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Study of long period weekly, monthly, seasonal and annual rainfall patterns at Hisar, Haryana

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ABSTRACT

The daily rainfall data for the period of 39 years (1980-2018) were collected from the National Data Center (NDC), India Meteorological Department (IMD), Pune, India for Hisar (Haryana) situated in semi-arid zone of North India. Every year, the region faces adverse effects of moisture deficiency. Generally, potential evapotranspiration requirements exceed the rainfall during eight months in a year except the monsoon season (June-September). The data were processed and analyzed to establish the long term averages of rainfall and variability on weekly, monthly, seasonal and annual basis. Different descriptive statistics techniques like mean, standard deviation (SD) and coefficient of variation (CV) were carried out. During the study period, the rainfall data showed that the annual daily rainfall received ranged between 257.5 mm (minimum) in 1997 to 691.6 mm (maximum) in 1988 indicating a very large range of fluctuation. The normal annual rainfall at Hisar was 411.1 mm with SD of 114.8 and CV of 27.9 %. The normal annual rainy day and crop day was 28 and 20.2 days with SD of 5 and 4.4 and CV of 17.8 and 20.2 %. July received maximum normal rainfall of 109.5 mm followed by August (90.2 mm). The stable rainfall period was of 16 weeks, which spread over 24th to 39th standard meteorological weeks (SMW). During South West (SW) monsoon season (June to September), seasonal normal rainfall was 275 mm which contributed 75 per cent to the total annual normal rainfall with a coefficient of variation of 44.4 per cent.

Key words: Characteristics of rainfall, Rainy day, Crop rainy day, rainy season, Coefficient of variance, Standard deviation

1. Introduction

While the subject of climate change is so vast, changing pattern of rainfall is at least one topic that deserves urgent and systematic attention, as it alter the availability of water and food production. The rainfall distribution on weekly basis is helpful in crop planning and by identifying the normal and excess amount of rainfall (Ray *et. al.*, 1980). The Indian summer monsoon rainfall plays an important role in economic growth, disaster management and watershed planning of the country. Weak and deficient monsoon may lead to crop failure, drought conditions and famine. So, it is important to monitor closely amount of rainfall received and variation of rainfall on weekly, monthly, seasonal and annual time scale. There were extensive researches on analysis of rainfall on monthly, seasonal and annual basis (Pramanik and Jagannathan, 1954; Parthasarathy, 1984; Mooley and Parthasarathy, 1983, 1984). In this region, information on rainfall and its variability on weekly, monthly, seasonal and annual basis is useful to design rainwater harvesting systems for field operations and overall in crop planning (Sharma et al, 1979). Crop production can be improved by the knowledge of the temporal and spatial variability of rainfall. Weekly rainfall data is useful to know (i) start of season (ii) end of season (iii) length of the rainy season. Victor et al. (1991) analyzed rainfall data of 21 districts of Andhra Pradesh on weekly basis for contingency crop plan. Rainwater saving cultivation practices and better management of surface water resources improve the food security of the country. So, scientist and researchers pay their utmost attention to optimize the usage of rainfall for improvement in agricultural activities. With the effect of climate change, crops should be protected against shortages of water. Therefore, study on long term average rainfall data and variability is vital. Agriculture production practices are usually associated with the annual precipitation cycle. Even if mean of annual or seasonal rainfall remains normal, an ill-timed variability of the monsoon rainfall can cause harmful effects on agriculture productivity. The analytical study of the spatial and temporal rainfall variations on micro scale is very important due to its socio-economic significance (Webster, 1998). The analysis of temporal shifts of rainfall on weekly and monthly basis will help to understand the rainfall variations during monsoon season. Changes in precipitation pattern would also have huge impact on agricultural ecosystem especially of semi-arid region. Hisar is located in semi-arid zone of North India. It is representative of the western Agro-climatic zone of Haryana which is also termed as Hot Arid Ecological Regions of Haryana. Summers are very hot and winters are fairly cold, receiving mean annual rainfall of about 470 mm, which is typical of arid regions. This amount of precipitation is just adequate to cover 15-20% of annual potential evapotranspiration (PET) demand which leads to large deficit of water throughout the year. The ecosystem represents hyperthermic soil temperature regimes and aridic soil moisture with an annual length of growing season of less than 90 days (Singh *et al.*, 2010).

2. Data Methodology

Rainfall

The daily rainfall data for a 39 year period (1980-2018) were obtained from the IMD, Pune for Hisar (Haryana) situated in semi-arid zone of north India. Hisar station is located at 29º 10' N latitude, 75º 46' E longitude and altitude of 215.2 m above MSL.

