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Monsoon rainfall patterns of Haryana in recent times

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Abstract

An effort was made here to examine the behaviour of Indian Summer Monsoon Rainfall (ISMR) at regional level in the state of Haryana. The monthly monsoon rainfall data of recent 30 years (1988-2017) of distinct stations of the state was used for the exploration. The mean rainfall during ISMR in the state ranged from 248.04 mm at Sirsa and 956.94 mm at Ambala. Monthly mean rainfall ranged between 43.55 and 134.09 mm (June), 81.23 and 340.21 mm (July), 68.76 and 331.23 mm (August) and 54.51 and 175.35 mm (September) at different locations. The significant portion of ISMR occurred during the month of July and August in the study area. Monthly mean rainfall during June, July, August and September at different locations ranged from 43.55 to 134.09 mm, 81.23 and 340.21 mm, 68.76 to 331.23 mm and 54.51 to 175.35 mm, respectively. An overall decreasing trend in ISMR was observed at all the locations during the course of study period.

Keywords: Monsoon, rainfall, ISMR, variability, trends

1. Introduction

The understanding of the processes of precipitation and its variability at spatial and temporal scale across pan Indian is very decisive for diverse applications viz., agriculture, hydrological management, power generation etc. India roughly receives around 3/4th of overall annual precipitation throughout ISMR (Ghosh *et al.* 2009). The agroclimatic planning at regional level pertaining to farming and allied sectors is basically a resource based preparation. In reality, the regional approach to climate change as well as its variability is a pursuit to ascertain regional vulnerability on the basis of which effective response interventions can be established to preserve ecological equilibrium and sustainable development, particularly in semi-arid tropics under monsoon variability. However most of the research that have been conducted so far were focused on projected changes in global parameters related to climate. So we need a switch from global generalities to regional specifics in order to make a practical impact assessment on a regional scale.

1.1 Monsoon Rainfall patterns

Hundal and Kaur (2002) [3] examined annual and seasonal variations in the precipitation and found significantly higher SD and CV which is revelatory of a prominent variations in the precipitation. De and Rao (2004) [1] reported a rise in ISMR for the period of 1951-2000 at Mumbai, Bangalore, Kolkata, Patna and Pune whereas it was decreasing at Nagpur which may be rapid industrialization leading to higher anthropogenic aerosols loading in the environment which acts as cloud condensation nuclei. This helps in rapid formation and growth of rain bearing clouds leading to enhanced rainfall.

Krishna Kumar *et al.* (2009) [5] found a decrement in ISMR while increment in post-monsoon season precipitation in Kerala. In evaluating the monthly, seasonal and annual precipitation patterns from 1871-2005. The magnitude and frequency variation in extreme monsoon rainfall occurrences in India from 1871 to 2005 was examined by Pal and Al-Tabbaa (2010) [11]. They found that intra-region variability for extreme monsoon season rainfall is higher, showing negative tendency owing to which the magnitude and frequency of "monsoon rainfall excess" has decreased whereas magnitude and frequency of "monsoon rainfall deficit" has increased. While studying ISMR over India, Pai *et al.* (2011) [10] found high intra-seasonal variability, which was strongly influenced by Madden Julian Oscillation (MJO).

Joshi and Pandey (2011)^[4] while analyzing rainfall patterns during 1901 to 2002 across whole India, found no significant trends in any region i.e. Central, SW, SE and NW India. Rana *et al.* (2012)^[13] noticed large variability in rainfall at Mumbai and Delhi. The study showed a non-significant reduction in long-term ISMR over Delhi and a little significant decreasing trend in Mumbai.

Menon *et al.* (2013)^[8] examined the possible impact of global warming on the Indian monsoon using future projections of CMIP-3 and concluded a wide range of trends with different magnitude and sign across models. A consistently rising trend in mean seasonal rainfall of Indian summer monsoon has been observed when evaluation of summer monsoon periods was done by using new generation of climate models. Oza and Kishtawal (2014)^[9] examined rainfall using long time data series for the period from 1901 to 2010 of different agroclimatic regions and found a decreasing trend in ISMR all over India. Greater reduction in the trend were observed specifically in the North East Indian Regions.

