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Rainfall probability for Haryana, Chandigarh and Delhi sub division

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ABSTRACT

An attempt has been made to understand the performance of monthly rainfall for June, July, August and September when the seasonal rainfall is reported as excess, deficient or normal. To know the dependence of seasonal rainfall on monthly rainfall, the probabilities of occurrence of excess, deficient and normal monsoon when monthly rainfall was reported to be excess or deficient, are worked out using historical data series of 30 years (1970-99) of monthly and seasonal rainfall of meteorological sub-division (Haryana, Chandigarh and Delhi). All locations received excess or normal rainfall in monsoon season when individual month received excess rainfall in the entire sub-division. From the probability analysis, it is seen that there is a rare possibility of occurrence of seasonal rainfall to be excess/deficient when the monthly rainfall of any month is deficient/excess in the entire sub-division.

Key words: Monsoon rainfall, spatial and temporal, excess, normal, deficit, probability

To ensure sustainable agriculture in a region, knowledge of the local water resources is vital. Planning is especially critical in monsoon regions which experience distinct wet and dry seasons. Advance information on availability of monsoon rainfall in the region will be extremely valuable for sustainable development in the region. Summer monsoon rainfall and its vagaries have attracted the attention of meteorological communities (Pramanik and Jagannathan, 1953) of the tropical countries for a long time. Parthasarathy *et al* (1984, 1987) observed large number of droughts/floods in Saurastra and Kutch, Punjab, west Rajasthan and a lower frequency along the west coast and northeast India. Raman (1990) suggested probabilistic rainfall analysis based on past data at different phases of the monsoon season. De and Biswas (1994) statistically investigated sub-division wise rainfall probabilities upto middle of monsoon season and its behaviour in the later stage of monsoon period. Subramanian (1994) also examined the possibility of various meteorological sub-divisions to recover any June+July rainfall deficiency during the later half of the southwest monsoon period. Karmakar and Khatun (1995) studied the variability and probabilistic estimate of rainfall extremes over Bangladesh during

Table 1: Selected locations with their code, coordinates and period of data series used

S.No.	Locations	Code	Latitude °N	Longitude °E	Altitude m a.m.s.l	Data series
1.	Sirsa	SRS	29°32'	75°27'	218	1970-99
2.	Hisar	HSR	29°10'	75°46'	215	1970-99
3.	Bhiwani	BHN	28°48'	76°08'	227	1970-99
4.	Narnaul	NRL	28°03'	76°06'	221	1970-99
5.	Rohtak	RTK	28°54'	76°35'	226	1970-99
6.	Gurgaon	GGN	28°28'	77°02'	230	1970-99
7.	Delhi	DEL	28°35'	77°10'	228	1970-99
8.	Karnal	KNL	29°43'	76°58'	245	1970-99
9.	Ambala	AMB	30°22'	76°47'	247	1970-99
10.	Chandigarh	CHD	30°40'	76°45'	261	1970-99

Table 2: Relative frequency (%) of different rainfall categories during monsoon season at different locations

Sr. No.	Locations	Excess	Normal	Deficient	Scanty
1.	SRS	33	37	23	7
2.	HSR	30	43	20	7
3.	BHN	43	20	30	6
4.	NRL	27	37	33	3
5.	RTK	20	60	17	3
6.	GGN	33	33	30	7
7.	DEL	27	50	23	0
8.	KNL	30	37	27	6
9.	AMB	30	43	20	7
10.	CHD	27	37	33	3
11.	Sub Div	23	47	27	3
12.	NW India	30	43	23	4
13.	All India	3	94	3	0

the SW monsoon period. Kothawale and Munot (1998) concluded rare possibility of occurrence of seasonal rainfall as excess/ deficient when the monthly rainfall of any month was deficient/excess. In this paper, an attempt has been made to study the probability of occurrence of seasonal rainfall in a meteorological sub-division to be excess, deficient and normal, whenever the rainfall in June, July and August was in one of three categories (excess, deficient, normal).