Statistical technique

The magnitude of temporal variability of rainfall was determined using various descriptive statistical techniques viz., standard deviation (SD) and coefficient of Variation (CV). The data were processed to analyze the amount of rainfall received and to study rainfall variability on weekly, monthly, seasonal and annual basis. The whole year was classified into four seasons as per the IMD classification viz., winter (January, February), pre-monsoon (March, April and May), monsoon (June, July, August and September) and post monsoon season (October, November and December). The values of rainfall are taken in millimetres to enable comparison with global details. Rainy days were considered as days with 2.5 mm or more rainfall and crop rainy days were considered as days with mm or more rainfall. In rainfall analysis on weekly basis, a year was divided into 52 standard meteorological weeks.

3. Results and Discussion

Characteristics of long period rainfall under semi-arid condition

Annual Normal Rainfall (mm) features

Annual wise Normal and Annual Rainfall (in mm) and rainy days are shown in Fig. 1. Where, the normal annual rainfall in Hisar, Haryana is 411.1 mm (ranges from 257.5 mm (1999) to 691.6 mm (1988)) mm spread over in 62 normal rainy days with standard deviation (SD) of 114.8 mm and coefficient of variation (CV) of 27.9 %. The descriptive statistical techniques viz., mean, standard deviation, coefficient of variation, maximum and minimum values of annual, and monthly rainfall are presented in table 2. The normal annual rainy days were 28.0 days with standard deviation of 5.0 and coefficient of deviation of 17.8 %. The normal annual crop rainy days were 20.2 days with standard deviation of 4.4 and coefficient of deviation of 21.6 % respectively. The lowest and highest annual rainy days were 19 (1999) and 38 days (2011). Lowest and highest annual crop rainy days were 13(1984, 85, 99, 2009) and 30 days (1998), respectively.

Monthly Normal Rainfall (mm) features

Analysis has shown that the highest normal monthly rainfall was received during July (109.5 mm) followed by August (90.2 mm) and September (64.1 mm) as shown in Table 2. July month received highest normal monthly rainfall of 109.5 mm in the study area with standard deviation of 65.5 and CV of 59.8 %. And November month received lowest normal monthly rainfall of 2.6 mm with standard deviation of 9.7 and CV of 369.6 %. Coefficient of Variation indicated that monthly rainfall was highly fluctuating in the data set. Coefficient of variation was highest in the month of October and November. July month also received highest rainy days (7) with SD of 2.9 and CV of 42.3 % and crop rainy days of 5 days respectively.

Seasonal Normal Rainfall (mm) features

During south west (SW) monsoon season (June to September), seasonal normal rainfall was 275 mm which contributed 75 per cent to the total annual normal rainfall with a coefficient of variation 44.4 per cent (Table 1).The number of rainy days in SW monsoon season were 16.5 days which contributed 65 per cent to the total annual normal rainy days. The mean rainfall during north-east (NE) monsoon season (October to December) was 14.9 mm and it accounts for 4 per cent of the annual normal rainfall with standard deviation of 25.3 mm and coefficient of variation of 169.6 percent. During summer season (March to May), normal rainfall was 53.5 mm which contributes 15 percent of annual rainfall and winter (Jan-Feb) normal rainfall was 23.8 mm which accounts 6 per cent of annual normal rainfall (Table 2). Though south-west monsoon was the major rain producing season over the country, other seasons also had significant contribution in some specific areas.

Weekly Normal Rainfall (mm) features

The standard meteorological week (SMW) from 1st to 23th SMW and 40th to 52th SMW received lowest rainfall amount (Figure 2). The normal weekly rainfall during 24th to 39rd SMW varied from 10.5 mm (39th SMW) to 29.0 mm (29th SMW) as shown in Table 3. The highest weekly normal rainfall appeared during 29th SMW with rainfall of 29.0 mm and second highest peak during 31th SMW with rainfall of 27.0 mm. In this period, coefficient of variation varied from 119.5 % (28th SMW) to 356.8 % (39th SMW). 27th to 31rd SMW was considered as an assured rainfall period since normal weekly rainfall is greater than 20 mm. The maximum normal weekly rainy days (2 days) appeared during 27th to 29th SMW.