Preethi *et al.* (2017)^[12] used CMIP5 model outputs of the South East Asia to investigate the summer monsoon variability and their teleconnections. They conducted thorough evaluation using nine models with greater depiction of latest monsoon teleconnections for dynamic Asian monsoon subsystems by utilizing historical simulations (1861-2005) as well as future projections under the RCP4.5 scenario (2006-2100) and discovered that teleconnections also display multi-decadal variability with alternating epochs of reinforcing and weakening interactions. Their analysis conclude that the oscillatory multi-decadal variability exist in the Asian summer monsoon, which will be there in the future also.

With minimal number of studies at regional level, trend analysis of ISMR across Haryana states becomes necessary and needs to be taken into consideration, given its significant impacts on agriculture, food sustainability, management of water resources and different sectors of the economy etc. (Dore 2005; Kumar *et al.* 2010)^[2, 7]. Thus, the present study is intended to make realistic assessment on monsoon rainfall variability on local/regional scale principally for the state Haryana.

2. Materials and methods

2.1 Study area

The study region (Figure 1) Haryana state is located in north western India and occupies about 1.3 per cent geographical area of the country. Latitudinal and longitudinal coverage of state extends from 27°39' to 30°55.5' N and 74°28' to 77°36.5' E, respectively. The total geographical area of the state is about 44,212 km².

2.2 Climatic features of study area

The state Haryana has semi-arid climate in the South-West and Gangetic plain environment in rest of the areas. The eastern agroclimatic zone of Haryana includes stations of district Ambala, Karnal, Yamunanagar, Kurukshetra and Sonapat. The zone defined as wet zone in comparative terms with that of Western zone. It receives more rains in northern and less in southern parts and the mean annual rainfall ranges from 500 to 1000 mm, of which more than 75 per cent is received during June to September. Remaining 10 to 15 per cent rains are received in winter, 5-10 per cent in summer and 5-10 per cent during the post monsoon season. Temperatures vary greatly in the zone, May and June are the hottest; and

January and February are the coldest months. During May-June, maximum temperature rises above 40°C and hot dry winds are common features. In January normal mean temperature remains around 6-8°C and frost may also occur during winter months for one or two days.

The western agroclimatic zone includes stations of district Hisar, Sirsa, Bhiwani, Rewari and Mahendragarh. A major part of southwest Haryana is arid, receiving less than 500 mm annual rainfall. The southwest monsoon contributes around 80-85 per cent of total annual rainfall. From October to mid-April, weather remains almost dry except occasional light showers during these months. Not only the quantum of rainfall is low in the region but the variability is also very high. An average minimum temperature of 4-6°C is recorded during winters. The higher temperature (35°C) in the months of September-October is responsible for late sowing of winter crops after the monsoon withdrawal in early September. Mainly four farming situations are found in this zone *viz*; rainfed farming, irrigated with limited canal and good quality tube-well water, irrigated with brackish water and the mixed farming.

