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Research Article

Decadal Features of Rainfall in Punjab

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ABSTRACT

An analysis was carried out to study of rainfall variability (1971-2010) basis of different categories of number of rainy days (2.5-25, 25-50, 50-75, 75-100 and >100 mm) were used for analyzing of rainfall variability. The rainfall (1971-2011) showed decreasing trend from 1971-2011 in Ludhiana, Roop Nagar, Hoshiarpur and Ferozpur). The probability of rainfall at different level of significance (90, 75, 50, 25, 10%) was computed highest probability rainfall was observed at 10% level and lowest rainfall probability was observed at 90% level of confidence. The study of drought, Faridkot (4), Mukatsar (4), Ludhiana (3), Sangrur (3) and Moga (3) highest time occur in these district of Punjab.

Keywords: *Rainfall trend, Drought, Probability, Moving average, Variability*

INTRODUCTION

The rainfall in meteorological sub-division consisting Haryana, Delhi and Chandigarh regions is received mainly between June-September as a result of SW monsoon. Temporal and spatial variability are the rules rather than exceptions for monsoon rainfall, hence, the planning for sustainable agriculture and maintaining ecological balance is difficult task in the arid and semi-arid regions. Since, monsoon fluctuations are of vital importance to agriculture, water supply and energy planning, numerous attempts have been made to develop techniques to predict monsoon rainfall and its variability. Virmani (1989) suggested three types of annual rainfall variation *viz.*, random yearly variation, trends in diminishing annual rainfall and oscillation in annual rainfall in a decade or two. The importance of monsoon prediction stems from the strong link between agricultural productivity and monsoon performance. Therefore, the understanding of monsoon behaviour viz., annual, seasonal and intra-seasonal variability in a particular region is necessary to identify the optimal cropping strategies that ensure the sustainable ecological development (Sinha et al., 1989).

Rajender Kumar and Desai (1999) analyzed Indian summer monsoon rainfall variability and concluded less interannual variability in the recent decade from 1987 to 1996 in comparison with the earlier decades. Hence present study was undertaken to study the inter annual and decadal rainfall variability in Punjab.

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The years of monsoon rainfall failure are based on the work of partasarthy and mooley (1978). The preliminary relationship presented above, with respect to the number of El-Nino years associated with a large number of monsoon failures over India, points out to the desirability of further work in this direction. The very indication that in some years or epochs an out of phase relationship exists between the poor performances of the monsoon rains over India and the abnormal rain over the eastern/ central pacific, suggests very large scale tele- connection which operates through the displacement of the east-west circulation resulting from the changes in the thermal forcing in the equatorial regions on the planetary scale.

A large amount of scientific literatutre on the Indian and asian monsoon in available (Chang & krishnamurti 1987) however possible connection between rainfall anomalies over the countries in the asian monsoon have received little attention. Some work in this direction has been done by investigating the relationship between rainfall variations over india with variations over china (kriplani and singh 1993) over Thailand (kriplani et al., 1995) and over Bangladesh and Nepal.

MATERIALS AND METHODS

Analysis of past 41 years data was carried out to examine the variability in rainfall features in different district of Punjab. The state of Punjab state receives rainfall ranging from 1000 to 1100 mm in the northern part of Punjab and less than 400 mm extreme in south western Punjab. The Punjab state is divided in 5 agro climatic zones-1. Central plain zone 2. Sub-mountain Undulating Zone 3. Undulating Plain Zone 4. Western Plain Zone 5. Western Zone. One district out of each zone was selected for rainfall analysis. The climate is generally very hot in summers and remarkably cold in winters. High temperatures of 45°C magnitude is recorded during the month of May in most parts of the sub-divisions, whereas, in winters the temperature goes down to –2 to –3°C for a few days.

1. Data collected:

The rainfall data of past 41 year were collected from school of climate change and agricultural meteorology, India Meteorological Department, Statistical Abstracts, Website of CRIDA.

The rainfall collected from different agencies was analysed using M.S. Excel and "Weather Cock" a software developed by Central Research Institute for Dry land Agriculture (CRIDA) Hyderabad.

