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Rainfall probability analysis using Markovchain model in Sabour region of Bihar

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ABSTRACT

Rainfall during monsoon season and its variability govern the cropping system in the Sabour region. Long-term rainfall data is used to analyse the probability of occurrence of deficit /normal /excess rainfall for better crop planning in the region.

During the 30 years (1972-01) there were about 13 per-cent drought, 10 per-cent flood and 77 per-cent normal years. Among drought years southwest monsoon rainfall was the lowest (646 mm) in 1977. Seed sowing in paddy nursery in the Sabour region generally takes place immediately after onset of monsoon rains during 23-25 standard meteorological weeks and transplanting is carried out around 27th or 28th standard week. The tillering, 50 per-cent flowering and dough stage are observed during 32-33rd, 37-38th and 40-41st standard weeks respectively.

Key words: Rainfall, drought, seasonal rainfall, *kharif* season, *rabi* season, monthly rainfall and weekly probability

The agricultural strategy to increase production on a sustained basis should make use of scientific information generated by the agrometeorological fraternity. Food production from dryland agriculture is always uncertain, due to large temporal and spatial variation in rainfall. In minimizing risk, climatological data of a location is very helpful (Vairavan *et.al*, 2002). According to Pandey *et al* (2002), seventy per-cent rainfalls occurs during the monsoon period, out of which the crops use only small amount and a large portion is lost as surface runoff. At Ludhiana rainfall analysis for the past 95 years (Hundal *et.al*.2002) showed an increasing trend over normal for both annual as well as kharif season rainfall in last 30 years. At Igatpuri, about 90 per-cent of annual rainfall is received from southwest monsoon, 8 per-cent from October to February and 2 per-cent in the pre monsoon season. The productivity of rice in this region is reported (Jayabhaye, *et.al.* 2003) to vary according to quantum and distribution of monsoon rainfall over the year.

MATERIAL AND METHODS

Daily rainfall data for 30 years (1972 to 2001) from Bihar Agricultural College Agromet observatory, Sabour, Bhagalpur located at 25°14'N latitude, 86°57'E longitude and 49 m amsl, were used for analysis of the probability and variability.

The months were classified as drought, normal and excessive rainfall months. If X is the mean monthly rainfall, then a month receiving rainfall less than A_1 is defined as drought month, between A_1 and A_2 is normal month and above A_2 is excessive month where A_1= X/2 and A_2 = 2X (Nath *et.al.* 2002). Similar criteria were used to define weeks as normal excessive rainfall or flood and drought as described for the month. The yearly rainfall is also classified as drought, normal and excessive rainfall years when particular year receives rainfall less than the Y-S, between Y-S and Y+S and above Y+S and respectively, where Y is mean of yearly rainfall and S represents the standard deviation of yearly rainfall.

The number of drought, normal and excessive rainfall or flood months and weeks in a year were listed in descending order of magnitude and probability analysis were carried out by using Weibull's formula P= m /(n+1). Where m is the rank of starting with one as the highest and n is the total no. of years for which analysis was carried out. Rainfall probability analysis was based on first order Markovchain as suggested by Virmani *et al*., (1980,1982). In this study a week is considered as dry when the rainfall is less than 30 mm. The drought based on normal deviation (ND) following (Nath and Deka, 2002) was used for classifying the years.

