

# DOES ABSENCE OF TROPICAL DISTURBANCES CAUSE DEFICIENT RAINFALL IN NORTH INDIAN SUB-DIVISIONS DURING THE MONSOON MONTHS ?

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The distribution of rainfall over North Indian plains has been studied for those months of July and August which did not experience tropical disturbances (i.e., monsoon depressions/storms) during 1891-1970. From this study, the contribution of tropical disturbances during July and August months to the monthly normal rainfall of north Indian plains has been found to be of the order of 19 per cent and 14 per cent respectively. If individual sub-divisions in this region are considered separately, the percentage departures in some of the subdivisions are very much in defect. Generally the sub-divisions worst affected by the absence of tropical disturbances are (a) Orissa, Rajasthan West, Gujarat, Saurashtra and Kutch. It has been noticed that the rainfall is practically normal (i.e.,  $\pm 10$  per cent of the normal) in the sub-divisions located along the periphery of Himalayas from Bihar plains in the east to Punjab in the west while it is slightly deficient in the remaining sub-divisions during the absence of these disturbances.

## INTRODUCTION

In the present study an attempt has been made to study the extent of deficiency in rainfall caused by the absence of tropical disturbances (i.e., depressions/storms) over the plain areas of north India lying roughly north of Lat.  $20^{\circ}\text{N}$  during the two principal monsoon months of July and August when depressions/storms are quite active over this region.

The influence of tropical disturbances over the monsoon rainfall of India was studied by Raghavan (1967) using the rainfall data of those days which were free from depressions/storms during the two monsoon months of July and August during the period 1948-57. Similar studies have also been carried out by Cry (1967) and Carter (1970) for those areas in U.S.A. which are generally affected by tropical disturbances.

## DATA AND TECHNIQUE

*Data used*—From the IMD publications of storm track atlas and weather reports, the years when there were no depressions/storms affecting the Indian Sub-continent during the principal monsoon months of July and August were sorted out. It was observed that during the 80-year period there were hardly 11 occasions in the month of July and 7 occasions in the month of August when the Indian Sub-continent was not affected by tropical disturbances (i.e., depressions/storms). Table I gives a list of these occasions.

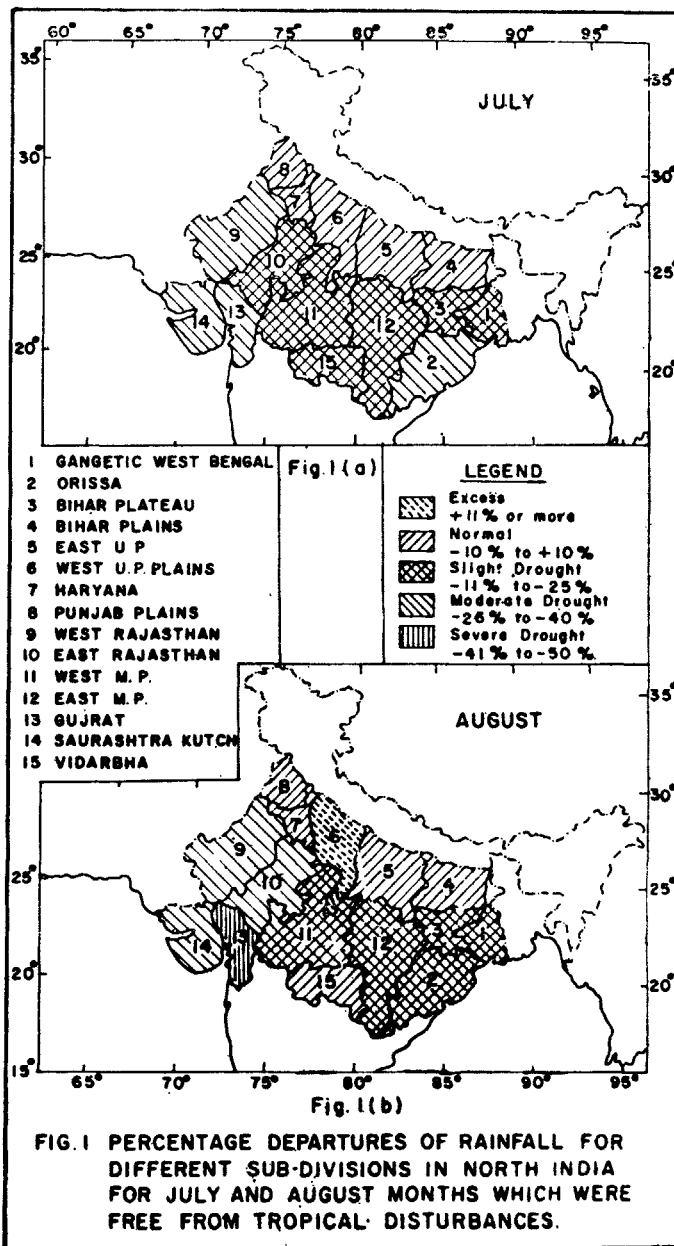
TABLE I  
*Years when the Indian Sub-continent did not experience  
 tropical disturbances (i.e., depressions /storms) in the months  
 of July and August (1891 to 1970)*