The moving average analysis conducted to remove the variability in the data for trend analysis for rainfall features (increasing/decreasing). Statistics in all the study was carried out with decadal time span in one districts of each agro climatic zone of Punjab. Number of rainy days in different categories (2.5-25, 25-50, 50-75, 75-100 and >100 mm) and rainfall probability with different confidence level were computed using. The long term trend in the rainfall on various time domain for the period (1971-2011) was conducted by taking 2, 3 and 5 years moving average analysis for the period (1971-2011) the weather cock software developed by the CRIDA, Hyderabad. The drought intensities of different levels were calculated using the weather cock software developed by CRIDA, Hyderabad assuming if:

Y= (i,1) – tyr/tyr*100 ; X=y*(-1).

If Y >= 0 and Y <= -25 Then No Drought

If x <= 25 Then No Drought

If x > 26 and x <= 50 Then Moderate Drought

If x > 50 Then Severe Drought

RESULT AND DISCUSSION

Decadal analysis: In Ludhiana district higher number of rainy days in the range of 2.5 to 25 mm rainfall in 2001 to 2010 (449) and lowest number of rainy days in 1981 to 1990 (334). Ludhiana district has been showing decreasing rainfall events from 1981to 1990 to 2001 to 2010 for 175 mm. Total number of rainy days were highest (47) in the decade 1991 to 2000 and followed by 2001 to 2010 were it was (43)

in the range 25 to 50 mm rainfall. Number of rainy days in the range of 50 to 75 mm increased from 2nd in 1981 to 1990 to 5th decade 2001 to 2010. Two events of extreme rainfall were reported 1981 to 1990 and it was followed by 1991 to 2000 decade where only one such events was observed (Table. 1). Bhatla et al. (2016) examine the variations in the seasonal rainfall during the period 1971-2010. The regression equation depicts a very small decreasing trend of the order of 2.5 mm/year. The highest cumulative rainfall of 1438.7 mm is observed in the year 1971 and lowest 511.3 mm is observed in 2004. The trend in the month of June for entire study period 1971-2010 is not noticeable, although, it is towards negative side.

In Hoshiarpur district highest number of rainy days in the category of 2.5 to 25 mm rainfall in 2001 to 2010 (708) and lowest number of rainy days in 1971 to 1980 (623). In the range of 25-50 mm number of rainy days during the decade 1981 -1990 the highest (75) and highest rainfall (896.3 mm) was reported in the decade 1991-2000. The highest number of extreme events (5) in the category of (>100 mm) have been 1991 to 2000 decade. The coefficient of variation was 18.1% with SD of 144.5 mm. Decadal analysis of monsoon rainfall has shown by Singh (2014) in the decade of 1991-2000 in east agro climatic region of Haryana (Table. 2). Bhatla et al. (2016) studied the decadal analysis of frequency of rainfall events and their contribution to total rainfall amount in each category is carried out for the monsoon season (Table 3). In all the three categories number of rainfall events has decreased in the recent decade.

In Roop Nagar highest number of rainy days in the range of 2.5 to 25 mm rainfall in 2001 to 2010 (673) and lowest number of rainy days in 1981 to 1990 (545). The extreme events were reported to decrease as reflected by decreasing number of rainy days. On the basis of data in Roop Nagar, number of rainy days from 60 to 57 & average rainfall also decreased more than 100 mm in 1971-1980 to 2001-2010 decade. The variation of frequency of occurrence of heavy and very heavy rainfall were studied in the light of antecedent synoptic situations. It was confirmed from 400 case studies that low pressure area producing around 50% of the total number of heavy and very heavy rainfall in July (Dubey et al., 2014). (Table. 3).

In Ferozpur highest number of rainy days in the range of 2.5 to 25 mm rainfall in 2001 to 2010 (346) and lowest number in 1971 to 1980 (302). The analysis carried out for Ferozpur district of Punjab it was observed that the rainfall in the recent past has decreased drastically from 449 mm in the range of 25 to 50 mm rainfall was in 1971 to 1980 decade. It was reduced to 19 in the decade 2001 to 2010 (Table. 4).

Rainfall trend:

The rainfall data of different districts of Punjab analysed by assessing the trend in the rainfall. The variability for rainfall data with respect to year was smoothing for batter presentation of the rainfall trend over the year that was done by taking 2 year, 3 year, and 5 year. Dubey et al. (2014) exmine in all, 59% of the stations did not show any trend. 19% of stations have shown positive significant trends. The positive significance trend is observed over east part of central region, i.e., east Madhya Pradesh while negative trend is observed in western parts of the region. For the time series 1971-2010, 31% stations show increasing trend 47 % decreasing trend and 22% stations indicate no trend. A trend line was then added ascertain decreasing trend of rainfall over the time series. Ludhiana which falls in the central plain agro climatic zone of Punjab and receives an average rainfall of 733 mm. It was found was smoothing of data with the moving average on 41 years that the rainfall has been decreasing over the year by 4.231 mm per year (Fig.1).