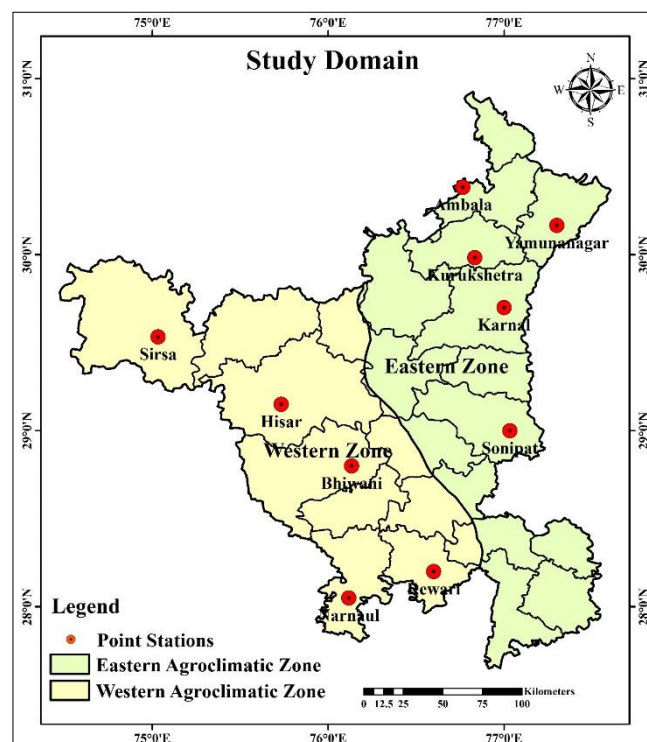


Fig 1: Map of Study Domain

2.3 Data collection and their analysis

The daily rainfall data of monsoon period (June-September) was obtained from Data Supply Portal of National Data Centre, Climate Research and Services, India Meteorological Department, Pune for the course of study period (1988 – 2017). Different statistical methods/techniques were used for the data analysis.

3. Results and discussions

3.1 Monsoon rainfall features

The mean monsoon rainfall in the entire state ranged between 248.04 mm (Sirsa) and 956.94 mm (Ambala) during 1988-2017, and the normal rainfall during monsoon season for whole Haryana state was 460.83 mm (Table 1). The value of standard deviation was highest at Ambala (285.9 mm) whereas it was lowest at Sirsa (115.46 mm). The values of coefficient of variation ranged between 25.35 %

(Yamunanagar) and 46.55 % (Sirsa) at various locations which showed high rainfall variability. Among the districts, the highest variability in rainfall was observed at Sirsa with a value of 46.55% and the lowest variability was observed at

Yamunanagar with a value of 25.35 % of coefficient of variation. The value of coefficient of variation for overall Haryana state is 30.91%.

Table 1: Features of normal monsoon season rainfall at different locations (1988-2017)

S. No	Locations	Mean (mm)	SD (mm)	CV (%)
1	Sirsa	248.05	115.47	46.55
2	Hisar	324.65	138.27	42.59
3	Bhiwani	361.79	146.62	40.53
4	Narnaul	404.51	168.16	41.57
5	Rewari	486.13	184.82	38.02
6	Sonipat	461.53	166.56	36.09
7	Karnal	495.42	175.64	35.45
8	Kurukshetra	589.31	232.30	39.42
9	Ambala	956.95	285.99	29.89
10	Yamunanagar	948.04	240.42	25.36
11	Haryana	460.83	142.46	30.91

3.2 Monsoon rainfall trend in the region

3.2.1 Linear trend and Five years moving average

Trend of monsoon rainfall for all the locations under study was computed during the course of investigation (1988 – 2017), using linear trend and five years moving average, and the trend, thus, observed have been depicted in Figure 2 to Figure 12. All locations under study have exhibited a decreasing trend of monsoon rainfall with epochal fluctuations during the entire period of investigation. For the districts lying in western Haryana, a slight rise in monsoon rainfall was observed at most of the locations from 1995, which started decreasing after 1999 till 2008 that subsequently increases and falls again thereafter. But overall the monsoon rainfall in these districts showed a consistently decreasing trend ranging from 1 to 7.2 mm per year at different locations. The observed rate of decrease in rainfall per year at Sirsa, Hisar, Bhiwani, Narnaul and Rewari was

2.04 mm, 1.00 mm, 2.68 mm, 0.22 mm and 7.20 mm, respectively. Similarly, in the districts lying in eastern Haryana, the moving average keeps on oscillating around the mean in a similar fashion as the districts lying in western Haryana, but the magnitude of variations is a bit higher than the ones present in western Haryana. Overall the monsoon rainfall in all these districts also showed a consistently decreasing trend ranging from 6.2 to 17.8 mm per year at different locations. The observed rate of decrease in rainfall per year at Sonipat, Karnal, Kurukshetra, Ambala and Yamunanagar was 6.19 mm, 7.97 mm, 13.66 mm, 17.86 mm and 8.99 mm, respectively. The trend line for overall Haryana state also depicts a decreasing trend of rainfall at the rate of 5.25 mm per year during the entire period of investigation. Recently Kulkarni *et al.* (2020) [6] also reported general decreasing trend in ISMR at different stations in India.