MATERIAL AND METHODS

The sub-division consisting Haryana, Chandigarh and Delhi in India is situated in sub-tropics and extends from 27°38' to 30°55' N latitude and 74°27' to 77°36'E longitude and altitude ranged between 215 to 261 m asml. The region is land locked from all sides and mostly forms a part of the Indo-Gangetic plains. The various locations for the investigation along with their codes, coordinates and period of data used are presented in Table 1. Most of the rainfall (75 to 80%) is received in SW monsoon season from June to September. Annual rainfall ranges from 300 to 1200 mm. The sub-division falls under arid, semi-arid and dry sub-humid climates as per Thornthwaite's classification.

The mean monthly monsoon rainfall data for the period 1970-99 (30 years) at selected locations in the region were collected from Department of Agril Meteorology, CCS Haryana Agricultural University, Hisar, India and Meteorological Center, Chandigarh, India Meteorological Department. The statistical methods/ techniques used included the mean, standard deviation, standard error, coefficient of variation, trend analysis (moving average), comparative analysis (deviation from normal value). The rainfall in monsoon season was categorized as

excess : rainfall 120 per cent or more,

normal : rainfall between 81 and 119 per cent,

deficient : rainfall between 41 and 80 per cent and

scanty : rainfall < 40 per cent of normal rainfall.

The rainfall categories used were classified as under:

i) High – when probability >70 per cent

ii) Moderate – when probability ranged between 70 and 50 per cent

iii) Low – when probability < 50 per cent

RESULTS AND DISCUSSION

Probability of rainfall categories

The probability (%) of occurrence of rainfall in different categories during monsoon season based upon relative frequencies at different locations in the sub-division (Table 2) show that the probability of excess and normal rainfall was more than 20 per cent and that of deficient rainfall was more than 17 per cent. The scanty rainfall probability ranged between 3 and 7 per cent except at Delhi over the period under study. The excess rainfall probability was highest

at Bhiwani (43%) and lowest at Rohtak (20%). The deficient rainfall probability was maximum at Narnaul (33%) and minimum at Rohtak (17%). However, compared to these, the All India normal monsoon rainfall probability was 94 per cent with 3 per cent each of excess and deficient rainfall probability.

Seasonal rainfall probability when rainfall was in excess/deficit in an individual month

The per cent probability of seasonal rainfall being excess, normal or deficient when individual month in the monsoon season received excess rainfall, are presented in Table 3. Whenever June rainfall was in excess, Narnaul received excess seasonal rainfall. At Rohtak, in all such cases where July received excess rainfall, the seasonal rainfall was normal. Similarly, Ambala received normal and Chandigarh received excess monsoon seasonal rainfall in all the cases of excess rainfall in August month. At Hisar, the seasonal rainfall was in excess category corresponding to all cases of excess rainfall in September during the period of investigation. Similar results were reported by Kothawale and Munot (1998).

The per cent probability of seasonal rainfall when an individual month in the monsoon season recorded deficient rainfall are given in Table 4. Many of the locations in the sub-division experienced deficient or normal monsoon rainfall when June rainfall was deficient except at Sirsa where 25 per cent cases were observed in excess category in monsoon season as a whole. When July or August rainfall was deficient, Bhiwani recorded excess seasonal rainfall on 20 and 17 per cent occasions, respectively.

On All India basis, the monsoon seasonal rainfall was excess in 17 per cent cases whenever July received deficient rainfall, as also reported by Kothawale and Munot (1998).

Probability of rainfall in individual month based on excess/ deficit rainfall in another month

Sirsa, Hisar and Rohtak received normal rainfall in July month corresponding to all events of excess rainfall recorded in June. Delhi, Karnal and Ambala showed deficient rainfall in July in 20, 33 and 25 per cent events of excess June rainfall. At All India level deficient rainfall in July was observed in 20 per cent events of excess rainfall in June month. For the different locations, rainfall probability of each of the monsoon months were worked out on the basis of excess or deficit rainfall recorded in other individual months (Tables 5 and 6). Inferences for a few months for these probabilities are given below.

