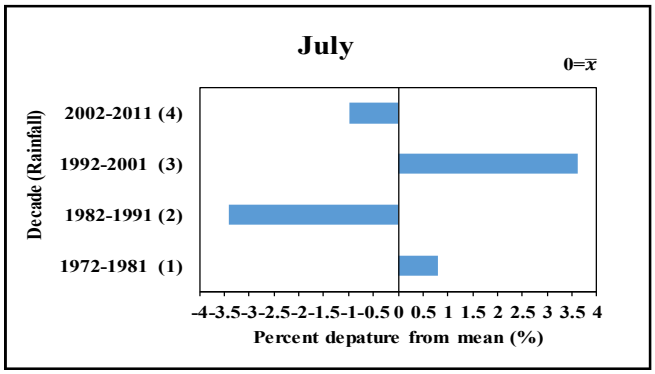

Fig.3: Per cent deviation of rainfall from mean for a month of July

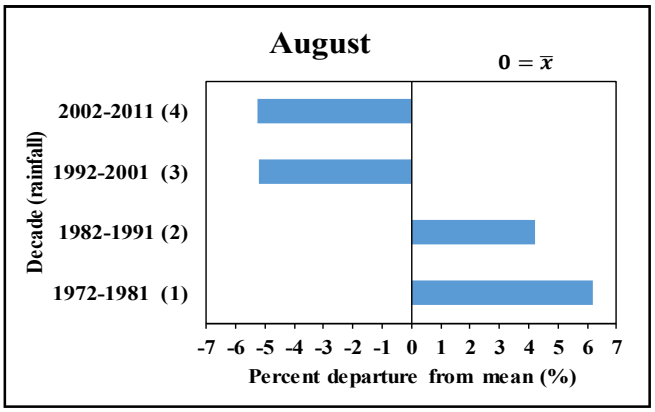

Fig. 4: Per cent deviation of rainfall from mean for August

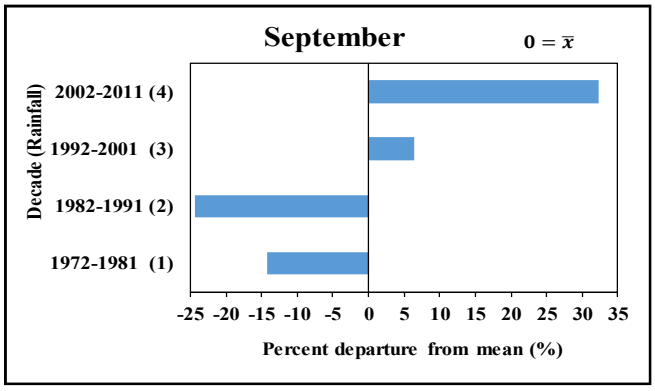

Fig. 5: Per cent deviation of rainfall from mean for a month of September

monthly (June- September) rainfall annual total for each decade were calculated.

The deviation from mean per cent contribution of rainfall for month of June for each decade were calculated and results are presented Table 7. Mean per cent contribution of rainfall for month of June was 25.73%. Period of 20 years from 1972-1981 a positive deviation from mean per cent contribution was observed. For period of 1992-2011 negative deviation from mean per cent contribution was observed. Deviation was maximum for the period of 1992-2001 and minimum for the period of 2002-2011.

Mean per cent contribution of rainfall for month of July was 34.4%. The deviation from mean per cent contribution of rainfall for a month of July for each decade were calculated and results are presented in Table 8. Positive deviation from mean per cent contribution were observed for the periods from 1972-1981 and 1992-2001. Negative deviation from mean per cent contribution were observed for the periods from 1982-1991 and 2002-2011. Deviation was maximum for the period of 1992-2001 and minimum for the period of 1972-1981.

Mean per cent contribution of rainfall for month of August was 23.9%. The deviations from mean per cent contribution of rainfall for month August for each decade were calculated and results are presented in Table 9. For 30 years period, positive deviation from mean per cent contribution were observed for the period from 1972-2001 and negative deviation was observed for the period 2002-2011. Deviation was maximum for the period of 2002-2011 and minimum for the period of 1972-1981.