July	August
1901	1901
1907	1905
1908	1930
1911	1932
1915	1961
1916	1962
1924	1966
1931	—
1953	—
1955	—
1957	—

It is seen from Table I that excepting the year 1901 there were no other years during the 80-year period when the Indian Sub-continent was free from depressions/storms during both the principal monsoon months of July and August of the same year. It is also seen from Table I that there were two occasions in the past when monsoon depressions/storms did not occur in the July month of two successive years (i.e., 1907 and 1908, 1915 and 1916) while during the month of August there is one such instance only (i.e., 1961 and 1962). The other fact that emerges from a perusal of Table I is that in the three decades, viz., 1901-1910, 1911-1920 and 1951-1960, there were maximum number of occasions (i.e., 3 occasions in each decade) when tropical disturbances did not affect the Indian Sub-continent in the month of July while in the month of August, the worst decade was the 1961-1970 in which there were three occasions (i.e., 1961, 1962 and 1966) out of a total of seven occasions when no tropical disturbances affected the Indian Sub-continent.

*Technique used*—In the North Indian plains, roughly north of Lat. 20°N, there are at present 15 meteorological sub-divisions excluding Assam region, North Bengal, Himachal Pradesh and Kashmir (*vide* Fig. 1(a), 1(b)). The average rainfall for plain areas of each of these 15 sub-divisions was worked out for all those months of July and August which were free from tropical disturbances. The percentage departures of rainfall from the normal (i.e., 1950 Rainfall Normals, India Meteorological Dept. 1962) were then worked out for each sub-division for those months of July and August which did not experience tropical disturbances and these values are shown in Tables II(a) and II(b) for different years. The weighted average rainfall for these two months (i.e., July and August) was also worked out for the entire north Indian plain area which is comprised of the 15 sub-divisions, shown in Figs 1(a) and 1(b).

Percentage departures of rainfall for north Indian plains for those months of July and August free from tropical disturbances are shown in Table II(a) and Table II(b).



DISCUSSIONS AND RESULTS

*July rainfall over North Indian plains*—Out of eleven July months which did not experience tropical disturbances during the last 80 years, percentage departures of rainfall from the July normal were negative in all the years excepting 1908 and 1924. In these two months the departures were positive and were of the order of

