Annals of Arid Zone 35(1) : 9-16, 1996

Distribution of Monsoon Rainfall in India During El Nino Associated Drought Situtations

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Abstract : The temporal and spatial variability of south west monsoon rainfall in India during years of (i) drought associated with El Nino, (ii) drought not associated with El Nino, and (iii) nondrought associated with El Nino during 1901-1990 were studied. The study revealed that August is the most dependable month for rainfall during drought years associated with El Nino. During drought not associated with El Nino, for most of the sub-divisions, June is the most dependable month. During nondrought years, associated with El Nino, the monsoon was found to start sluggishly in June, but subsequently it picked up, in amount of rainfall during July and August. Most of the sub-divisions received normal or excess rainfall during these months. Rainfall scenario at individual sub-divisions can be derived from the results.

Key words: El Nino, drought, monsoon.

The agricultural production of India largely depends on the variability of rainfall during the monsoon season (June to September). Hence, prediction of the monsoon rainfall is of paramount importance. Considerable efforts have been made to predict the behaviour of monsoon employing the teleconnection signals depicted by various features of general circulation including El Nino.

Attempts to predict monsoon rainfall, based on global circulation features, have been a continuous process (Hilderbrandson, 1897; Lockyer and Lockyer, 1902). The first appearance of positive sea surface temperature (SST) anomalies (2-4°C) off the south American coast usually precedes the monsoon several months. Considering teleconnections between them, attempts were made to predict monsoon rainfall based on distant signals like El Nino and Southern Oscillation (SO). Bjerkins (1969) related SO with El Nino phenomenon, which involves a warming of 2-4°C in the eastern tropical Pacific Ocean. Thapliyal (1981, 1982) developed an autoregressive integrated moving average (ARIMA) model with 500 mb ridge as the leading parameter for forecasting the rainfall of peninsular India. Datta (1986) found that between 1901-1982, 33 out of the 44 below normal rainfall years were associated with either present or past El Nino events.

The long range weather prediction model developed by IMD/DST (Gowariker et al., 1989, 1991), in which El Nino present year/past year are used as one of the predictor parameters, is able to predict overall rainfall anomalies of the country as a whole for the monsoon season. But these forecasts do not provide information on temporal and spatial variation. Saseendran and Datta (1993), by taking one strong signal of El Nino and using long range rainfall forecast of IMD, provided monthly rainfall forecast for different meteorological sub-divisions with good probability of success.

The present study is an extension of the above work and attempts to bring out the temporal and spatial performance of monsoon

Table 1. Meteorological sub-divisions and average rainfall during monsoon

Meteorological sub-divisions		S W Monsoon (June - September)	
		Rainfall (mm)	Percentage of annual
1.	Andaman and Nicobar Islands	1777	59
2.	Arunachal Pradesh	2743	66
3.	Assam and Meghalaya	1838	67
4.	Nagaland, Manipur, Mizoram and Tripura	1610	66
5.	Sub-Himalayan West Bengal and Sikkim	2436	78
6.	Gangetic West Bengal	1085	76
7.	Orissa	1137	76
8.	Bihar Plateau	1126	82
9.	Bihar Plains	1023	85
10.	East Uttar Pradesh	889	88
11.	Plains of West Uttar Pradesh	1379	84
12.	Hills of West Uttar Pradesh	723	87
13.	Haryana, Chandigarh and Delhi	450	83
14.	Punjab	461	76
15.	Himachal Pradesh	1157	72
16.	Jammu & Kashmir	472	48
17.	West Rajasthan	652	93
18.	East Rajasthan	277	89
19.	West Madhya Pradesh	947	91
20.	East Madhya Pradesh	1229	87
21.	Gujarat region, Daman, Dadra and Nagar Haveli	930	96
22.	Saurashtra, Kutch and Diu	450	93
23.	Konkan & Goa	2696	94
24.	Madhya Maharashtra	770	84
25.	Marathwada	645	83
26.	Vidarbha	957	87
27.	Coastal Andhra Pradesh	570	57
28.	Telengana	369	55
29.	Rayalaseema	757	82
30.	Tamil Nadu and Pondicherry	332	33
31.	Coastal Karnataka	2862	88
32.	North Interior Karnataka	441	65
33.	South Interior Karnataka	842	67
34.	Kerala	2003	67
35.	Lakshadweep	987	63

rainfall in India during drought years associated with El Nino (ED), drought years not associated with El Nino (NED) and non-drought during El Nino years (END) during 1900 through 1990, and to bring out the risk associated with the dependency on the rainfall patterns evolved for the different sub-divisions.