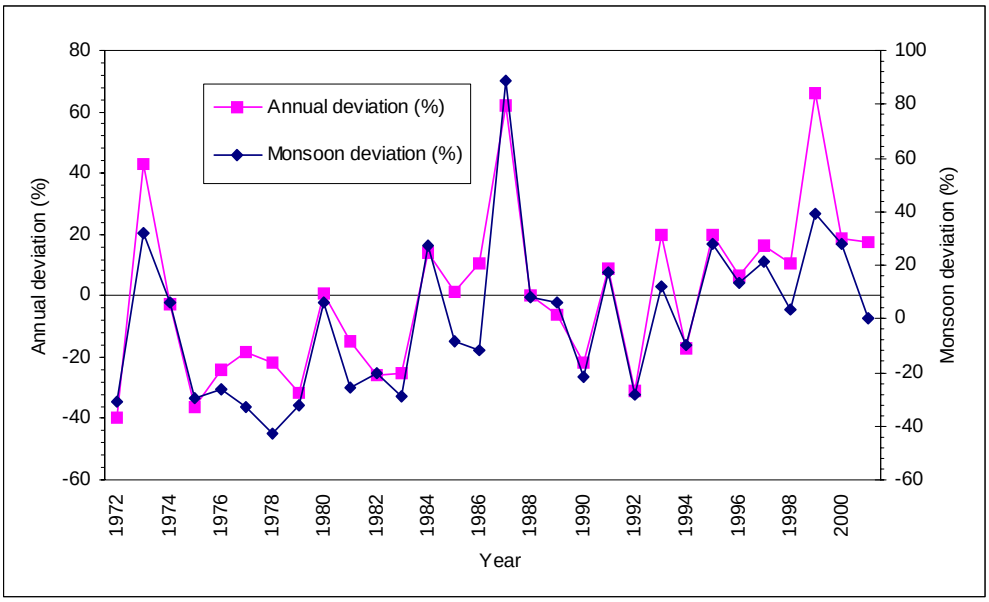

Fig: 1 : Annual and monsoon rainfall deviations from the normal at Sabour (1971-2001)

$$ND = (X - \bar{X}) / \bar{X} \quad *100$$

X is the total precipitation for each year, and $\bar{X}$ is the annual average precipitation

RESULTS AND DISCUSSION

Annual and monsoon rainfall deviations from normal are deficit in fig1. During the study period of 30 years, there were about 13 per-cent drought, 10 per-cent excessive or flood and 77 per-cent normal years (Table-1). In the monsoon period of 30 years, there were 23 per-cent of drought, 10 per-cent of excessive and 67 per-cent of normal occurrences. The annual rainfall was the lowest (721.1mm) in 1972 as well as rainy days (42). The southwest monsoon rainfall was the lowest (646 mm) in 1977 and rainy days were lowest (37) in 1972. The coefficient of variation and standard deviation of southwest monsoon rainy days were 15 per-cent and 7 mm (Table-1) respectively. A rainfall of 721 mm could be expected with 97 per-cent probability while 937 mm, 1205 mm and 1398 mm of rainfall may be expected with 75, 50 and 25 per-cent probability (Table. 1).

Seasonal rainfall

The rainfall data on mean, standard deviation, coefficient of variation and per-cent contribution of seasonal rainfall to total annual are presented in Table-2. The mean rainfall of 963 mm is received in *kharif* season contributing 80.2 per-cent to total annual rainfall with coefficients of variation of 28 per-cent and standard deviation of 275 mm indicating its dependability. Summer rainfall also contributes substantial amount of 112 mm and (9.3 per-cent to the total) with the coefficient of variations of 78 per-cent.

Monthly rainfall

It is seen that rainfall in this region increases from January onwards, attains a flat peak during July and August and then falls to the lowest value of 7 mm in December. Premonsoon showers normally start from mid May itself. During 30 years, deficiency occurred only twice in July and thrice-in August (Table 2). July was the wettest month (319 mm) followed by August (259 mm). It is the main source of *kharif* rainfall in Sabour and brings rain from 1st week of June. December was the least contributing month (7 mm) followed by January (16 mm) during *rabi* growing season.