Mean per cent contribution of rainfall for month of September was 11.3%. The deviations from mean per cent contribution for month of September rainfall for each decade were calculated and results are presented table 10. For a 20 years period of 1972-1991 showed positive deviation from mean per cent contribution whereas the period 1992-2011 showed negative deviation. Deviation was maximum in the period of 2002-2011 and minimum

Table 7: Deviation from mean per cent contribution for month of June

Year	June	
	Mean contribution (%)	Deviation from mean per cent contribution
2002-2011	25.03	-0.69
1992-2001	20.94	-4.79
1982-1991	28.76	3.03
1972-1981	28.19	2.46

Mean per cent contribution of rainfall for month of June(1972-2011): 25.73 %

Table 8 : Deviation from mean per cent contribution for month of July

Year	July	
	Mean contribution (%)	Deviation from mean per cent contribution (%)
2002-2011	33.08	-1.35
1992-2001	36.39	1.95
1982-1991	33.64	-0.79
1972-1981	34.63	0.20

Mean of per cent contribution of rainfall for month of July(1972-2011):34.43 %

Table 9: Deviation from mean per cent contribution for month of August

Year	August	
	Mean contribution (%)	Deviation from mean per cent contribution (%)
2002-2011	22.91	-0.99
1992-2001	24.11	0.19
1982-1991	24.55	0.63
1972-1981	24.08	0.16

Mean per cent contribution of rainfall for month of August (1972-2011):23.91%

Table 10: Deviation from mean per cent contribution for month of September

Year	September	
	Mean contribution (%)	Deviation from mean per cent contribution (%)
2002-2011	14.96	3.57
1992-2001	13.00	1.61
1982-1991	8.34	-3.04
1972-1981	9.24	-2.14

Mean of per cent contribution of rainfall for month of September (1972-2011): 11.38%

in the period of 1992-2001.

Trend analysis :

Seven years moving averages were performed on annual rainfall and monthly rainfall data series for the months of June to September for the study period of 1972-2011. The data for the same is presented in Table 11.

It was observed that, month of June, July and August observed the decreasing trend and month of September observed increasing trend and decreasing trend for annual rainfall was observed.

Summary and conclusion :

From the present study it is revealed that, for the month of June, decadal averages have decreased in current two decades to 766.85 mm (decrease by 147.9 mm) in 1992-2001 and 894.80 mm (decrease by 19.96 mm) in 2002-2011. Average rainfall of June in first two decades 1972-1981 and 1982-1991 was 996.68 mm and 1000.73 mm, respectively which were found more than forty years mean for June *i.e.*, 914.77 mm. Similarly average rainfall of current September in first two decades 1972-1981 and 1982-1991 was 354 mm and 312.72 mm, respectively, which was found much less than forty years mean for September (413.04 mm). The average for the September has increased for current two decades 439.25 mm (increase by 26.20 mm) in 1992-2001 and 546.16 mm (increase by 133.11 mm) in 2002-2011.

Forty-year mean contributions of June, July, August and September in the annual total were 25.75 per cent, 34.44 per cent, 23.92 per cent and 11.38 per cent, respectively. For the June Mean per cent contribution for first two decades 1972-1981 and 1982-1991, during analysis period was 28.19% and 28.76%, respectively which was found more than forty year per cent contribution of June (25.73 %). This Mean per cent contribution of June has decreased in current two decades 20.94 % (decrease by 4.70 %) in 1992-2001 and 25.03% (decrease by 0.7 %) in 2002-2011.

For the August Mean per cent contribution for first three decades 1972-1981 and 1982-1991, 1992-2001 during analysis period was 24.08 %, 24.55% and 24.11%,

Table 11: Seven year moving averages of monthly and annual rainfall data (All rainfall depth are in millimetre)