Materials and Methods

The period of study was from 1900 through 1990. Data provided by Rasmusson (1984) for years upto 1983 and current records for years after 1983 were used. Total forty El Nino years selected, including weak, moderate

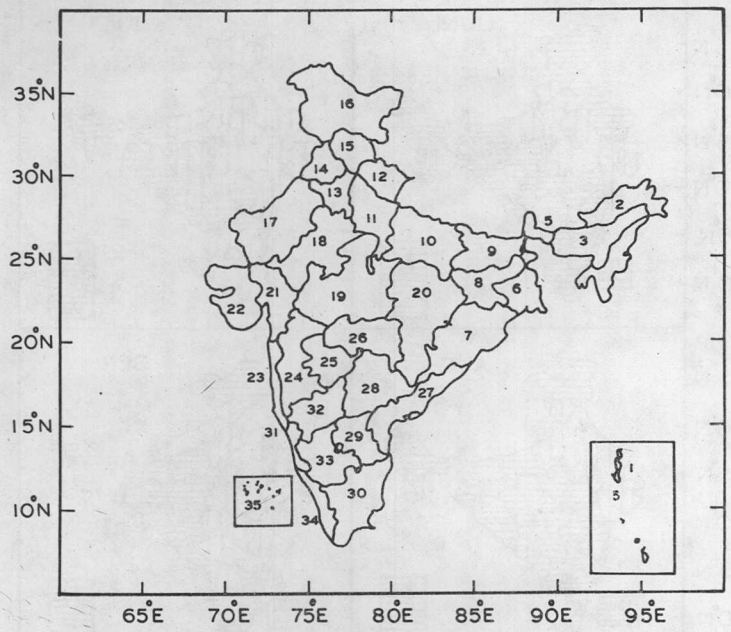

Fig. 1. Map of India showing meteorological sub-divisions.

and strong events, for El Nino-Drought (ED) were 1905, 1911, 1918, 1941, 1951, 1965, 1972, 1982, 1986 and 1987, for Non El Nino-Drought (NED) were 1901, 1904, 1920, 1966, 1968, 1974 and 1979 and for El Nino-Non Drought (END) were 1902, 1912, 1914, 1917, 1919, 1923, 1925, 1926, 1929, 1930, 1932, 1939, 1940, 1943, 1944, 1953, 1957, 1958, 1969, 1973, 1976, 1983 and 1989. The summer monsoon rainfall of various sub-divisions for these years were collected from the India Meteorological Department. The meteorological sub-divisions of India are shown in Figure 1 and the rainfall is given in Table 1. The monthly rainfall scenarios during the individual years, as well as mean situations for the three different situations given above were studied separately and the mean scenario only is presented for brevity. The probability for a particular sub-division

Table 2. Distribution of rainfall under different scenarios for selected stations

Sub-division	June	July	August	September
El Nino - Drought				
East Rajasthan	-35	-49	-21	-46
Coastal A.P.	- 6	-14	- 7	-14
El Nino - Non Drought				
East Rajasthan	-12	12	7	0
Coastal A.P.	1	2	10	- 1
Non El Nino - Drought				
East Rajasthan	-22	7	-24	-77
Coastal A.P.	-24	-18	-30	-10