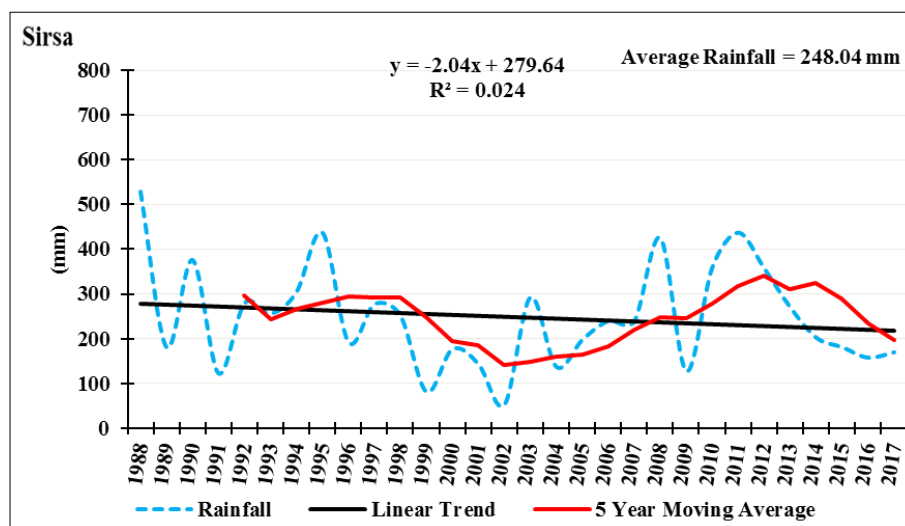


Fig 2: Five year moving average and linear trend of monsoon season rainfall at Sirsa (1988-2017)

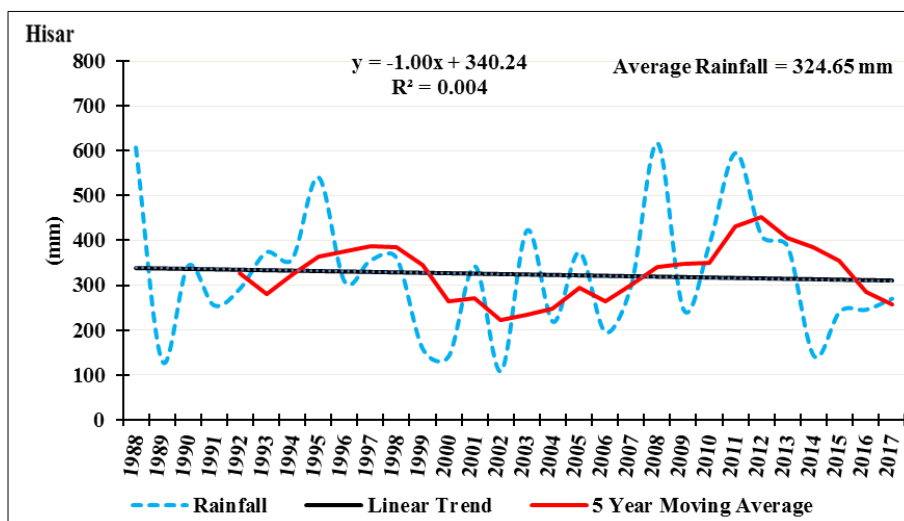


Fig 3: Five year moving average and linear trend of monsoon season rainfall at Hisar (1988-2017)