Hoshiarpur, district high rainfall region (931 .71mm) rainfall was also found to have decreasing trend of the rainfall. The moving average analysis attempt at 2 year, 3 year, 5 year interval showed a slightly

decreasing trend of rainfall (6.573mm per year). It was also reflected that the rainfall actually observed also showed a decreasing rainfall over the year (Fig. 2).

Roop nagar district of Punjab received 918.12 mm rainfall 2 year, 3 year, 5 year moving average was attempt on the data and it has been clear that the rainfall showed the decreasing trend for all the scenario of moving average including the actual rainfall (Fig. 3).

Ferozpur district is south western agro climatic zone of Punjab has been characterized as a zone of low intensity rainfall and received 445.35 mm rainfall annually. The rainfall of this region has been showing a dramatically trend and observed that after the year 1996 the rainfall drastically decreasing and the decreasing rate is 7.892 mm per year (Fig. 4).

Bathinda district which also falls in the south western Punjab received 408 mm average rainfall annually is characterized low rainfall zone. The analysis over the 41 year of time series data showed that the rainfall has been showing a decreasing for all the moving average and actual rainfall also. The overall decreasing in the amount of rainfall was 4.2 mm per year (Fig. 5).

Probability of the rainfall:

The probability of rainfall was calculated using the weather cock software developed by the CRIDA, Hyderabad. The probability was computed on 10,25,50,75 and 90 per cent confidence level. The probability analysis for rainfall was attempted based on the long term data using weather cock software. The probability of rainfall was attempted on different levels of significant 90,75,50,10 % and mean. The probability rainfall was found to increase from 90 percent level of significance to 75, 50, 25, 10 percent and mean levels. Kumar Sunil et al. (2014) as discussed above, rainfall at 75% and 90% probability is assured rainfall and at 50% probability is the median limit for taking risk. The minimum weekly rainfall amount expected at 50, 75 and 90% probability level is presented for Pusa, Purnea, Sabour and Patna. The highest rainfall probability of rainfall was reported at the probability level of 10 percent for all the district of Punjab. On the other hand lowest probability was observed when the probability level is kept at 90percent (Fig 6). Baweja (2011) studied the rainfall probability for different level of significance for Himachal Pradesh).

Drought intensity:

Spatio-temporal variability of draught in Punjab

The data was analysed for drought condition of varying intensity by using weather cock software developed by Central Research Institute for Dryland Agriculture (CRIDA). The drought condition were determined as per the limits provided in the Weather Cock for computation of drought intensities. It was observed that at Amritsar, Ferozepur, Gurdaspur, Hoshiarpur, Nawan Shaher and Roop Nagar, no severe droughts were observed during the period under study. The moderate drought were reported in different districts during different time span. At Amritsar moderate type of drought occurred 4 times during 1971, 2009, 2010, 2011, at Bathinda (12 times), Faridkot (15 times), Fatehgarh sahib (20 times), Gurdaspur (5 times), Hoshiarpur (4 times), Jalandhar (3 times), Kapurthala (5 times), Ludhiana (3 times), Mansa (14 times), Moga (9 times), Muketsar (7 times), Nawan sahar (9 times), Patiala (15 times) and Sangrur, (9 times) were observed.

Severe Drought intensity was observed at Faridkot (4 times), Fatehgarh sahib (once), Jalandhar and Kapurthala (2times), Ludhiana (3 times), Mansa (once), Moga (3 times), Mukatsar (4 times), Patiala (once), Sangrur (3 times). However, no sever drought was observed at Amrisar, Bathinda, Ferozpur, Gurdaspu, Hoshiarpur, Nawansahar and Roop Nagar during the time series of 41 years (Table. 5).

