

Drought in Gujarat districts and state as key indicators to all India drought

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ABSTRACT

Drought is a frequent phenomenon over the Gujarat state. 'key' areas in Gujarat to which highest probabilities of spatial coherence of occurrence of drought are associated with individual districts, with state and with country, during the period 1901-2000 have been identified using rainfall departure from the normal.

Major parts of Saurashtra and Kutch region have high probabilities of spatial coherence of drought with state level drought occurrence. Bulsar district has highest probability of 59% for spatial coherence of drought with All India drought. Within the Gujarat state, the spatial extent of drought is the highest (in 94% of the districts) with Broach and Surat taken as 'key' districts.

Key Words: Drought, coherence, probability, 'key' areas.

Occurrence of meteorological drought in various subdivisions of India, methods of drought assessment, probabilities of drought, droughts in relation to regional and global features, droughts in various spatial scales, trends in occurrences of drought, dry and wet week studies etc., are the different aspects of drought studies. Chowdhury and Abyankar (1979) studied changes in rainfall pattern over Gujarat state. Bhalme and Mooley (1980) and Mooley *et al.* (1984) studied large scale droughts over India. Rainfall variability over Kutch has been reported by Singh *et al.* (1991) and relation between El Nino and summer monsoon rainfall over India have been reported by Mooley (1997) and Kane (1998). Droughts over Maharashtra state were related to spells of dry weeks by Gore and Thapliyal (2000). Gore and Ray (2002) worked on

droughts over Gujarat and Maharashtra states. Droughts over Gujarat state is a frequent phenomenon and its identification, intensity, area spread, spatial coherence, impact are important aspects. However, very few studies have been made regarding spatial coherence. This approach was attempted by Chowdhury *et al.* (1976) for studying incidence of drought in various subdivisions of India and Gore and Ray (2001) worked out coherence in drought incidence in Maharashtra state. An attempt has been made here, to study 'key' areas, spatial coherence and extent of drought in the state of Gujarat and also the coherence of 'key' areas in Gujarat with All India drought.

MATERIALS AND METHODS

The basic data used comprises of daily

Table 1 : Drought years for Gujarat state and all India

1901-1910	1911-1920	1921-1930	1931-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000
Gujarat State									
1901	1911	1923	1931	1942	1951	1962	1972	1982	1991
1904	1915	1924	1936	1948	1952	1963	1973	1985	1993
1905	1918	1925	1938		1955	1965	1974	1986	1995
	1920	1927	1939		1957	1966		1987	1997
		1929	1940		1960	1968		1990	1999
									2000
All India									
1901	1911			1941	1951	1965	1972	1982	
1904	1918					1966	1974	1987	
1905	1920					1968	1979		

rainfall data for Gujarat for the period 1901-2000 collected from National Data Centre, India Meteorological Department, Pune. A meteorological drought at a location is defined as a situation when the rainfall received is below 75% of the climatological normal. Years with seasonal rainfall deficit of more than 25% for southwest monsoon season, for different districts in the Gujarat state have been identified as drought years. If in an year 25% or more of the area of the state is affected by drought, then that year is considered as one in which the state suffered from drought. When the rainfall deficiency during southwest monsoon season for the country as a whole is more than 10% of normal in amount and if more than 20% of the country's area is affected by drought conditions, the situation is defined as an All India drought year. Drought years for Gujarat state and the

country levels are shown in Table 1.

Frequencies, probabilities and recurrence period of occurrence of drought were worked out over districts of Gujarat for the period 1901-2000. Determination of the probabilities of simultaneous occurrence of drought with respect to a particular area gives a measure of spatial extent of coherence in drought incidence. The base 'area' with which simultaneous occurrence of drought in other areas is examined, is termed as 'key area'. Year to year variation of drought over the state of Gujarat and the country considered as single whole units has been examined. The probabilities of simultaneous occurrence of drought over various districts at 'state' and the 'country' levels have been worked out. The spatial coherence for drought incidence among the districts within the state was also studied. For this purpose, each district was

chosen as 'key' area and years were determined when it was affected by drought. The probability exceeding 50% was considered as significant. The process was repeated for all districts, chosen as 'key' districts. The probabilities and recurrence period of drought occurrence for different districts with state, with the country and with the 'key' districts is shown in Table 2.

RESULTS AND DISCUSSION

Probabilities and recurrence period over districts of Gujarat

The results on probabilities of drought incidence in the last 100 years over districts of Gujarat and the corresponding recurrence periods for the districts with the probability >10% (Table 2), reveal that the districts Banaskantha, Amreli, Jamnagar, Junagarh, Kutch, Rajkot and Surendranagar have probabilities of droughts exceeding 30%; Kutch has maximum of 41% probability. 16 out of 18 districts from Gujarat show drought probability >20%. As such, major parts of Gujarat are drought prone. The drought may recur in most of these districts once in 3 - 4 years. Kutch district has a minimum recurrence period of 2-4 years, while Dangs and Bulsar districts have maximum recurrence period of 5-6 years for drought occurrence.