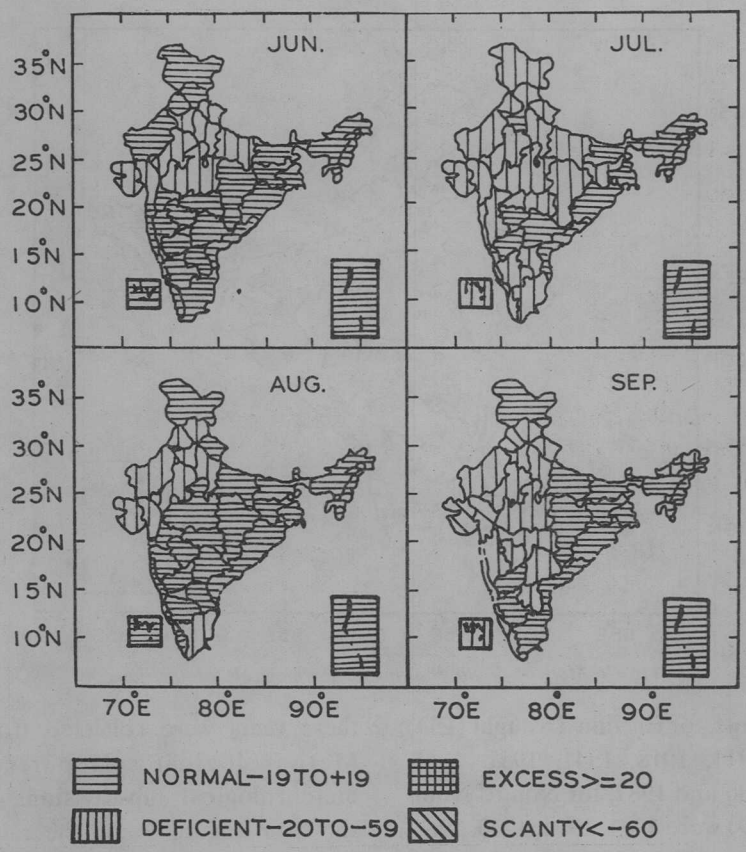

Fig. 2. Distribution of rainfall (% departure from normal) during drought years associated with El Nino.

to realise the mean rainfall scenario in a particular month is also calculated and presented.

Results and Discussion

El Nino associated with drought

The number of sub-divisions having below normal rainfall were the least in the month of August and maximum in the month of September (Fig. 2). Further, August was the most dependable month followed by July, June and September for rainfall during drought years associated with El Nino phenomenon.

For east Rajasthan, the month of August is the most dependable with an average rainfall departure of -21% from normal and was followed by June, September and July with departures in the order of -35%, -46% and -49% of normal (Table 2). The rainfall behaviour of coastal Andhra Pradesh was also similar to that of the east Rajasthan with rainfall departures in the order of -7%, -6%, -14% and -14% for the months of August, July, September and June, respectively (Table 2). Similar information can be derived for other sub-divisions.

El Nino associated with no drought

Distribution of rainfall during years of good monsoon associated with El Nino phenomenon