Table: 1. Decadal features of rainfall at Ludhiana

Period	Average Rainfall (mm)	Total No of Rainy Days (2.5-50 mm)	Total No of Rainy Days (25-50 mm)	Total No of Rainy Days (50-75 mm)	Total No of Rainy Days (75-100 mm)	Total No of Rainy Days (>100 mm)
1971-1980	594.5	406	36	4	1	0
1981-1990	653	344	41	2	3	2
1991-2000	557	403	47	8	2	1
2001-2010	478.5	449	43	5	3	0
Mean	570.7	400.5	41.75	4.75	2.25	0.75
SD (mm)	73					
CV (%)	12.8					

Table: 2. Decadal features of rainfall at Hoshiarpur

Period	Average Rainfall (mm)	Total No of Rainy Days (2.5-50 mm)	Total No of Rainy Days (25-50 mm)	Total No of Rainy Days (50-75 mm)	Total No of Rainy Days (75-100 mm)	Total No of Rainy Days (>100 mm)
1971-1980	830.5	623	60	1	1	1
1981-1990	877.5	631	75	12	4	0
1991-2000	896.3	678	62	12	3	5
2001-2010	584.4	708	54	7	1	1
Mean	797.175	660	62.75	8	2.25	1.75
SD (mm)	144.5					
CV (%)	18.1					

Table: 3. Decadal features of rainfall at Roop Nagar

Period	Average Rainfall (mm)	Total No of Rainy Days (2.5-50 mm)	Total No of Rainy Days (25-50 mm)	Total No of Rainy Days (50-75 mm)	Total No of Rainy Days (75-100 mm)	Total No of Rainy Days (>100 mm)
1971-1980	845.5	566	60	8	5	0
1981-1990	948	545	58	11	6	3
1991-2000	783	596	45	14	3	2
2001-2010	730	673	57	9	2	1
Mean	826	595	55	10.5	4	1.5
SD (mm)	93.6					
CV (%)	11.3					

Table: 4. Decadal features of rainfall at Ferozpur

Period	Average Rainfall (mm)	Total No of Rainy Days (2.5-50 mm)	Total No of Rainy Days (25-50 mm)	Total No of Rainy Days (50-75 mm)	Total No of Rainy Days (75-100 mm)	Total No of Rainy Days (>100 mm)
1971-1980	449	302	31	2	0	0
1981-1990	423	310	27	6	4	0
1991-2000	344	333	28	9	2	1
2001-2010	159	346	19	2	1	0
Mean	343.75	322.75	26.25	4.75	1.75	0.25
SD (mm)	131					
CV (%)	38.1					

Table: 5. Temporal variability of drought condition in different districts of Punjab

District	Moderate Drought	Severe Drought
Amritsar	1987, 2009, 2010, 2011 (4 times)	Nil
Bathinda	1974, 1979-1982, 1984, 1987, 1991-1992, 1999, 2002, 2004 (12 time)	Nil
Faridkot	1974, 1979-1982, 1991-1994, 2004-2009 (15 times)	1971, 2000-2002 (4 times)
Fatehgarh Sahib	1974-1989, 1984, 1992, 2002, 2007 (20 times)	1987(once)
Ferozpur	1974, 1979, 1982, 1989, 1991, 1999, 2001-2002, 2004, 2009 (10 times)	Nil
Gurdaspur	1972, 1974, 1987, 1991, 2002 (5 times)	Nil
Hoshiarpur	1972, 1974, 1987, 1991(4 times)	Nil
Jalandhar	1976, 1987, 1991(3 times)	1972, 1974 (2 times)
Kapurthala	1976, 1987, 2009-2011 (5 times)	1972, 1974 (2 times)
Ludhiana	1979,1992,1999 (3 times)	1974, 1984, 1987 (3 times)
Mansa	1972, 1979-1980, 1984-1985, 1987, 1991-1992, 1999-2002, 2004, 2009 (14 times)	1989(Once)
Moga	1979-1982, 1985-1986, 1989, 1992, 1999 (9 times)	1974, 1984, 1987 (3 times)
Mukatsar	1974, 1989, 1982, 1991, 1994, 2004, 2009 (7 times)	1971, 2000, 2001 and 2002 (4 times)
Nawansahar	1972, 1974-1975, 1979 (4 times)	Nil
Patiala	1974, 1979-1987, 1992, 1997, 1999, 2002, 2007 (15 times)	1984 (Once)
Roop Nagar	1974, 1979, 1987 (3 times)	Nil
Sangrur	1979-1982, 1985-1986, 1989, 1992, 1999 (9 times)	1974, 1984, 1987 (3 times)

