

A Comparative Analysis of El-Nino and Rainfall Over India and Goa (1901-2000)

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Abstract

Though Goa, situated on the west coast of India, receives a fairly high amount of monsoon rainfall, it has to face occasional droughts and floods. The present paper looks at the occurrence of these phenomena, their severity and tries to find out if there exists a relationship between the El-Nino Southern Oscillation (ENSO) and irregularities in the monsoon rainfall in Goa.

Introduction

Agriculture, industry and hydel-power in any part of India are dependent on the performance of the south-west monsoon rains. 75 to 90% of the annual rainwater potential over most of the country depends on this monsoon. Although Goa is part of the more humid area of the Western Coastal Plain, it does not form an exception. The Indian monsoon is rightly described as 'The Life and Soul of the Country' as the livelihood of the majority of its people depends upon timely and adequate rains. The Indian monsoon is known for its vagaries, unpunctuality in intensity, frequency and duration. Moreover, the monsoon is characterised by irregularities in its advent and retreat resulting in floods and droughts in one or the other part of the country. The country spends billions of rupees to combat floods and droughts, an amount, which could be otherwise made available for developmental purposes. Hence, the analysis of rainfall deserves special attention at the micro level for better planning and management of the vital and precious water resource.

The El-Nino is one of the 16 parameters taken into account by the Indian Meteorological Department while forecasting the monsoon rainfall. The present paper tries to find out whether the annual rainfall in Goa is influenced by El-Nino episodes which are believed to result in drought and flood years in the central Circum-

Pacific region, and, if so, to what extent? For this purpose, annual and seasonal rainfall data for the period 1901-2000 for Panaji (Observatory) and Marmagao (Aerodrome) were analysed. These were compared to the All-India mean data. The objectives were as follows:

- 1) To prepare a summary of drought and flood years with reference to
 - a) Association between EL-NINO years and drought / flood / normal years.
 - b) Association between non EL-NINO years and existence of drought / flood / normal years.
- 2) To assess the intensity of drought / flood years with reference to EL-NINO and non EL-NINO years.
- 3) To examine the extent of such probability.
- 4) Decadal analysis of drought / flood years.

Methodology

The criteria adopted in identifying the drought/ flood/ normal years is the percentage departure from the rainfall normals (officially used by the I. M. D. Pune). Their probability level has been worked out. Based upon standard deviation the drought categories of mild, moderate, phenomenal to severe were assessed. For the significance level Standard Error technique has been applied.

The coefficient of variation and the decadal distribution of drought/flood have been worked out.

Analysis

The occurrence of the El-Nino phenomenon is centered in the central Pacific Ocean between 20 degree North and 10 degree south of the equator. However it influences the surface sea temperature of the Indian Ocean in different ways. During the EL-NINO episode there is an unusual rise in the temperature of the Peruvian Current, which is attributed to weakening of easterlies in this area. At the same time the temperature of the Arabian Sea also increases (Khole Medha, 1999), Pune) weakening South-West winds and changing the strength of Arabian Sea Branch of the monsoon.

The El Nino / Southern Oscillation (ENSO) phenomenon has its core region in the Pacific to Indian Ocean basin. It does not affect the climatic variability in the core region alone, but is of great importance to the global climatic system. The ENSO phenomenon occurs every 2 to 7 years. During the hundred-year period 1901-2000, twenty-five years were El Nino years out of which the years 1940/41, 1982/83 and 1997/98 are considered to have been super El-Nino years.

Table No. 1 gives the rainfall departure in percentage and standard deviation during the Summer Monsoon for EL-NINO as well as non EL-NINO years for Panaji, Marmagoa along with the all-India mean (after Parthasarthy; data available only upto 1991). For Panaji and Marmagoa, out of 100 years the rainfall percentage departure for 28 years is given. The mean per annum and standard deviation as well as coefficient of variation has been calculated. The table reveals that the values of mean per annum are less than mean values of such years showing the standard deviation (+/-). Standard deviation is (+/-) 60.00 and 54.00 for Panaji and Marmagoa which is quite high as compared to the all India (+/- 10.35).