TABLE II (a) *Percentage departures from normal for the month of July*

S. No.	Meteorological Sub-divisions of North Indian Plains	Percentage departures from normal for those July months in different years which were free from tropical disturbances												11-year Average Rainfall (cm)	Normal rainfall (cm)	Percentage departure from normal (%)
		1901	1907	1908	1911	1915	1916	1924	1931	1953	1955	1957				
1.	Gangetic W. Bengal	-15	-35	+17	-48	-29	-52	-2	+10	+11	+0	-7	27.5	31.8	-13	
2.	Orissa	-24	-45	-16	-55	-37	-32	-41	-35	-26	-37	-12	23.7	35.2	-33	
3.	Bihar Plateau	-29	-37	-12	-58	-25	-32	+19	+4	+22	+5	+17	31.6	35.8	-12	
4.	Bihar Plains	-23	-18	-38	-39	-3	+26	+57	+38	+42	+64	+6	34.3	31.1	+10	
5.	East U.P.	-29	-47	-19	-73	-8	-4	+70	-10	+55	+69	+12	30.7	30.2	+2	
6.	West U.P. Plains	-18	-23	+35	-77	-15	+26	+14	-13	+51	-15	+18	24.2	24.6	-2	
7.	Haryana	-11	-28	+38	-83	-55	-2	-34	+28	+58	-31	+33	14.4	15.6	-8	
8.	Punjab Plains	+5	-52	+23	-83	-63	+38	+17	+8	+33	-13	+27	16.1	17.0	-5	
9.	West Rajasthan	-17	-43	+136	-97	-75	-30	-8	-26	-21	-88	+18	7.3	9.9	-26	
10.	East Rajasthan	-26	-50	+75	-82	-69	-24	+12	-3	-34	-73	-5	18.3	24.3	-25	
11.	West M.P.	-21	-45	+13	-64	-39	-30	+8	-20	-10	-9	-36	26.9	35.0	-23	
12.	East M.P.	-14	-46	+9	-51	-11	-36	-11	-29	-1	-31	-1	34.3	42.9	-20	
13.	Gujarat	-29	-6	+39	-82	-67	-51	-13	+2	-93	-71	-27	25.5	40.0	-36	
14.	Saurashtra and Kutch	-47	+9	+39	-91	-49	-35	-35	-31	-37	-86	+11	14.0	20.6	-32	
15.	Vidarbha	-22	-20	-6	-48	-31	+0	-17	+7	-17	-25	-17	28.2	34.3	-18	
	Weighted rainfall over Plain areas of North India (cm)	23	18.9	33.9	10.5	19.7	23.0	31.1	26.1	28.3	23.3	27.7	(a)	Average weighted rainfall over the plains of north India based upon rainfall data of July months given in Table I = 24 cms		
	Percentage departures from normal (normal = 29.5 cm)		-22	-36	+15	-64	-33	-22	+2	-11	-4	-21	-6	(b) Normal rainfall for July = 29.5 cm.		
														(c) Percentage departures from normal = -19%		

TABLE II (b)  
Percentage departures from Normal for the month of August

S. No.	Meteorological Sub-divisions of North Indian Plains	Percentage departures from normal for those August months in different years which were free from tropical disturbances							7-year average rainfall (cm.)	Normal rainfall (cm.)	Percentage departure from normal (%)
		1901	1905	1930	1932	1961	1962	1966			
1.	Gangetic W. Bengal	-20	-17	-9	-16	-22	-33	-28	25.3	31.9	-21
2.	Orissa	-20	-24	-12	-29	-2	+2	-38	27.7	33.6	-18
3.	Bihar Plateau	+3	-11	-3	-16	+3	-26	-26	31.6	35.4	-11
4.	Bihar Plains	-2	+51	-22	-22	+3	+17	-7	32.3	31.4	+3
5.	East U.P.	+2	+0	-9	-5	+36	+32	-3	31.8	29.6	+7
6.	West U.P. Plains	+45	-61	.13	-23	+62	-15	+23	27.4	24.4	+12
7.	Haryana	+27	-78	-39	-15	+87	-19	+64	14.9	14.3	+4
8.	Punjab Plains	-3	-49	-55	0	+28	-23	+64	15.3	16.1	-5
9.	West Rajasthan	-45	-91	-60	+2	-20	-38	-16	6.7	11.0	-39
10.	East Rajasthan	-15	-84	-27	-15	-5	-25	-34	16.2	22.9	-29
11.	West M.P.	+44	-42	-29	-58	+23	-24	-29	24.7	29.5	-16
12.	East M.P.	+41	-31	-33	-32	+10	-28	-35	33.3	39.5	-16
13.	Gujarat	-11	-83	-29	-40	-22	-30	-69	14.3	24.1	-41
14.	Saurashtra and Kutch	-30	-84	-56	-63	+37	+21	-87	6.5	10.4	-37
15.	Vidarbha	+45	-32	-29	-35	+44	+1	-21	24.8	25.8	-4
Weighted rainfall over the Plain areas of North India (cm)		29.4	17.0	19.7	19.0	30.3	23.1	20.4	(a) Average weighted rainfall over the plains of north India based upon rainfall data of August months given in Table I = 22.7 cm.		
Percentage departures from normal (normal = 26.3 cm).		+12	-35	-25	-28	+15	-12	-22	(b) Normal rainfall for August = 26.3 cm.		
									(c) Percentage departure from normal = -14%		