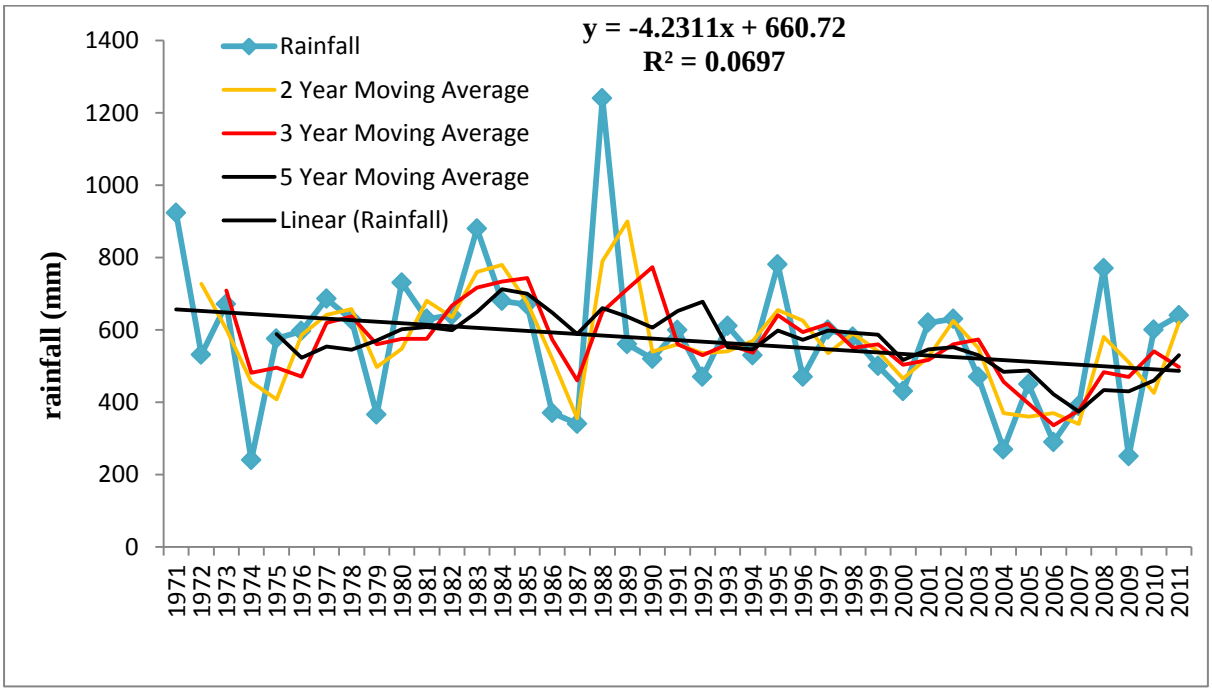

Fig. 1: Annual rainfall variability in Ludhiana from 1971-2011

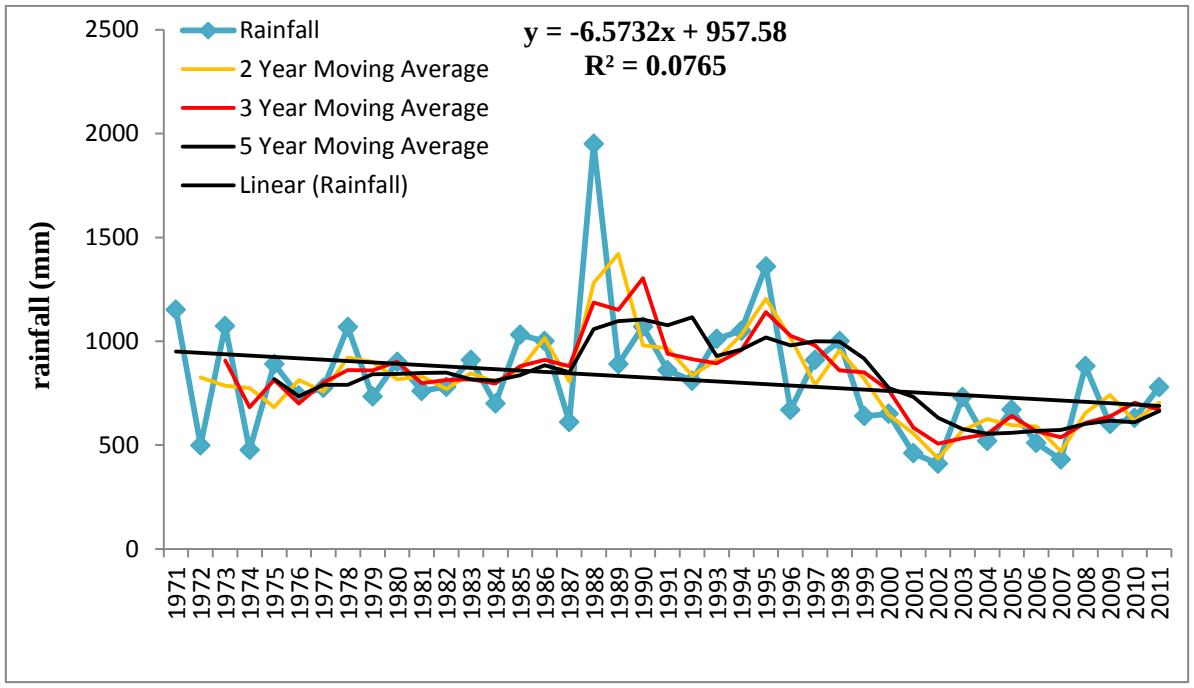

Fig. 2: Annual rainfall variability in Hoshiarpur from 1971-2011