Weekly probability

The weekly probability of receiving assured rainfall of 30, 50 and 70 mm the initial P (W) and conditional P (W/W) probability were worked out using Markov chain model for Sabour region. Analysis revealed that initial and conditional probability of

Table 1: Rainfall features during monsoon months and distribution of classification at Sabour (1972-2001)

Years	Rainfall (mm)		Rainy days		Classification	
	Annual	Monsoon	Annual	Monsoon	Annual	Monsoon
1972	721	663.1	42	37	Drought	Drought
1973	1717	1268.6	69	46	Excess	Excess
1974	1170	1024.1	49	38	Normal	Normal
1975	765	678.3	55	42	Drought	Drought
1976	914	712.1	53	41	Drought	Drought
1977	979	646	67	45	Normal	Drought
1978	937	681.2	71	52	Drought	Drought
1979	821	655	46	32	Drought	Drought
1980	1207	1020.6	66	53	Normal	Normal
1981	1024	713.7	64	41	Normal	Drought
1982	892	764.8	49	39	Drought	Drought
1983	896	687.9	50	36	Drought	Drought
1984	1368	1223.4	67	59	Normal	Excess
1985	1220	884.1	61	47	Normal	Normal
1986	1331	851.6	61	42	Normal	Normal
1987	1945	1817.9	61	53	Excess	Excess
1988	1205	1040.6	60	47	Normal	Normal
1989	1128	1020	58	52	Normal	Normal
1990	941	755.9	65	49	Drought	Drought
1991	1306	1127.7	65	48	Normal	Normal
1992	826	691.1	52	41	Drought	Drought
1993	1441	1077.9	72	48	Excess	Normal
1994	996	871.9	53	43	Normal	Normal
1995	1439	1233.2	56	44	Excess	Excess
1996	1278	1095.7	61	48	Normal	Normal
1997	1398	1167.5	71	55	Normal	Excess
1998	1330	999.3	66	46	Normal	Normal
1999	1995	1338.1	75	56	Excess	Excess
2000	1423	1230.1	68	57	Normal	Normal
2001	1414	964.6	73	52	Normal	Normal
Mean	1201	963	61	46		
CV	27	28	14	15		
SD	323	275	9	7		

Table 2: Normal, above normal and drought statistics based on monthly and seasonal rainfall analysis for Sabour.

Season	Months	Mean (mm)	SD	CV (%)	A1 (mm)	A2 (mm)	EM	EP (%)	NM	NP (%)	DM	DP (%)
Summer	March	11	15	138	5.5	22	5	16.7	10	33.3	15	50.0
	April	19	25	129	9.5	38	5	16.7	11	36.7	14	46.7
	May	82	68	83	41.0	164	2	6.7	16	53.3	12	40.0
	Total	112	29	78			12		37		41	
Kharif	June	185	120	65	92.5	370	1	3.3	23	76.7	6	20.0
	July	319	122	38	159.5	638	-	0	28	93.3	2	6.7
	August	259	152	59	129.5	518	1	3.3	26	86.7	3	10.0
	September	200	122	61	100	400	3	10	20	66.7	7	23.3
	Total	963	275	28			5		97		18	
Rabi	October	82	97	119	41.0	164	6	20	14	46.7	10	33.3
	November	10	23	234	5.0	20	5	16.7	4	13.3	21	70.0
	December	7	14	202	3.5	14	5	16.7	5	16.7	20	66.7
	January	15	16	111	7.5	30	5	16.7	10	33.3	15	50.0
	February	12	13	105	6.0	24	8	26.7	8	26.7	14	46.7
	Total	126	60	236			29		41		80	
Annual		1201	323	27	1524	878	46		175		139	

A1= dry limit month, A2= excessive rainfall month limit, EM = no. of years having excessive rainfall month, EP = per-cent of excess month, NM = no. of years having normal month, NP = per-cent of normal month, DM= no. of years having drought month and DP= per-cent of drought month.