Year	Annual		June		July		August		September	
	Total mean rainfall depth	7 year moving average	Total mean rainfall depth	7 year moving average	Total mean rainfall depth	7 year moving average	Total mean rainfall depth	7 year moving average	Total mean rainfall depth	7 year moving average
1972	2444.0		925.1		1073.1		276.2		128.2	
1973	3960.9		631.8		1116.0		1428.1		632.8	
1974	4483.7		1245.0		1368.5		1418.5		341.2	
1975	5132.9		1099.7		1452.7		1730.3		640.2	
1976	3513.0		875.4	955.40	1556.4	1313.34	548.4	1080.30	392.5	426.98
1977	3826.2		633.8	897.14	1670.2	1432.76	750.6	1175.18	547.8	510.90
1978	3973.2	3904.84	1461.4	1063.06	1134.0	1436.36	865.8	1062.72	316.2	447.58
1979	3045.5	3990.77	997.4	1013.54	974.1	1357.48	677.4	914.50	272.4	433.82
1980	3597.0	3938.78	1313.2	1056.24	867.0	1240.34	1125.0	793.44	162.9	338.36
1981	2491.2	3654.14	784.0	1037.96	1068.8	1142.82	439.0	771.56	106.2	281.10
1982	2749.0	3313.58	483.4	1007.88	1062.4	1021.26	724.3	766.30	297.7	231.08
1983	4469.7	3450.25	1154.8	946.56	1232.2	1040.90	1310.8	855.30	685.0	304.84
1984	3018.0	3334.80	979.8	943.04	1391.2	1124.32	382.6	796.34	195.0	289.36
1985	4974.2	3477.80	2027.8	1085.96	1370.8	1225.08	1171.1	805.56	99.0	276.58
1986	2421.7	3388.68	1103.5	1149.86	431.0	1097.52	827.9	883.34	41.0	263.54
1987	2427.7	3221.64	1046.4	1262.46	612.8	1007.60	401.6	818.80	65.9	217.18
1988	3445.3	3357.94	523.4	1136.18	1422.7	1045.70	713.7	699.38	769.7	234.12
1989	3199.4	3422.28	729.6	1086.14	1370.4	1041.54	753.0	773.46	247.6	244.64
1990	5290.8	3539.58	997.0	879.98	900.0	947.38	1051.0	949.44	649.4	354.72
1991	3772.5	3647.37	961.6	851.60	1975.8	1256.34	751.2	934.10	76.9	361.90
1992	2992.7	3364.30	364.0	715.12	1073.3	1348.44	1222.1	1098.20	255.0	399.72
1993	3848.0	3568.05	784.9	767.42	1254.4	1314.78	824	1120.26	848.1	415.40
1994	2918.3	3638.14	675.2	756.54	983.2	1237.34	555.5	1080.76	612.6	488.40
1995	3140.1	3594.54	361.3	629.4	1116.1	1280.56	665.6	803.68	753.2	509.16
1996	3112.5	3582.12	417.5	520.58	1533.6	1192.12	619.5	777.34	363.4	566.46
1997	3843.1	3375.31	995.3	646.84	1455.2	1268.5	853.6	703.64	405.5	596.56
1998	3830.1	3383.54	714.6	632.78	1388.6	1295.34	1013.4	741.52	395.5	506.04
1999	4226.5	3559.80	1695.4	836.82	1298.8	1358.46	454.6	721.34	441.4	471.80
2000	4619.1	3669.95	1250.3	1014.62	1645.5	1464.34	1315.8	851.38	84.0	337.96
2001	2403.4	3596.40	410.0	1013.12	876.5	1332.92	741.4	875.76	233.8	312.04
2002	2739.5	3539.17	980.8	1010.22	568.1	1155.50	799.8	865.00	278.8	286.70
2003	3004.8	3523.78	957.4	1058.78	1196.5	1117.08	597.3	781.78	247.0	257.00
2004	3535.6	3479.85	1097.6	939.22	1093.0	1075.92	905.3	871.92	322.0	233.12
2005	3654.2	3454.72	672.3	823.62	1333.0	1013.42	817.6	772.28	717.9	359.90
2006	3558.8	3359.34	686.2	878.86	1248.6	1087.84	841.8	792.36	444.2	401.98
2007	4262.0	3308.32	1273.5	937.4	971.1	1168.44	1067.6	845.92	919.4	530.10
2008	3011.4	3395.18	940.8	934.08	678.8	1064.90	767.5	879.96	591.6	599.02
2009	2697.3	3389.15	259.6	766.48	1190.5	1084.40	439.4	786.78	511.0	636.82
2010	4721.1	3634.34	1161.4	864.30	1750.0	1167.80	688.0	760.86	905.2	674.28
2011	4932.2	3833.85	998.4	884.60	2034.2	1324.92	1336.1	859.72	524.5	690.34