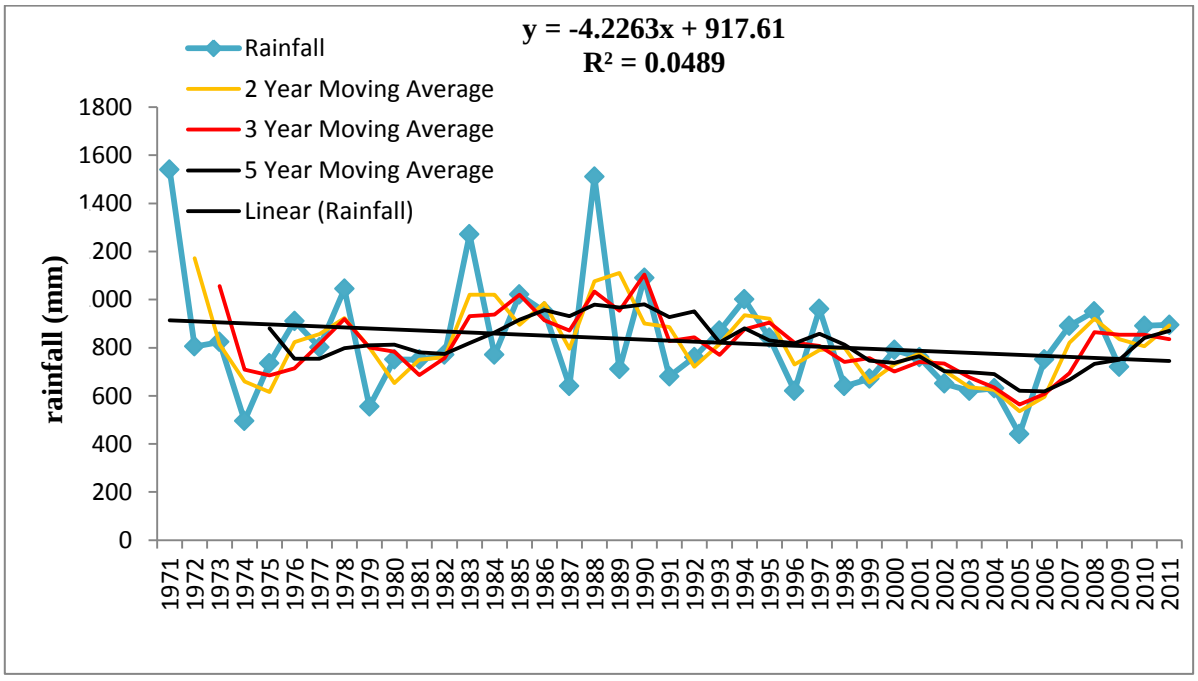

Fig. 3: Annual rainfall variability in Roop Nagar from 1971-2011

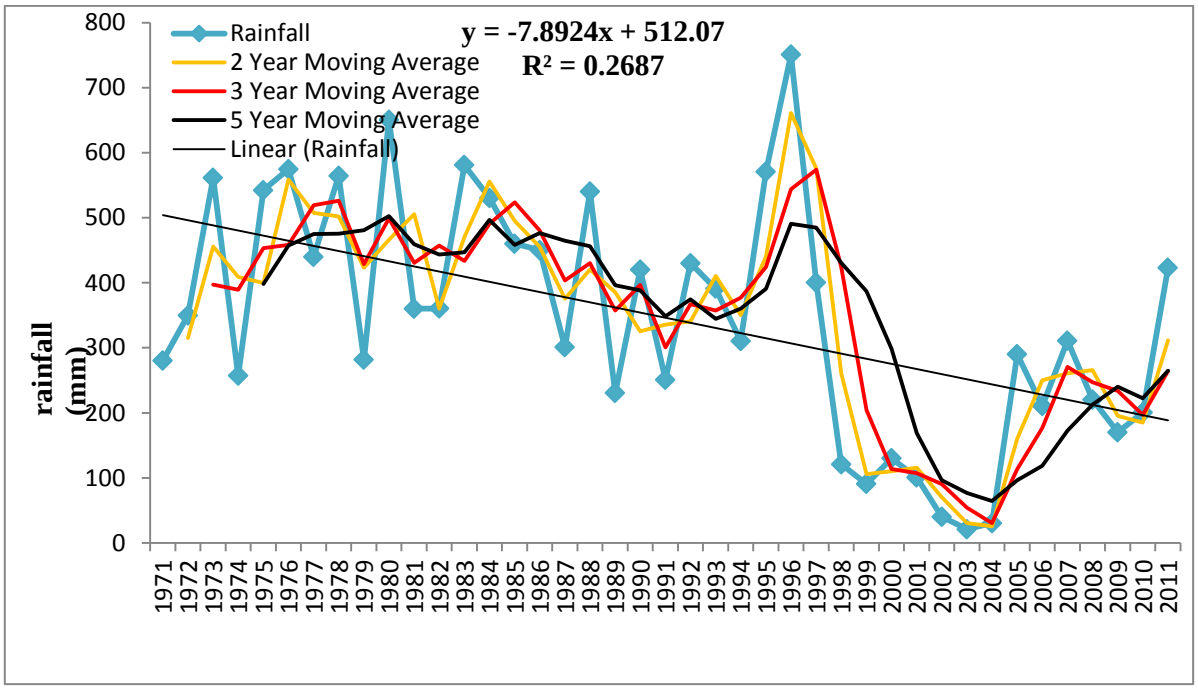

Fig. 4: Annual rainfall variability in Ferozpur from 1971-2011