+15 per cent and +2 per cent respectively. In the remaining July months the percentage departures were negative and ranged from —4 per cent to —64 per cent. The average weighted July rainfall over the entire North Indian plains based upon the individual rainfall averages of these eleven occasions was worked out and found to be 81 per cent of the normal rainfall. It is thus seen that on an average due to absence of monsoon depressions/storms, the average rainfall over the north Indian plains was in defect by about 19 per cent. In other words, if we consider the rainfall classification given by Krishna Rao (1953) in his paper on Madras rainfall, the north Indian plains as a whole on an average experienced slight drought conditions. However, if we consider individual July months given in Table II(a) the worst July month for the entire north Indian plains was that of 1911 when the percentage departure of rainfall was in defect by about 64 per cent of the normal and this region suffered disastrous drought conditions. Next in severity of deficient rainfall were the July months of 1907 and 1915 which experienced percentage departures of the order of —36 per cent and —33 per cent respectively i.e., the region suffered moderate drought conditions in these two years.

*Synoptic situations causing rainfall during July months in the absence of depressions/storms*—A study was also made of the attendant meteorological situations which caused rainfall in all those July months (*vide* Table I) which were free from tropical disturbances. It was seen that in such situations the north Indian plains generally experienced well distributed rainfall in association with the following meteorological situations :—

(i) The axis of the monsoon trough remaining practically in its normal position with both branches of monsoon being fairly active. If and when the axis of the trough shifted to the foot of the Himalayas from its normal position, there was a considerable decrease in rainfall over the plains of north India. Actually, the severe deficiencies in July rainfall of 1901, 1907, 1911, 1915 and 1916 were mainly caused by setting in of prolonged “breaks in monsoon” which in turn were caused by the shifting of the axis of the monsoon trough to the foot of the Himalayas.

(ii) Passage of low pressure areas from the Bay across the North Indian plains caused fairly good distribution of rainfall over this region. If these low pressure areas moved across North Indian plains one after another in quick succession, the rainfall received over some of the North Indian divisions was in excess of the monthly normal. This happened in 1908, 1924, 1931, 1953, 1955 and 1957.

In the July months of 1907, 1911, 1915 and 1916 no low pressure areas traversed the North Indian plains which resulted in causing serious deficiencies in rainfall over some of the north Indian divisions. In July, 1911 the percentage departures from the normal for some of the worst affected divisions in North India were as follows :—

<i>Division</i>	<i>Percentage departure from normal</i>
(a) West U.P. plains	—77%
(b) Haryana	—83%
(c) Punjab plains	—83%
(d) West Rajasthan	—97%

(e) East Rajasthan	—82%
(f) Gujarat	—82%
(g) Saurashtra and Kutch	—91%

Thus apart from the absence of tropical disturbances if no low pressure areas move across the northern half of the country and on the other hand there are prolonged breaks in monsoon, the drought situation over North India can become very acute.

*July rainfall over North Indian sub-divisions*—The average rainfall for the 15 North Indian sub-divisions was worked out for those July months which were free from tropical disturbances. From this statistics, percentage departures were worked out for each sub-division and these are plotted in Fig. 1(a). It is seen that in the absence of tropical disturbances in the month of the July, the areas, where slight drought conditions (i.e., percentage departures —11 per cent to —25 per cent) prevailed, were the following sub-divisions :—

(a) Gangetic West Bengal; (b) Bihar plateau; (c) East and West M.P.; (d) East Rajasthan; and (e) Vidarbha.

Moderate drought conditions (i.e., percentage departures —26 per cent to —40 per cent) prevailed over the following sub-divisions :

(a) Orissa; (b) West Rajasthan; (c) Gujarat; and (d) Saurashtra and Kutch.

The rainfall of the following sub-divisions was more or less normal (—10 per cent to +10 per cent).

(a) Bihar plains; (b) East U.P.; (c) West U.P. plains; (d) Haryana; and (e) Punjab plains.