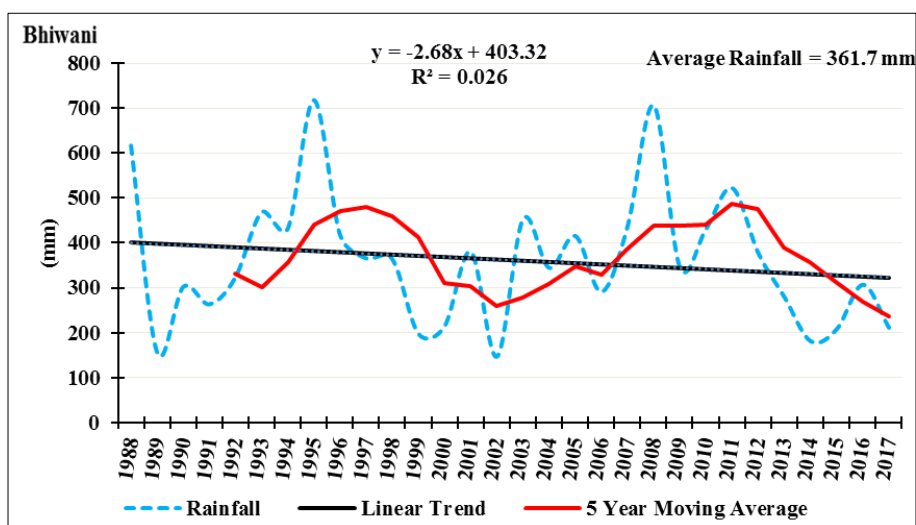


Fig 4: Five year moving average and linear trend of monsoon season rainfall at Bhiwani (1988-2017)

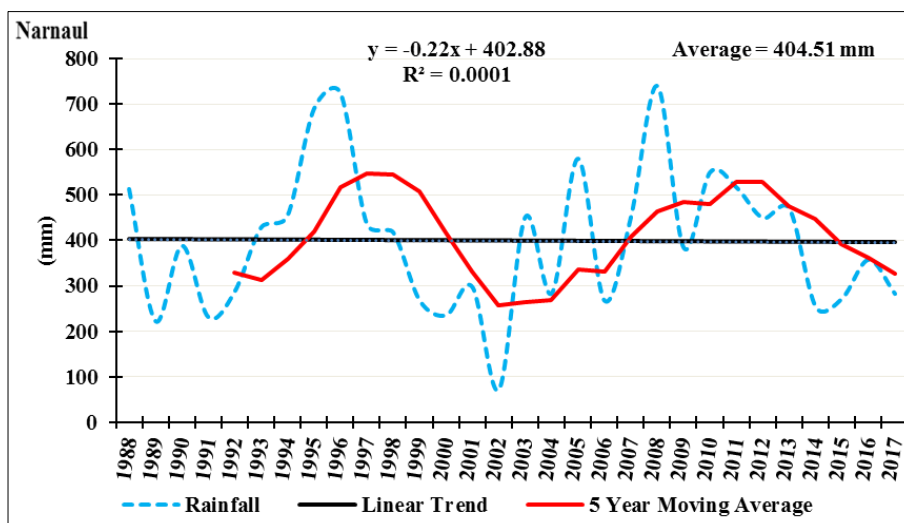


Fig 5: Five year moving average and linear trend of monsoon season rainfall at Narnaul (1988-2017)