Narnaul, Ambala and country as a whole, experienced normal rainfall in August in all events of excess rainfall received in July (Table 5). Delhi and Chandigarh observed excess rainfall in August in only 20 and 25 per cent events of excess rainfall received in July.

Narnaul and Ambala experienced

Table 3: Probablity of seasonal rainfall (%) when individual month's rainfall was in excess at different locations

Category	June			July			August			September		
Locations	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.
SRS	50	50	0	20	80	0	33	67	0	33	67	0
HSR	0	100	0	33	67	0	20	80	0	100	0	0
BHN	60	40	0	40	60	0	67	33	0	17	83	0
NRL	100	0	0	50	50	0	50	50	0	33	67	0
RTK	0	100	0	0	100	0	33	67	0	50	50	0
GGN	67	33	0	25	75	0	75	25	0	75	25	0
DEL	40	60	0	40	60	0	60	40	0	33	67	0
KNL	33	67	0	20	80	0	50	50	0	25	75	0
AMB	25	75	0	67	33	0	0	100	0	50	50	0
CHD	25	75	0	50	50	0	100	0	0	50	50	0
Sub Div	33	67	0	33	67	0	67	33	0	57	43	0
NW India	20	80	0	40	60	0	40	60	0	40	60	0
All India	40	60	0	67	33	0	67	33	0	33	67	0

Table 4: Probability of seasonal rainfall (%) when individual month's rainfall was deficient at different locations

Category	June			July			August			September		
Locations	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.
SRS	25	50	25	0	25	75	0	50	50	0	50	50
HSR	0	40	60	0	0	100	0	67	33	0	62	38
BHN	0	67	33	20	20	60	17	33	50	0	62	38
NRL	0	71	29	0	67	33	0	33	67	0	78	22
RTK	0	80	20	0	50	50	0	33	67	0	0	100
GGN	0	0	100	0	67	33	0	33	67	0	40	60
DEL	0	75	25	0	100	0	0	60	40	0	67	33
KNL	0	67	33	0	75	25	0	71	29	0	50	50
AMB	0	100	0	0	50	50	0	40	60	0	75	25
CHD	0	67	33	0	60	40	0	43	57	0	20	80
Sub Div	0	50	50	0	67	33	0	57	33	0	57	43
NW India	0	25	75	0	0	100	0	60	40	0	25	75
All India	0	60	40	17	33	50	0	60	40	0	25	75

normal rainfall in August in all events of deficient rainfall in July (Table 5). Delhi observed excess and normal rainfall in August in 50 per cent events each when deficient rainfall was received in July month. Hisar and Narnaul experienced normal rainfall in September in all events of excess rainfall in July. However, locations Sirsa, Bhiwani, Rohtak and Delhi experienced either excess or normal rainfall in September in all events of excess rainfall in July.

Rohtak experienced normal rainfall in September in all events of deficient rainfall in July (Table 5). However, Bhiwani, Narnaul, Ambala, Chandigarh, entire sub-division and country as a whole, reported excess rainfall in September in 20, 33, 40, 20, 33 and 17 per cent events of deficient rainfall received in July, respectively.

Sirsa and Karnal received normal rainfall in September in all events of excess rainfall in August (Table 6). However, locations other than Bhiwani, Narnaul, Gurgaon and Ambala received either excess or normal rainfall in September month in all events of excess rainfall received in August.

Rohtak experienced normal rainfall in September month in all events of deficient rainfall in August. However, Gurgaon, Karnal, Ambala and country as a whole experienced excess rainfall in September in only 25, 14, 20 and 10 per cent events of deficient rainfall received in August (Table 6).

All locations in the entire sub-division received either excess or normal monsoon rainfall in all events of excess rainfall in first half of monsoon season (June+July). Rohtak experienced normal and north-west India observed excess monsoon rainfall in all events of excess rainfall in June+July (Table 6).