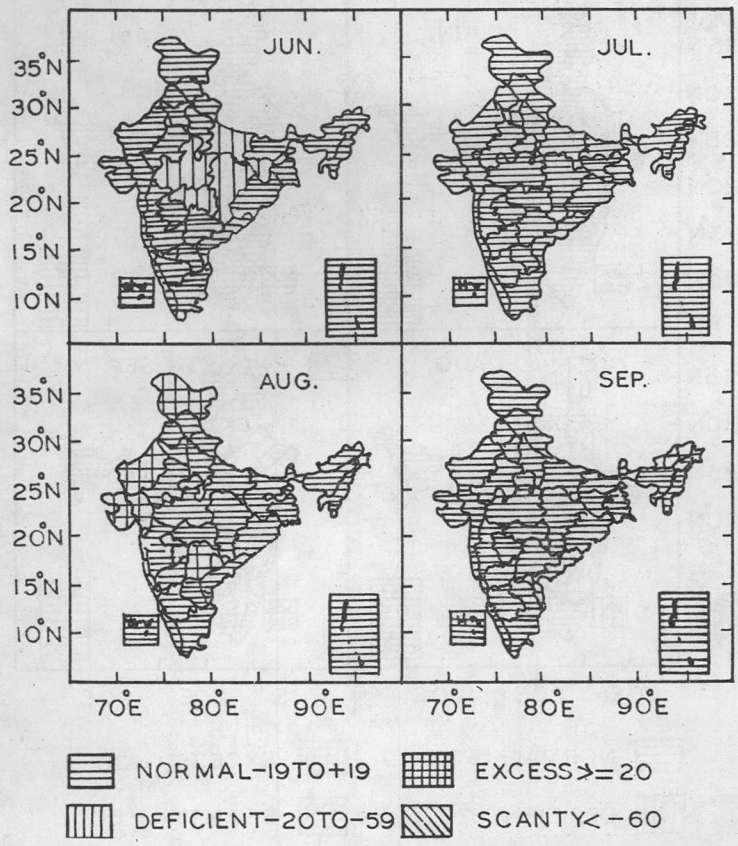

Fig. 3. Distribution of rainfall (% departure from normal) non-drought years associated with El Nino.

is given in Figure 3. The order of dependability of the months for rainfall under this scenario was July, August and September (Fig. 3 and Table 2). June was the worst month. In other words, during good monsoon years associated with El Nino, monsoon started sluggishly but picked up by July and gave reasonable amount of rainfall in the following months.

For both east Rajasthan and coastal Andhra Pradesh, monsoon rainfall in the month of June was lower than the normal but it picked up in the month of July and August, with decreased rainfall received in the month of September (Table 2).

No El Nino associated with drought

In case of droughts not associated with El Nino, the month of June followed by July were the dependable months for rainfall for most of the sub-divisions of the country (Fig. 4). August was the worst month, probably due to prolonged breaks in monsoon rains. Rainfall scenario at individual sub-division, viz., east Rajasthan showed above normal rainfall (7%) in July, followed by June and August with departures of -22% and -24%, respectively. September was the worst month with -77% departure from the normal. In the case of coastal Andhra Pradesh, September was

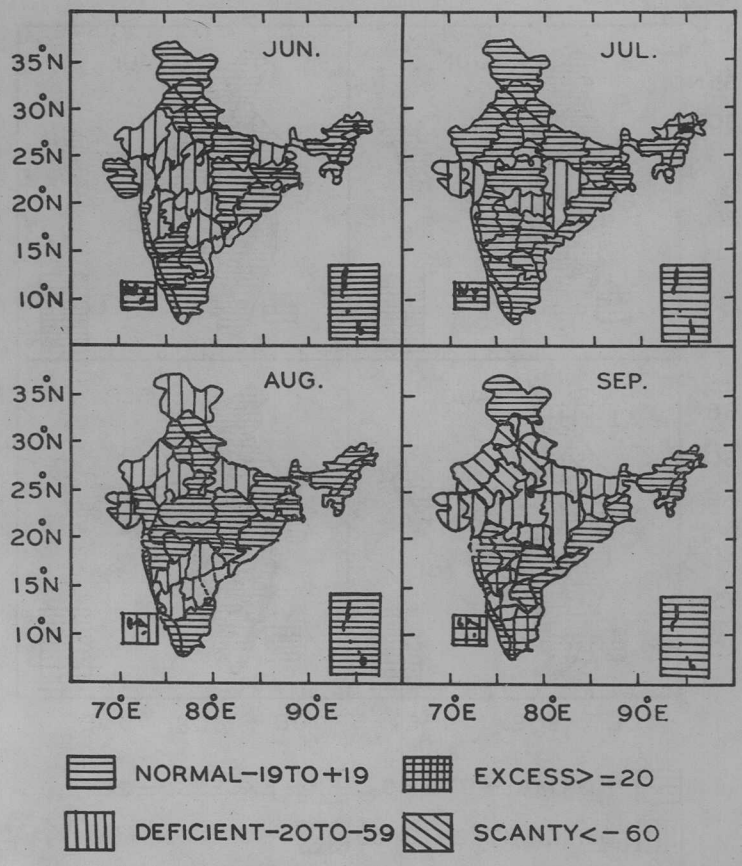

Fig. 4. Distribution of rainfall (% departure from normal) during drought years not associated with El Nino.

the best month with above normal rainfall of the order of -10%, followed by June and July with -24% departures and August was the worst month with -30% departure from the normal (Table 2).