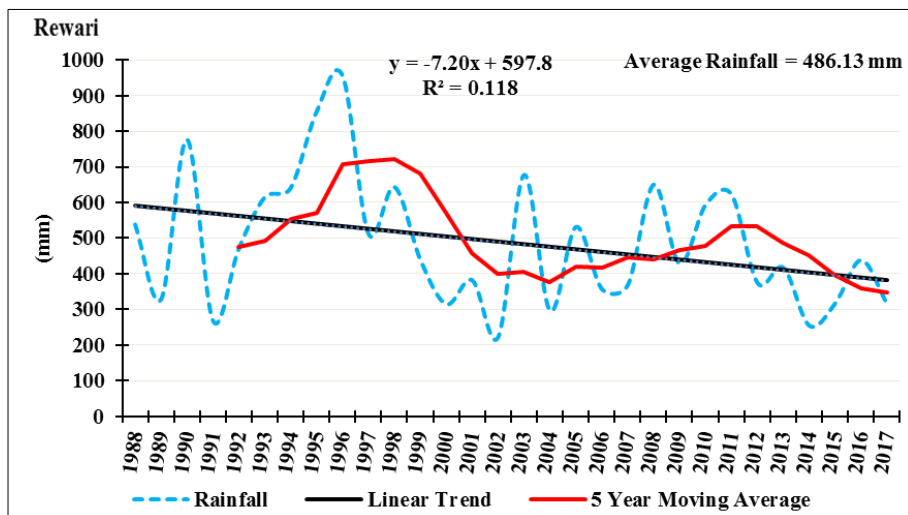


Fig 6: Five year moving average and linear trend of monsoon season rainfall at Rewari (1988-2017)

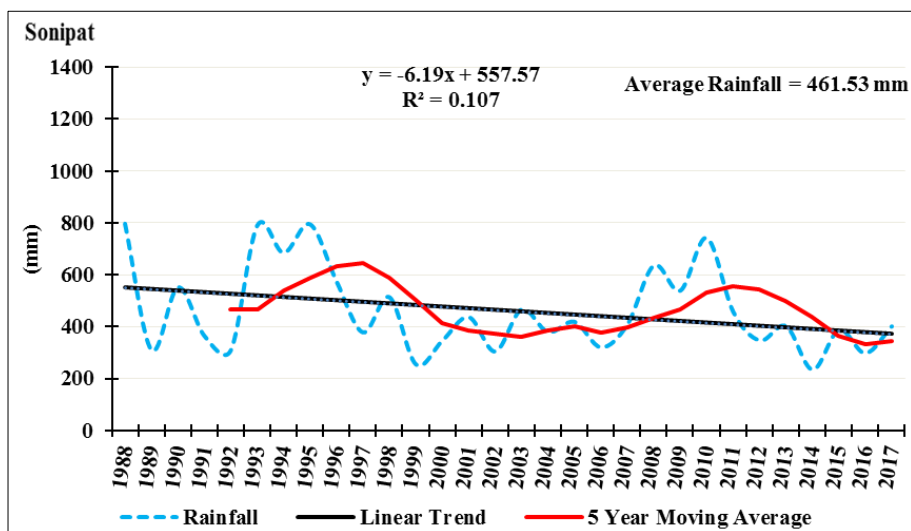


Fig 7: Five year moving average and linear trend of monsoon season rainfall at Sonipat (1988-2017)