Decadal analysis of rainfall

Decadal rainfall features at the Hisar station during four decades viz., 1980-1989, 1990- 1999, 2001-2010 and 2011-2018 (Table 4). In Hisar station, mean monthly rainfall was increasing from normal in 7 months in 1980-89, 5 months in 1990-99, 5 months in 2000-09 and 4 months in 2010-2018. Maximum departure was seen in June (8.8 mm) followed by March (4.6 mm), April (2.8 mm) and August (1.3 mm) in the latest decades (2010-2018). Rainfall in the two months of active monsoon period had decreased from mean monthly rainfall from normal (departure was -24.6 mm for July and -3.9 mm for September). CV was highest for October (156.0 %) and minimum for July (44.3 %) in latest decades. Variability of rainfall (CV) in the months of January, March, April, June, July and September to December (9 months) in the latest decades had decreased as compared to normal CV of these months. The CV of rest of the months viz. February, May and August had increased. Annual mean rainfall was increasing from 1980-1989 to 1990-1999 and then it was decreasing in 2000-09 and again increased in latest decades. Highest annual mean rainfall was during 1990-1999 decade with 439.0 mm, while the lowest (388.8 mm) was during 2010-2018. January, April, November and December months had their highest rainfall during the decade of 1980-1989 and July -October months had their highest rainfall during the decade of 1990-99. A February and May month had their highest rainfall during the decade of 2000-09. March & June months had their highest rainfall during the decade of 2010-18. Since four decades, CV of monthly rainfall was showing a mixed trend (Table: 4).

4. Conclusion

The results were revealed that the normal and annual rainfall received ranged between 257.5 mm i.e. lowest amount to 691.6 mm (highest amount of rainfall) indicating a very large range of fluctuation analyzed in the region during the study period. The normal annual rainfall at Hisar was 411.1 mm with SD of 114.8 and Coefficient of variation of 27.9 %. The normal annual rainy day and crop day were 28 and 20.2 days with Standard deviation 5 & 4.4, CV% of 17.8 and 20.2. July month were received highest amount of normal rainfall of 109.5 mm followed by August (90.2 mm). About 75% of annual rainfall was received from the Southwest Monsoon season. The pre-monsoon, post monsoon and winter season rainfall contributed 15, 14.9 and 6 % rainfall to the annual rainfall respectively. The rainfall amount during the rainy season has evaluated very highly variable. The quantified and noticeable period of an average duration of rainy season was from 24th to 39th SMW. The highest weekly normal rainfall appeared was found during 29th SMW with rainfall of 29.0 mm and second highest peak during 31th SMW with rainfall of 27.0 mm that found under the course of study.