Spatial coherence of drought occurrence over Gujarat state and country

The probability of simultaneous occurrence of drought over Gujarat state and All India drought is 33%. The year to year variation of the area affected by

drought for Gujarat state and for the country as a whole for the period 1901 to 2000 is depicted in Fig.1. In several years, it shows simultaneous drought occurrence over Gujarat state and All India drought years. Statistically, it gave a significant correlation coefficient of 0.63.

Spatial coherence of drought occurrence over individual districts of Gujarat and state of Gujarat as a whole

The probabilities of simultaneous occurrence of drought for individual districts and the state as a whole are shown in Table 2. The spatial variation of these probabilities is depicted in Fig. 2(a). In general, it shows that northwestern and western parts of the state have higher probabilities (>70%) of spatial coherence of drought occurrence with that of the state. The probabilities are higher for most of the districts in Saurashtra and Kutch, with Kutch district having the highest probability of 88%. Comparatively, the districts Dangs, Bulsar and Mehsana have lower probabilities ranging from 37 to 47% for spatial coherence of drought with state.

Spatial coherence of occurrence of drought over districts of Gujarat and All India drought

The probabilities of simultaneous occurrence of drought for individual districts and the country as a whole are also shown in Table 2. The spatial variation of these probabilities (Fig. 2(b)) shows that these are lower as compared to probabilities of spatial coherence of drought at state level. They range from 28 to 59% for

Table 2 : Spatial coherence in drought occurrence within Districts / State of Gujarat with significant probabilities

Key district	Drought Probability / recurrence period	District / Probability (%)																		% No. of districts out of 18	Prob. of spatial coherence with state / country (%)
Ahmedabad (AHM)	27/3.7	BNK 85	ERD 74	BRC 67	BLS 55	KRA 81	MHS 63	PCM 81	SBK 89	SRT 63	AMR 59	BHV 63	JMR 70	JNG 67	KTC 81	RJK 78	RJK 89	-			
Banaskantha (BNK)	36/2.8	AHM 64	ERD 58	BRC 53	KRA 61	MHS 67	PCM 67	SBK 53	SRT 53	AMR 58	BHV 58	JMR 55	JNG 72	KTC 69	RJK 75	-	-	-			
Baroda (BRD)	25/4.0	AHM 80	ERD 84	BRC 72	KRA 68	MHS 88	PCM 84	SBK 64	SRT 60	AMR 60	BHV 60	JMR 60	JNG 64	KTC 76	RJK 72	RJK 84	-	-			
Bulsar (BLS)	17/5.9	AHM 88	ERD 76	BRC 65	KRA 71	MHS 71	PCM 76	SBK 71	SRT 82	AMR 71	BHV 76	JMR 71	JNG 82	KTC 76	RJK 71	RJK 88	-	-			
Dangs (DNG)	19/5.3	AHM 68	ERD 74	BRC 63	KRA 63	MHS 63	PCM 63	SBK 63	SRT 68	AMR 53	BHV 58	JMR 53	JNG 74	KTC 63	RJK 74	-	-	-			
Kaira (KRA)	26/4.1	AHM 85	ERD 85	BRC 73	KRA 69	MHS 88	PCM 65	SBK 61	SRT 61	AMR 65	BHV 73	JMR 85	JNG 81	KTC 81	RJK 65	-	-	-			
Mehsana (MHS)	23/4.3	AHM 74	ERD 96	BRC 74	KRA 70	MHS 83	PCM 52	SBK 52	SRT 61	AMR 70	BHV 65	JMR 74	JNG 74	KTC 74	RJK 74	-	-	-			
Panchmahals (PCM)	28/3.6	AHM 79	ERD 86	BRC 79	KRA 79	MHS 82	PCM 82	SBK 82	SRT 68	AMR 68	BHV 71	JMR 68	JNG 71	KTC 82	RJK 82	-	-	-			
Sabarkantha (SBK)	29/3.5	AHM 83	ERD 86	BRC 72	KRA 65	MHS 79	PCM 86	SBK 86	SRT 59	AMR 65	BHV 65	JMR 72	JNG 69	KTC 90	RJK 83	RJK 79	-	-			
Surat (SRT)	22/4.5	AHM 77	ERD 86	BRC 77	KRA 86	MHS 64	PCM 64	SBK 77	SRT 50	AMR 82	BHV 77	JMR 73	JNG 82	KTC 77	RJK 86	RJK 77	RJK 91	-			
Amreli (AMR)	31/3.2	AHM 55	ERD 65	BRC 52	KRA 58	MHS 65	PCM 65	SBK 65	SRT 55	AMR 65	BHV 71	JMR 84	JNG 74	KTC 65	RJK 65	-	-	-			
Bhavnagar (BHV)	28/3.6	AHM 61	ERD 75	BRC 57	KRA 68	MHS 61	PCM 68	SBK 68	SRT 68	AMR 71	BHV 68	JMR 75	JNG 86	KTC 75	RJK 75	-	-	-			
Jamnagar (JMR)	40/2.7	AHM 49	ERD 51	BRC 51	KRA 49	MHS 49	PCM 84	SBK 62	SRT 62	AMR 51	BHV 62	JMR 62	JNG 62	KTC 62	RJK 62	-	-	-			
Junagadh (JNG)	34/2.9	AHM 53	ERD 59	BRC 50	KRA 53	MHS 56	PCM 59	SBK 62	SRT 53	AMR 56	BHV 62	JMR 76	JNG 71	KTC 68	RJK 62	-	-	-			
Kutch (KTC)	41/2.4	AHM 54	ERD 63	BRC 49	KRA 54	MHS 56	PCM 56	SBK 59	SRT 59	AMR 80	BHV 63	JMR 73	JNG 61	KTC 61	RJK 61	-	-	-			
Rajkot (RJK)	32/3.1	AHM 63	ERD 78	BRC 56	KRA 59	MHS 66	PCM 50	SBK 72	SRT 53	AMR 63	BHV 66	JMR 84	JNG 72	KTC 94	RJK 81	-	-	-			
Surendranagar (SRN)	31/3.2	AHM 77	ERD 87	BRC 68	KRA 65	MHS 68	PCM 55	SBK 74	SRT 74	AMR 71	BHV 65	JMR 65	JNG 65	KTC 65	RJK 81	-	-	-			