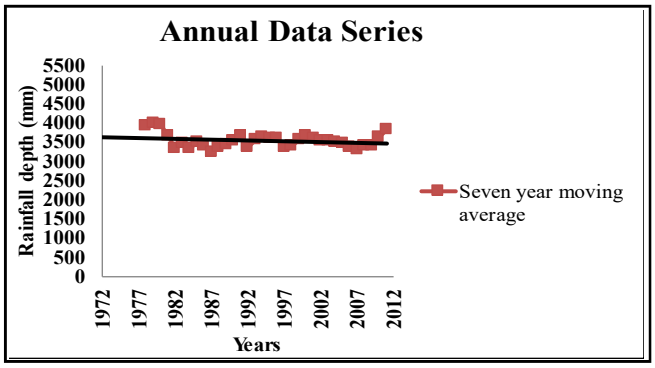

Fig 6: Plot of seven year moving averages for annual rainfall depths

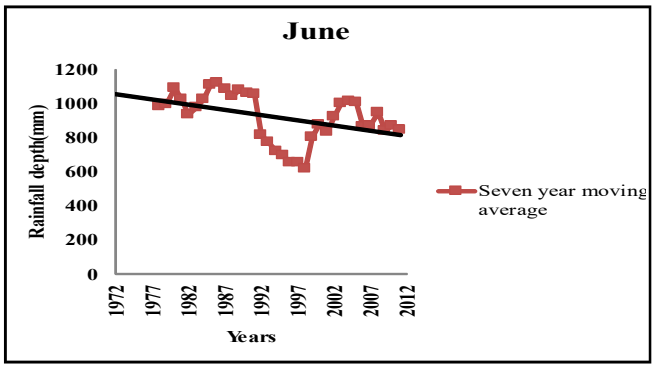

Fig 7: Plot of seven year moving average rainfall depths of June

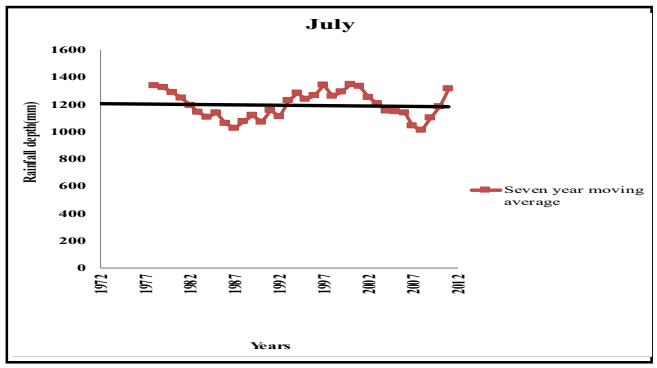

Fig. 8: Plot of seven year moving average rainfall depths of July

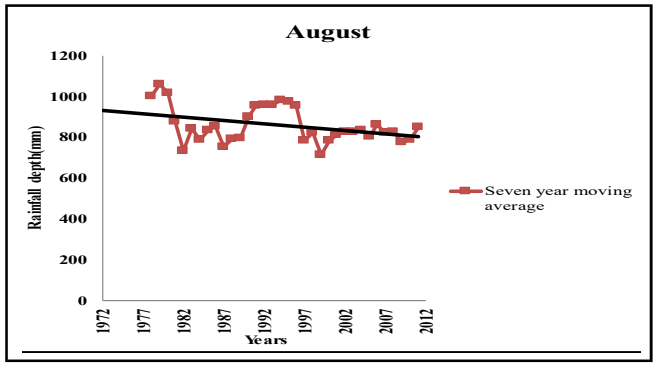

Fig 9: Plot of seven year moving average rainfall depths of August

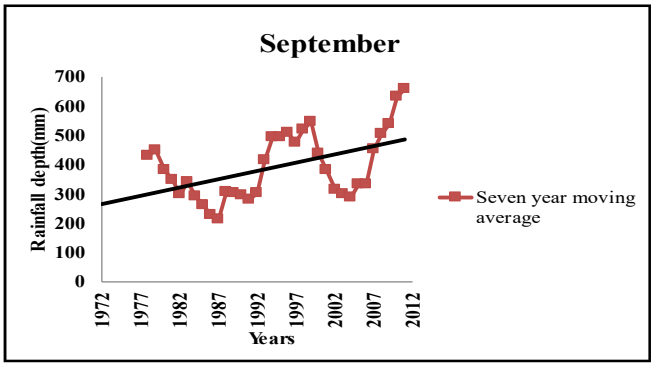

Fig 10: Plot of seven year moving average rainfall depths of September

respectively which was found more than forty year per cent contribution of August (23.91 %). This mean per cent contribution of August has decreased in current decade 22.91 % (decrease by 1%) in 2002-2011. Similarly, mean per cent contribution of September in first two decades 1972-1981 and 1982-1991 during analysis period was 9.25 % and 8.34 %, respectively which was found less than forty year per cent contribution of September (11.4 %). This Mean per cent contribution of September has increased in current two decades 13.0 % (increased by 1.62 %) in 1992-2001 and 14.96 % (increased by 3.6 %) in 2002-2011.

Moving averages of order of 7 years were performed and graphs were plotted from which it was observed that, rainfall for the months of June, July and August was found decreasing and for month of September rainfall was found increasing. In annual rainfall graph a slight decline was observed.

From the results of present study, following conclusions were drawn:

– Decadal mean rainfall depths for the month of June and August were found decreasing and those for the month September were found increasing over the study period (1972-2011).

– Temporal distribution pattern is showing some subtle shift in monthly contribution from August to September.

– Rainfall depths for the months of June, July and August were found decreasing and for month of September rainfall was found increasing. In annual rainfall graph a slight decline was observed.

– For study period average annual rainfall was more or less same.

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