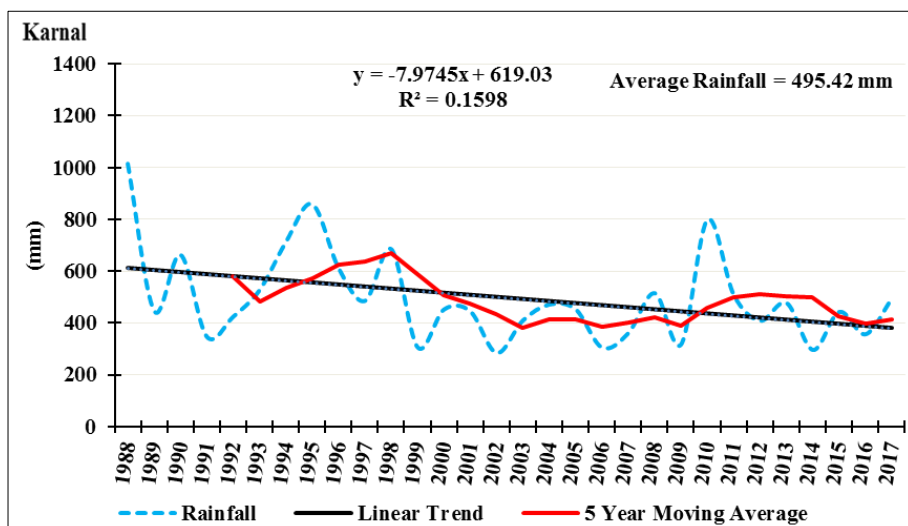


Fig 8: Five year moving average and linear trend of monsoon season rainfall at Karnal (1988-2017)

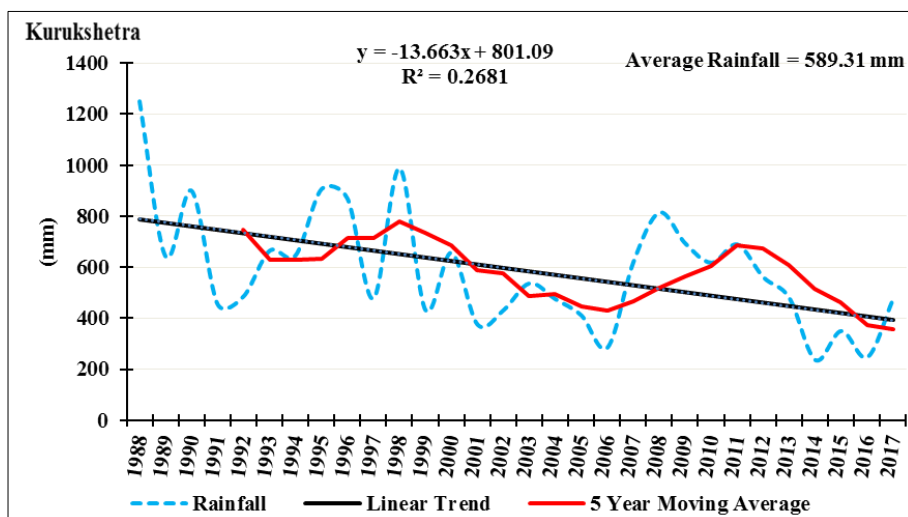


Fig 9: Five year moving average and linear trend of monsoon season rainfall at Kurukshetra (1988-2017)

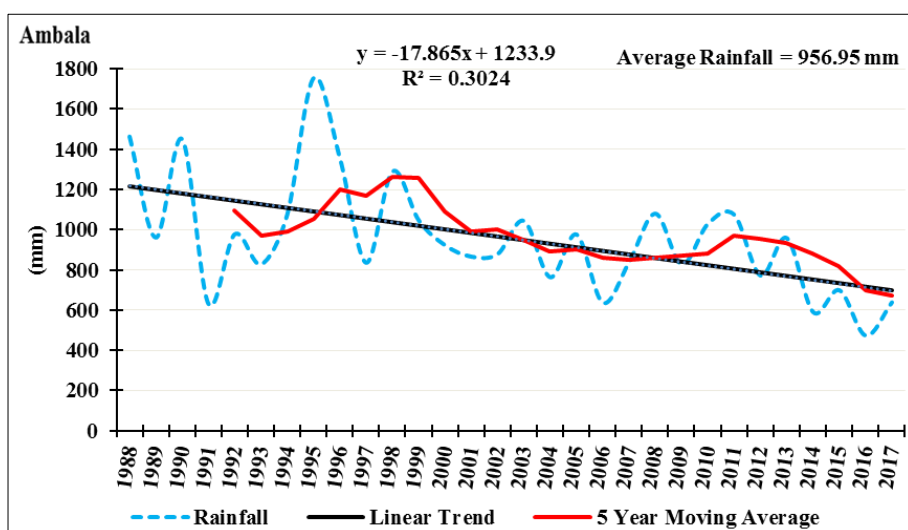


Fig 10: Five year moving average and linear trend of monsoon season rainfall at Ambala (1988-2017)