Under all-India droughts we understand that large areas of the country experience monsoon failure. Out of 20 years of all-India drought, twelve droughts coincided with El-Nino years while eight occurred in non-El-Nino years. In the case of Goa, not all-India drought years were drought years. They were either drought, flood, wet or normal years. Drought years are years with a standard deviation of -1.00, flood years with standard deviation +1.00 and wet years with a standard deviation of +0.07. Out of 28 years Panaji had 12 drought/flood years, 8 of which coincided with the El-Nino and 4 with non El Nino years. Marmagoa had 10 drought/flood years, 6 coinciding with El Nino and 4 with non El Nino years (Table 2). Whereas at the all India level years of the super El-Nino phenomena are severe drought years, Goa experienced 1941 a severe drought but 1982/83 and 1997/98 flood years.

Minor variations at annual and seasonal level may be the outcome of certain phases of development of EL-Nino during the year.

Table No.3 shows drought categories based on Standard Error. Mild drought years are 6 for India, and 3 and 2 for Panaji and Marmagoa respectively, moderate drought years are 8, 4 and 0 respectively. At India level severe and phenomenal drought years are 3 each but there are no wet and flood years. Goa experienced severe but no phenomenal drought years. Panaji experienced 2 severe drought years and Marmagoa 3 such years. However, Panaji and Marmagoa have 7 and 8 wet years respectively and 5 flood years each.

Conclusions

- 1) There were 3 severe and 3 phenomenal all-India drought years; all are linked with EL-NINO episodes.
- 2) The severe drought years in Goa also show a relationship with EL NINO years.
- 3) Nearly half of the EL NINO years are normal years in Goa

Table No. 1 EL-NINO Episodes & Rainfall Over Goa and and All India (1901 to 2000)

No	Drought / flood years	Rainfall Departure in Percentage						Standard Deviation (●)		
		All India		Panaji		Marmagao		All-India	Panaji	Marmagao
		A	S	A	S	A	S	A	A	A
1	1901	-10.14	-15.29	-2	-7	-1.2	-6	-1.6	0.02	-0.08
2	1902 – ENSO	-	-	-19.6	14.7	30	23		1.09	1.43
3	1904	-10.61	-11.97	-2	1.8	-5	-7	-1.2	0.3	0.18
4	1905 – ENSO	-15.56	-15.93	-45	-45	-34	-34	-1.6	-1.8	1.56
5	1911 – ENSO	-11.27	-13.59	-26	-26	-26	-26	-1.4	-0.98	-1.19
6	1918 – ENSO	-21.30	-23.63	-28	-27	-10	-10	-2.1	-1.03	-0.43
7	1920 – ENSO	-15.48	-15.63	-34	-35	-20	-23	-1.7	-1.32	-0.88
8	1925 – ENSO	-		-15	-16	-10	-11	--	-0.48	-0.43
9	1928	-4.95	-9.89	-4	-4	7.5	7.5	-0.9	0.03	0.39
10	1941 – ENSO	-12.15	-14.55	-44	-46	-43	-45	-1.4	-1.8	-1.98
11	1951 – ENSO	-10.80	-13.29	-3	-4	6	+5.5	-2.0	0.05	0.32
12	1965	-20.00	-16.78	8	-1.5	5	-3	-1.5	0.5	0.28
13	1966 – ENSO	-11.03	-13.20	-4	-11	-10	-19	-1.4	0.03	0.4
14	1968 – ENSO	-11.82	-11.47	-2	-5	-9	-12	-1.1	0.10	0.4
15	1969 – ENSO		--	-11	-12.5	-4	-7	—	-0.28	-0.13
16	1972 – ENSO	-22.18	-23.40	-32	-32	-40	-40	-2.3	-1.24	-1.8
17	1974	-10.73	-12.24	31	29	32	32	-1.2	1.61	1.52
18	1979	-11.74	-16.96	-15	-19	7	-21	-1.9	-0.5	OJ7
19	1982 – ENSO	-10.18	-13.73	12	10.6	6	4	-1.3	0.74	0.34
20	1983		--	32	30.8	39	37	--	1.63	1.85
21	1985	-7.62	-10.86	6	5.5	16	15	-1.0	0.48	0.79
22	1986	-8.80	-12.83	-37	-39	-27	-39	-1.3	1.46	-1.22
23	1987 – ENSO	-11.48	-18.20	-	-	1	-	-1.8	0.22	0.09
24	1991 – ENSO	-7.80	-7.96	-15	-16	-4	-6	-1.0	0.5	-0.17
25	1992	--	--	14	-1	-	-	--	0.83	0.03
26	1997 – ENSO	--	--	24	20	24	19	--	1.28	1.17
27	1998 – ENSO	--	--	13	10.5	14	12	--	0.78	0.68
28	2000	--	--	29	-	35	-		1.52	1.66
No. of years		20	20	28	27	28	27			
Mean (cm)		109.23	85.24	260	-	250	-			
Mean/annum		100.30	78.20	272	-	252	-			
S.D		+/-10.35	+/-8.47	+/-60	-	+/-54	-			
C.V.		10.32	10.8	22.05	-	21.42	-			