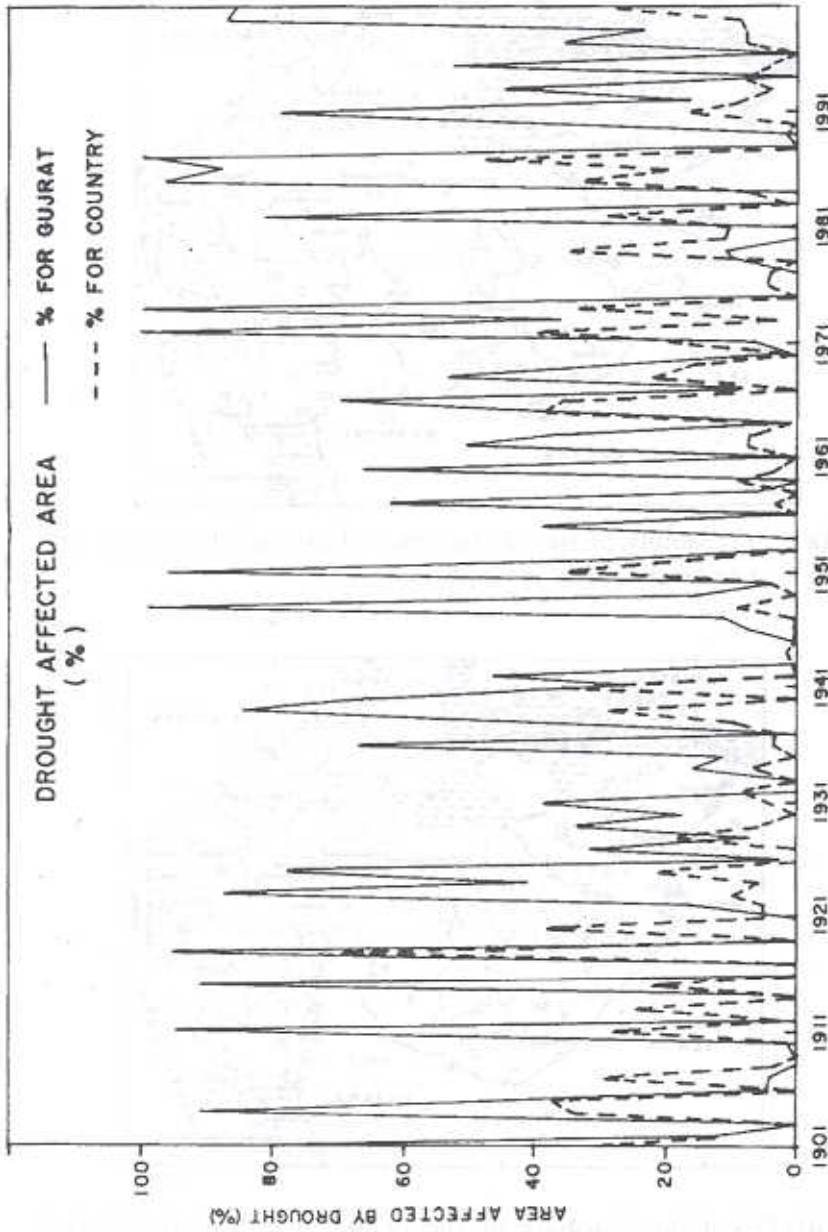


Fig. 1 : Drought affected area over the country and over the state of Gujarat for the period 1901 to 2000