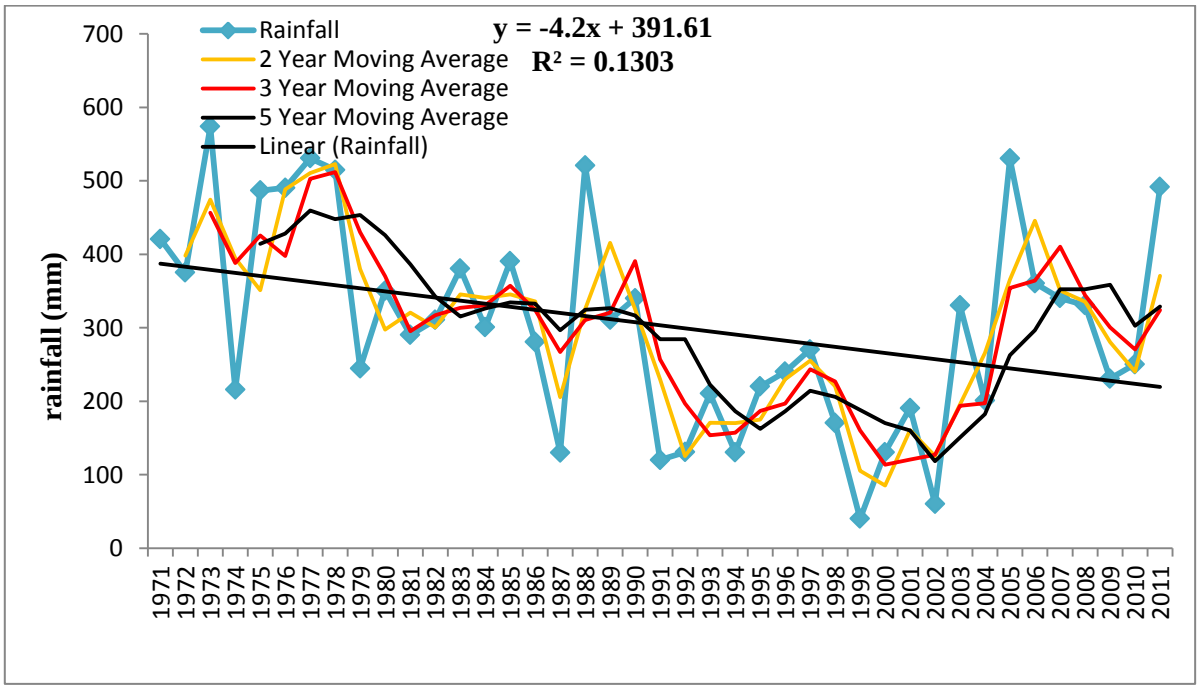

Fig. 5: Annual rainfall variability in Bathinda from 1971-2011

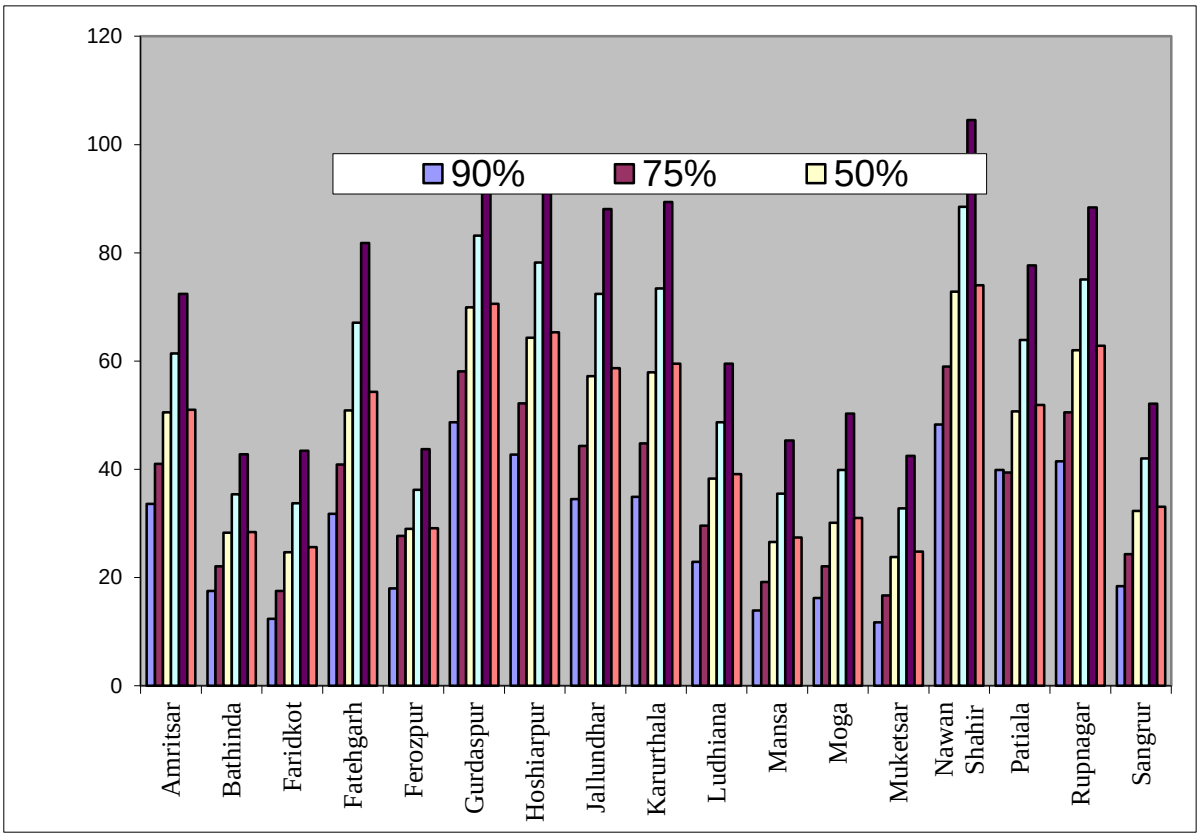

Fig. 6: probability of the rainfall

CONCLUSION

In Punjab state which average rainfall in decadal have decreasing and number of heavy Rainfall has increasing. Annual rainfall variability in Punjab (1971-2011) have reported decreasing trend of rainfall.

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