Note: A – Annual S - Seasonal

Table No. 2 Probability Level

Categories of years	India		Panaji		Marmagao	
	No of years	No of years	Prob	No of years	Prob	
1. Non-ENSO years but drought / flood years	8	4	0.04	4	0.04	
2. ENSO years but not drought years.	0	9	0.09	11	0.11	
3. ENSO years and drought / flood years.	12	8	0.08	6	0.02	
4. Non ENSO Normal years	0	7	0.07	7	0.07	
5. Total No. of Years+	20	28		28		

Table No. 3: Drought categories based up on standard error(s)

Categories of drought	S. D. Range	India	Panaji	Marmagao
1. Mild	1 - 1.24	6	3	2
2. Moderate	1.25-1.49	8	2	-
3. Severe	1.5-2.00	3	2	3
4. Phenomenal	>2.00	3	-	-
5. Wet years	>0.071	-	7	8
6. Flood years	> 1 S. D.	-	5	5
Normal Years		-	9	10
Total No. of years		20	28	28

Table No. 4 Decadal Distribution of Floods/Drought years (1901 – 2000)

Decade	No. of ENSO years	India		Panaji		Marmagao	
		Drought	Floods	Drought	Floods	Droughts	Floods
1901-10	2	3	1	1	1	1	1
1911-20	3	3	-	3	-	1	-
1921-30	3	1	1	-	-	-	-
1931-40	4	-	-	-	-	-	-
1941-50	1	1	-	1	-	1	-
1951-60	3	1	-	-	-	-	-
1961-70	3	3	1	-	-	-	-
1971-80	2	3	-	1	1	1	1
1981-90	2	4	1	1	1	1	1
1991-2000	2	1	4	-	2	-	2
	25	28 years		28 years		28 years	
P		0.20	0.8	0.07	0.05	0.05	0.05

- 4) In Goa ENSO years can be either drought or flood years.
- 5) EL-NINO-Monsoon interaction is a complex issue and is a challenge to the climate sciences as the Indian monsoon may be dependant on many more factors such as atmospheric, oceanic and terrestrial conditions.

References:

Allan, R. J. (2000) ENSO - Climatic Variability in the past 150 years. In: Diaz H. F. and Markraf V. (Ed). *El Nino And The Southern Oscillation : Multiscale variability and Global and Regional Impacts*, Cambridge University Press, pp 1-55.

Allan, Robert J: *EL NINO Southern Oscillation influences in the Australasian Region: Pages 313-335.* (Flinder Institute for Atmosphere and Marine Sciences, Flinders University, South Australia.)

Khole, Medha (1999): *of the IMD-PUNE, SST Over Indian Ocean during 1997 EL-NINO Event.* *Current Science*. Vol. No. 77, No. 10. pp 1241-1245.

Down To Earth: Year of the Girl Child. Vol 7, Issue No. 9, September 30, 1998, Page 7.

Down To Earth : The Child Gives Ocean a Fever. Vol. 8, No. 24, May 15, 2000, Page 49.

Singh Tapeswar (2000): *Drought and EL-NINO, Down To Earth*, Vol. 8, No. 24, 2000, Pages 24-26.

Parthasarathy, B., Sontakke, N. A., Monot, A. A., and Kothawale. D. R.. (1987): *Drought/Floods in the Summer Monsoon Season Over Different Meteorological Sub-Division of India for the Period 1871 to 1984*, *Journal of Climatology*. Vol 7, pp 57-70

Hema Malini, B. et. al. (2001): *Enso Events and Weather Extremes : Indian Experience*, *Deccan Geographer*. Vol. 39, pp 45-56.

Supplee. C. (1999): *El Nino La Nina - Natures Vicious Cycle*, *National Geography*, Vol 195, No. 3, pp 72-87 & 93-95.

David Halpen: *Satellites, Oceanography and Society*, Glantz, Michael H., *Why Care About EL-NINO and LA-NINA?* © 2000, Elsevier Science B. V., Chapter 8. Pages 149-168.

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