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Figures

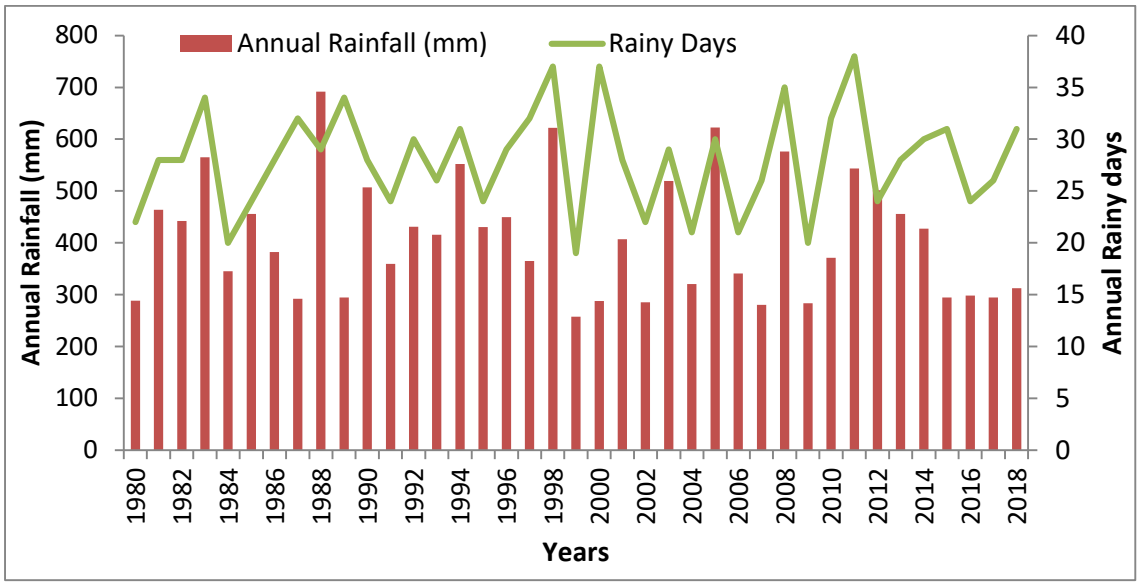

Fig. 1: Year wise Normal and Annual Rainfall (in mm) and rainy days

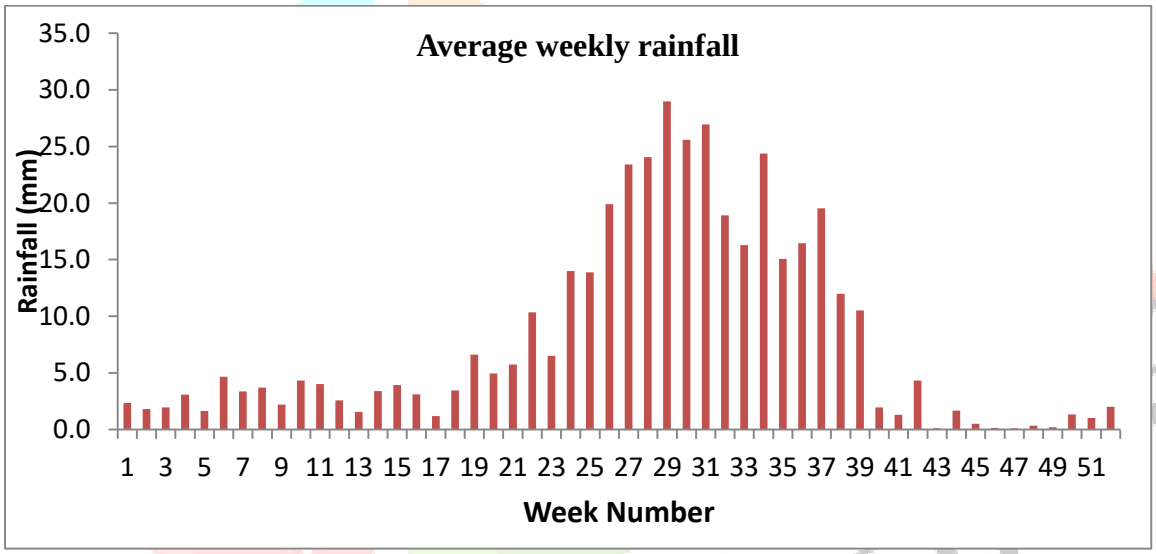

Fig. 2: Average weekly rainfall of Hisar during the period 1980-2018

Tables

Table 1: Characteristics of seasonal and weekly rainfall (in mm) and rainy days

Season	Particulars	Mean	SD	CV(%)	Highest (mm)	Lowest (mm)
Winter (Jan-Feb)	Rainfall (mm)	23.8	16.5	69.5	78.7 (2005)	0.0
	Rainy Days	2.5	1.5	58.5	6 (2005)	0.0
Pre Monsoon (Mar- May)	Rainfall (mm)	53.5	39.7	74.3	152.1(1982)	0.0
	Rainy Days	4.9	3.2	64.7	11(2014)	0.0
SW Monsoon (Jun-Sept)	Rainfall (mm)	275	122	44.4	665.6(1988)	94.3
	Rainy Days	16.5	4.7	28.4	28(2010)	9.0
NE Monsoon (Oct- Dec)	Rainfall (mm)	14.9	25.3	169.6	144.5(1998)	0.0
	Rainy Days	1.3	1.3	96.3	5 (2018)	0.0
Weekly	Rainfall (mm)	7.9	8.5	107.5	29	0.1
	Rainy Days	0.5	0.5	89.5	2	0

Table 2: Summary of statistics for normal monthly and annual rainfall (mm), rainy days and crop rainy days (day).

Months	Parameters	Mean	SD	CV (%)	Maximum	Minimum
January	Rainfall (mm)	9.8	10.2	103.9	34.5(1994)	0
	Rainy days	1	1.1	94.4	3	0
	Crop rainy days	1	0.7	121.3	2	0
February	Rainfall (mm)	14	15	107.1	56.5(2005)	0
	Rainy days	1	1.4	100.3	4	0
	Crop rainy days	1	1.2	127.8	4	0
March	Rainfall (mm)	13.3	15.6	117	56.5(2005)	0
	Rainy days	1	1.6	113.5	6	0
	Crop rainy days	1	1.3	146.9	4	0
April	Rainfall (mm)	12.8	20.5	160	108.4(2002)	0
	Rainy days	1	1.5	126.5	6	0
	Crop rainy days	1	1.1	147.1	5	0
May	Rainfall (mm)	27.4	26.5	96.8	107.0(1983)	0
	Rainy days	2	1.8	80.4	7	0
	Crop rainy days	1	1.4	96.2	5	0
June	Rainfall (mm)	55	32.7	59.3	140.6(2017)	5.6 (1984)
	Rainy days	4	1.7	49.3	7	1
	Crop rainy days	3	1.7	60.8	7	0
July	Rainfall (mm)	109.5	65.5	59.8	279.5(2003)	0 (2004)
	Rainy days	7	2.9	42.3	15	0
	Crop rainy days	5	2.7	49.6	12	0
August	Rainfall (mm)	90.2	65.7	72.8	282.5(2012)	4.9 (2006)
	Rainy days	6	3.1	56.2	15	1
	Crop rainy days	4	2.7	65.1	12	0
September	Rainfall (mm)	64.1	63.3	98.7	313.6(1988)	0(1980,81)
	Rainy days	3	2.5	77.3	11	0
	Crop rainy days	3	2	77.9	8	0
October	Rainfall (mm)	7.7	23.2	299.6	139.5(1998)	0