Thus excepting the northern sub-divisions along the periphery of the Himalayas, the absence of tropical disturbances in the months of July does cause slight to moderate drought conditions over the remaining sub-divisions of northern India, the worst hit divisions being Orissa, West Rajasthan, Gujarat and Saurashtra.

*August rainfall over entire North Indian plains*—From Table II(b) it is seen that out of seven occasions during the last 80 years, percentage departures of rainfall from the normal over entire North Indian plains were negative in respect of 5 years. From this Table it is seen that in the months of August of 1901 and 1961 percentage departures were positive and ranged from +12 per cent to +15 per cent respectively and in the other years percentage departures were negative and ranged from —12 per cent to —35 per cent. The average weighted rainfall over the entire North Indian plains based upon the individual averages of these seven occasions worked out to be 86 per cent of the normal rainfall over this area. It is thus evident that on account of the absence of tropical disturbances, the average rainfall over the North Indian plains was in defect by about 14 per cent. In other words, on an average the North Indian plains as a whole experienced slight drought (i.e., —11 per cent to —25 per cent) conditions. Of the seven occasions mentioned in Table II(b) it is seen that the worst affected months of August were those of 1905, 1930, 1932 and 1966. Of these the August 1905 experienced the lowest percentage departure of —35 per cent. Next to it were the August months of 1932 and 1930 which experienced the percentage departures of —28 per cent and —25 per cent respectively.

*Synoptic situations causing rainfall during August months which are free from depressions/storms*—Synoptic situations responsible for causing rainfall during the seven August months mentioned in Table I were also examined. It was seen that on all these occasions rainfall was caused either by the passage of low pressure areas from the Bay or by the movement of upper air cyclonic circulations over different parts of North India. The main meteorological situation which caused deficiency of rainfall during these August months was the setting in of “break monsoon” conditions. This happened in years 1905, 1930, 1932, 1962 and 1966. However, it is also seen that in some years the deficiency in rainfall was also caused by the weakening of either the Arabian Sea-current or the Bay-current or the failure of both the currents to establish themselves over the North Indian plains. This happened in 1901, 1905, 1932, 1961 and 1962.

*August rainfall over North Indian sub-divisions*—The average rainfall received during the month of August over each of the 15 North Indian sub-divisions was worked out for all those occasions mentioned in Table II(b). The percentage departures for each of these sub-divisions had been worked out and are plotted in Fig. 1(b). It is seen from this figure that in the absence of tropical disturbances, the sub-divisions worst affected by moderate (—26 per cent to —40 per cent) to severe (—41 per cent to —50 per cent) drought condition were the following :—

(a) Gujarat; (b) Saurashtra and Kutch ; (c) East Rajasthan; and (d) West Rajasthan.

Slight drought (—11 per cent to —25 per cent) conditions also prevailed in the following sub-divisions :

(a) Gangetic West Bengal; (b) Bihar plateau; (c) Orissa; (d) East M.P.; and (e) West M.P.

It was, however, observed that the remaining divisions in North Indian plains experienced normal rainfall and one of them viz., West U.P. plains experienced slight excess of rainfall (+12 per cent).

Thus like the month of July, in this month also, the sub-divisions along the periphery of the Himalayas experienced normal rainfall in the month of August when there were no tropical disturbances. In addition, in this month, Vidarbha sub-division also experienced normal rainfall. The rest of the divisions of the North Indian plains experienced slight to severe drought condition.

#### SUMMARY AND CONCLUSIONS

From the foregoing, it is evident that in the absence of tropical disturbances affecting the Indian Subcontinent during the two principal monsoon months of July and August, the average monthly weighted rainfall over the entire North Indian plains (roughly to the north of Lat. 20°N) was in defect by about 19 per cent and 14 per cent respectively. It has also been seen that during the month of July, excepting the sub-divisions along the periphery of the Himalayas, the rest of the sub-divisions experienced slight to moderate drought conditions. The picture was almost the same for the month of August excepting that in the sub-division of Gujarat, the severity of drought becomes slightly more. The rainfall departures for Vidarbha



showed that in the month of August, the rainfall was nearly normal while in July it was slightly deficient in the absence of tropical disturbances.

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