From these results it may be concluded that during poor monsoon associated with El Nino (ED), most of the sub-divisions except plains of west Uttar Pradesh (11), Punjab (14), Himachal Pradesh (15), west Rajasthan (17), Gujarat (21), Saurashtra (22) and Tamil Nadu and Pondicherry (30) can depend on good rainfall during August (Fig. 5).

Sub-divisions, viz., 14, 15, 17, and 30 get normal rainfall in June and 11, 21 and 22 do not receive normal rainfall in any of the months. September is the worst month for all the sub-divisions in north west, west coast and central India, except east Madhya Pradesh (Fig. 6). During years of El Nino but not associated with drought (END), July and August are the most dependable months. June is the worst month for some of the sub-divisions (6 out of 35). All the sub-divisions receive normal and excess rainfall during the months of July, August and September in the Central Peninsula. During years of drought not associated with El Nino (NED), June is the most dependable month for most of the sub-divisions except 5, 9, 17, 18, 19, 24, 25, 26, 27 and 28, and is followed by July. August

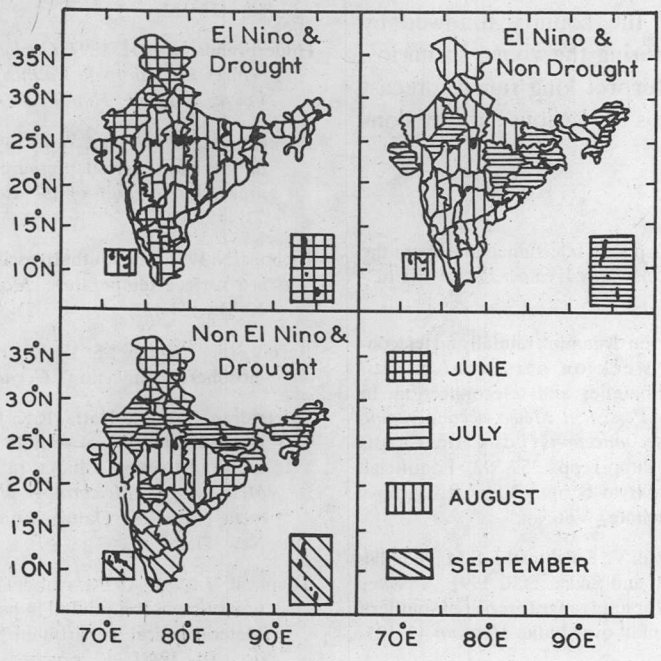

Fig. 5. Distribution of the best rainfall month.

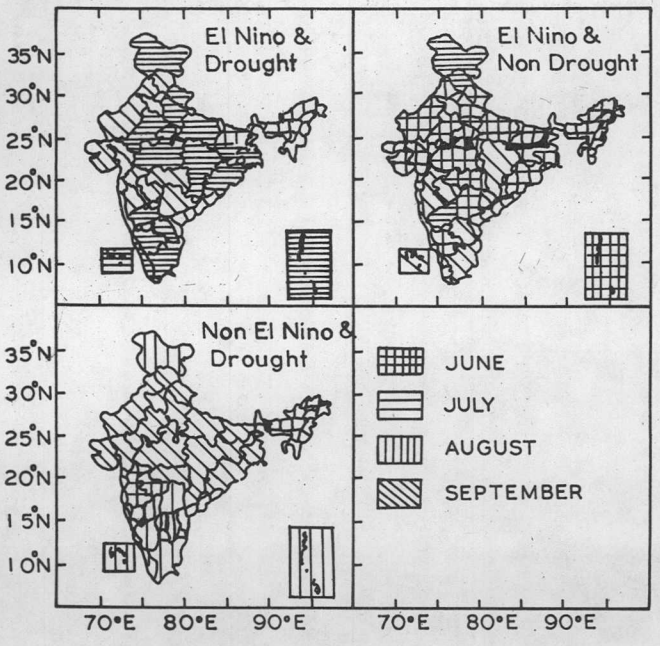

Fig. 6. Distribution of the worst rainfall month.

is the worst month for most of the sub-divisions (11 out of 35) of the country followed by September. Considering the above scenarios, it is possible to interpret long range forecast in terms of scenarios for various sub-divisions in the country.

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