	Rainy days	1	0.8	160.5	3	0
	Crop rainy days	0	0.7	207	3	0
November	**Rainfall (mm)**	2.6	9.7	369.6	60.7(1981)	0
	Rainy days	0	0.6	231.9	3	0
	Crop rainy days	0	0.5	350.9	3	0
December	**Rainfall (mm)**	4.6	6.2	135.9	29.3(1980)	0
	Rainy days	1	0.8	140.3	3	0
	Crop rainy days	0	0.4	172.5	1	0
Annual	**Rainfall (mm)**	411.1	114.8	27.9	691.6(1988)	257.5
	Rainy Days	28	5	17.8	38(2011)	19.0
	Crop Rainy Days	20.2	4.4	21.6	30(1998)	13.0

Table 3: Long term average weekly rainfall amount and rainy days during S.W. monsoon period

SMWs	Date under SMWs	Rainfall (mm)	Rainy days (day)
1 week	4 Jun-10 Jun	6.5	1
2 week	11 Jun-17 Jun	14.0	1
3 week	18 Jun-24Jun	13.9	1
4 week	25 Jun-1 Jul	19.9	1
5 week	2 Jul-8 Jul	23.4	1
6 week	9 Jul-15 Jul	24.1	2
7 week	16 Jul-22 Jul	29.0	2
8 week	23 Jul-29 Jul	25.6	2
9 week	30 Jul-5 Aug	27.0	1
10 week	6 Aug-12 Aug	18.9	1
11 week	13 Aug-19 Aug	16.3	1
12 week	20 Aug-26 Aug	24.4	1
13 week	27 Aug-2 Sep	15.1	1
14 week	3 Sep-9 Sep	16.5	1
15 week	10 Sep-16 Sep	19.6	1
16 week	17Sep-23 Sep	12.0	1
17 week	24 Sep-30 Sep	10.5	1

Table 4: Decadal analysis of Rainfall: Hisar (% departure from normal)

Months	Decadal mean				Decadal SD				Decadal CV			
	1980-89	1990-99	2000-09	2010-18	1980-89	1990-99	2000-09	2010-18	1980-89	1990-99	2000-09	2010-18
Jan	4.0	-0.4	-1.9	-1.6	2.1	2.4	-2.6	-2.8	-14.4	-7.4	-7.4	-13.8
Feb	-5.1	2.7	5.6	-3.7	-7.1	0.4	5.3	-2	-18.2	-3.3	-3.3	18.2
Mar	0.6	-3.4	-1.4	4.6	-3.6	-2.4	3.4	3	-31.1	42.3	42.4	-13.5
Apr	5.4	-3.6	-4.4	2.8	15.2	-9	-12.5	-4.8	36	-64.8	-64.8	-59.9
May	-1.9	-11.7	16.6	-3.2	-1.7	-12.2	3.8	2.8	0.5	-27.9	-27.9	24.6
Jun	-8.6	-5.7	6.7	8.8	4	-7.9	3.7	0.4	19.8	-0.3	-0.3	-7.3
Jul	8.3	18.3	-4.5	-24.6	-16.8	13.2	19.4	-27.9	-18.5	21.1	21.1	-15.5
Aug	8.3	24.3	-33.6	1.3	-4.5	0.9	-19.6	16.2	-10.7	8.6	8.6	16.7
Sep	-4.6	5.6	2.7	-3.9	30.8	-5.9	-10.4	-17.2	59.3	-19.5	-19.5	-22.1
Oct	-2.0	6.6	-2.7	-1.9	-15.3	20.8	-11.9	-14.2	-160.6	-74.7	-74.7	-144.6
Nov	4.3	-1.9	-2.0	-0.3	9.3	-8.1	-8.4	-7.2	-93.9	-158.8	-158.8	-258.2
Dec	2.4	-2.5	0.3	-0.4	2.5	-2.5	0.6	-2.5	-11.9	2.5	2.5	-47.5