All locations in the entire sub-division received either excess or normal monsoon rainfall in all events of cumulative excess rainfall in second half (August+September) of the monsoon season (Table 6). Rohtak and Gurgaon experienced excess rainfall in all events and Karnal and Ambala recorded normal rainfall in monsoon season in 65 per cent events of cumulative excess rainfall received in August and September.

It may be concluded here that in event of excess rainfall received in individual month, many of the locations received either excess or normal rainfall during the ensuing months. In the event of deficient rainfall received in individual month, most of the locations received either deficient or normal rainfall during the ensuing months.

CONCLUSIONS

- Many of the locations in the sub-division experienced deficient or normal monsoon seasonal rainfall when June rainfall was deficient except at Sirsa where only 25 per cent cases recorded excess rainfall.
- Sirsa, Hisar and Rohtak received normal rainfall in July month corresponding to all events of excess rainfall recorded in June.
- Hisar and Narnaul experienced normal

Table 5: Probability (%) of rainfall in an individual month based on excess or deficit rainfall in another individual month

Category	Rainfall in August when excess in July			Rainfall in August when deficit in July			Rainfall in Sept when excess in July			Rainfall in Sept. when deficit in July		
Locations	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.
SRS	0	20	80	20	40	40	20	20	60	0	40	60
HSR	0	33	67	0	33	67	0	0	100	0	33	67
BHN	0	20	80	20	20	60	20	20	60	20	60	20
NRL	0	0	100	0	0	100	0	0	100	33	67	0
RTK	0	17	83	0	25	75	0	17	83	0	0	100
GGN	0	25	75	33	33	34	25	0	75	0	67	33
DEL	20	20	80	50	0	50	0	40	60	0	20	80
KNL	0	60	40	25	25	50	40	0	60	0	25	75
AMB	0	0	100	0	0	100	67	0	33	40	20	40
CHD	25	50	25	0	20	80	25	0	75	20	40	40
Sub Div	0	33	67	0	33	67	33	0	67	33	33	34
NW India	0	20	80	0	50	50	20	0	80	0	100	0
All India	0	0	100	17	33	50	33	0	67	17	33	50

Table 6: Probability (%) of rainfall in an individual month/season based on excess or deficit rainfall in another individual/two months

Category	Rainfall in Sept. when excess in Aug.			Rainfall in Sept. when deficit in Aug.			Seasonal rainfall when excess in Jun-July			Seasonal rainfall when excess in July+Aug		
Locations	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.	Exc.	Nor.	Def.
SRS	0	0	100	0	25	75	25	0	75	40	0	60
HSR	20	0	80	0	20	80	25	0	75	50	0	50
BHN	25	25	50	0	33	67	67	0	33	60	0	40
NRL	50	50	0	0	33	67	75	0	25	67	0	33
RTK	33	0	67	0	0	100	0	0	100	100	0	0
GGN	25	25	50	25	50	25	40	0	60	100	0	0
DEL	20	0	80	0	20	80	50	0	50	67	0	0
KNL	0	0	100	14	14	72	40	0	60	33	0	67
AMB	0	33	67	20	0	80	60	0	40	25	0	75
CHD	50	0	50	0	43	57	33	0	67	80	0	20
Sub Div	67	0	33	0	43	57	40	0	60	60	0	40
NW India	20	0	80	0	33	67	100	0	0	50	0	50
All India	67	0	33	10	20	70	67	0	33	50	0	50

rainfall in September in all events of excess rainfall in July.

- Bhiwani, Narnaul, Ambala, Chandigarh, entire sub-division and country as a whole reported excess rainfall in September in 20, 33, 40, 20, 33 and 17 per cent events of deficient rainfall received in July, respectively.
- Seasonal rainfall received at all the locations in entire sub-division was either excess or normal, for all events of excess rainfall in first half of monsoon season (June+July). There was no deficiency at sub-divisional level.
- All locations in the entire sub-division received either excess or normal monsoon seasonal rainfall in all events of cumulative (August+September) excess rainfall in second half of the monsoon season.

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