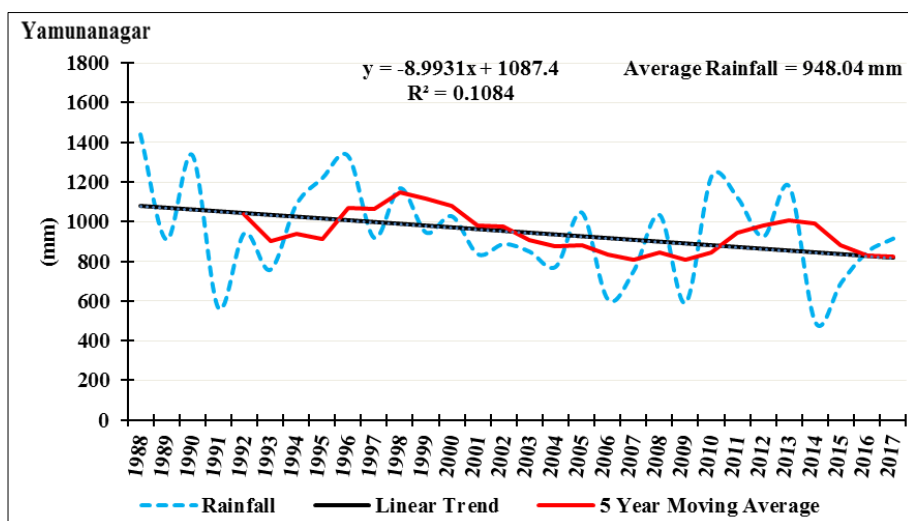


Fig 11: Five year moving average and linear trend of monsoon season rainfall at Yamunanagar (1988-2017)

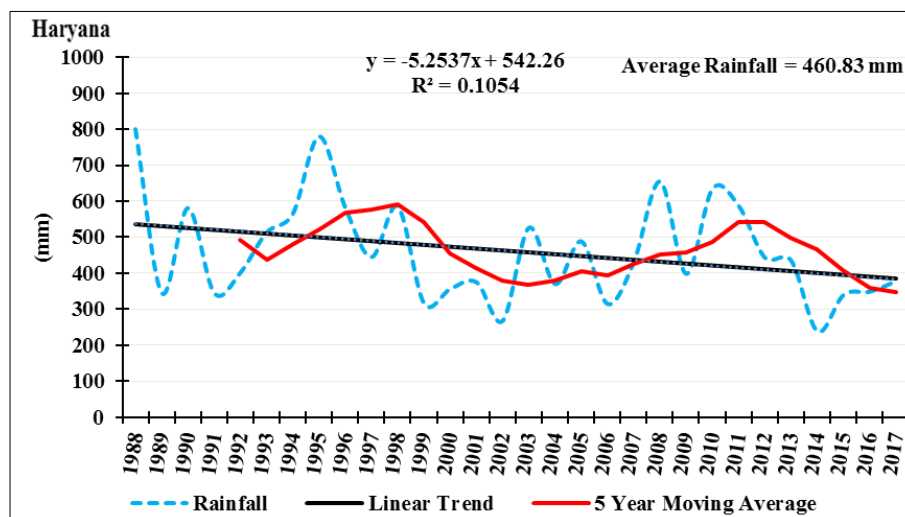


Fig 12: Five year moving average and linear trend of monsoon season rainfall at Haryana (1988-2017)

4. Conclusion

The study provide a very clear picture that the mean monsoon rainfall in the state ranged between 248.04 mm at Sirsa and 956.94 mm at Ambala. All locations showed a general decreasing trend in the rainfall behaviour in recent times. The variability of rainfall was higher for the districts lying in western Haryana as compared to the ones lying in eastern Haryana. Such information and datasets are crucial for agricultural and hydrological planning as well as disaster management at regional level.

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