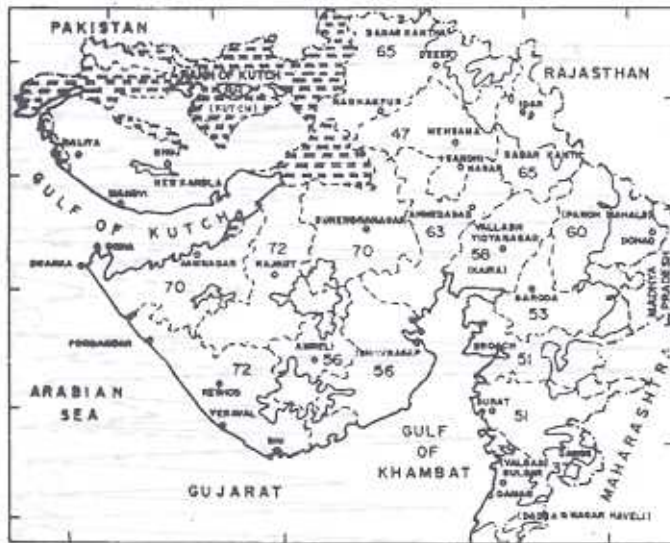


Fig. 2(a) : Probability of spatial coherence of drought in districts with state level drought in Gujarat

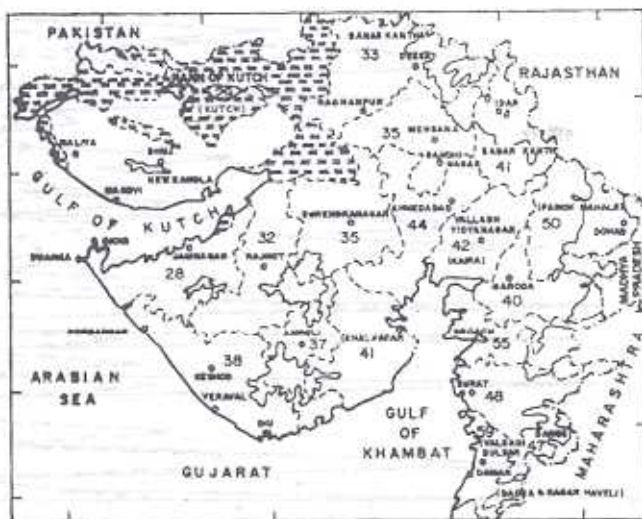


Fig. 2(b) : Probability of spatial coherence of drought in districts of Gujarat with all India drought

different districts of the state with maximum probability of 59% for the Bulsar district in south Gujarat. These areas are significant indicators in relation to All India drought occurrence.

Spatial coherence among various districts of Gujarat state and important 'key' districts

Table 2 shows various 'key' districts and the group of districts simultaneously experiencing drought with the 'key' district having significant probability. Also, it provides an indication of associated districts affected by drought with the occurrence of drought over 'key' district. In general, high degree of coherence among the districts is evident. It is the highest (94%) for Broach and Surat as 'key' districts. There are nine districts with probability more than 85% for simultaneous drought occurrence with Broach as 'key' district. Similarly, there are 4 to 5 districts with more than 85% probability for simultaneous occurrence of drought with Surat, Baroda and Kaira as 'key' districts.

CONCLUSIONS

1. A coherence in drought incidence at all All India level with that over Gujarat state is noticed with a significant correlation coefficient of 0.63.
2. The probabilities of spatial coherence of drought for individual districts with All India drought are lower than those with state level drought occurrence. Bulsar district in the south east has the

highest probability (59%) for spatial coherence of drought with All India drought.

3. Northwestern and western parts of the state are important 'key' areas for spatial coherence with state level drought.
4. Kutch district from Saurashtra and Kutch Subdivision has minimum recurrence period of 2.5 years for drought occurrence.
5. The high probabilities (>85%) of spatial coherence of occurrence of drought in many districts are noticed when Broach, Surat, Baroda, Kaira are taken as 'key districts'.

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