getting 30, 50 and 70 mm rainfall during 26th to 39th standard weeks were more than 50 per-cent (Table 3). The probability of receiving 30 mm rainfall exceeded the dependable limit in 25th week and continued till 42nd week. To utilize monsoon rain most effectively, upland rice can be substituted with other low water requiring high value crops like maize, cowpea, pigeonpea, groundnut etc. through sole or intercropping ensuring proper weed management. The higher amount of rainfall could be utilized for rice transplanting starting from the first fortnight of July. Another advantage of growing these crops in the first fortnight of June is that they could be harvested within September and other crops like blackgram, greengram etc. could be sown immediately utilizing rainfall of September and October. There is continuous dry period from 1st to 22nd week and from 43rd week onwards i.e., last week of October, which could be utilized for harvesting of *kharif* crops and field preparation for *rabi* crops. Since the winter rainfall is uncertain and erratic, residual moisture in medium and low land can properly be utilized for growing second crop under rainfed conditions. High value winter crops could be grown only with supplemental irrigation starting from the first week of November.

The surplus of water exceeding 40 to 100 mm can be harvested successfully in the years of its occurrence and can be recycled not only to save the crop during period of severe moisture stress but also to raise a second crop like wheat, gram and mustard for increasing the cropping intensity and net return from the agriculture cultivated lands.

REFERENCES

Deka, R.L.and Nath, K.K. (2000). Rainfall analysis for rainfall crop planning in the upper Brahmputra valley zone of Assam. *J. Agrometeorol* 2 (1): 47-53.

Hundal, S.S.and Kaur, Prabhjyoti.(2002). Annual and Seasonal climatic variability at different location of Punjab state. *J. Agrometeorol* 4 (2): 113- 125.

Jadhav, J.D. Mokashi, D.D. Shewale, M.R. and Patil, J.D. (1999). Rainfall probability analysis for crop planning in scarcity zone of Maharashtra. *J. Agrometeorol.,* 1 (1): 59-64.

Jayabhaye, P.R., Purkar, J.K. and Andhale, R.P. (2003). A note of relationship of monsoon rainfall with yield of rice (Oryza sativa) crop at Igatpuri. *J.*

Table 3: Initial and conditional probabilities of rainfall (30, 50 and 70 mm) at Sabour (1972-2001)

Week	Mean rainfall (mm)	30 mm			50 mm			70 mm		
		(W)	(W/W)	(W/D)	(W)	(W/W)	(W/D)	(W)	(W/W)	(W/D)
22	21.1	0.20	0.25	0.18	0.10	0.00	0.13	0.07	0.00	0.07
23	29.6	0.33	0.50	0.29	0.23	0.67	0.19	0.13	0.00	0.14
24	38.6	0.40	0.60	0.30	0.33	0.43	0.30	0.23	0.75	0.15
25	42.5	0.50	0.67	0.39	0.33	0.20	0.40	0.27	0.00	0.35
26	76.9	0.77	0.67	0.87	0.50	0.40	0.55	0.43	0.38	0.45
27	76.6	0.73	0.70	0.86	0.57	0.47	0.67	0.40	0.38	0.41
28	80.4	0.60	0.64	0.50	0.60	0.71	0.46	0.43	0.50	0.39
29	54.1	0.70	0.72	0.67	0.43	0.39	0.50	0.33	0.31	0.35
30	72.1	0.70	0.67	0.78	0.47	0.54	0.41	0.37	0.30	0.40
31	76.6	0.67	0.76	0.44	0.47	0.57	0.38	0.43	0.55	0.37
32	48.9	0.53	0.50	0.60	0.43	0.36	0.50	0.27	0.23	0.29
33	52.5	0.50	0.56	0.43	0.37	0.31	0.41	0.23	0.13	0.27
34	72.0	0.67	0.60	0.73	0.57	0.45	0.63	0.47	0.43	0.48
35	41.0	0.53	0.55	0.50	0.33	0.29	0.38	0.20	0.14	0.25
36	46.6	0.53	0.63	0.43	0.37	0.40	0.35	0.23	0.17	0.25
37	51.1	0.53	0.50	0.57	0.47	0.45	0.47	0.33	0.14	0.39
38	44.8	0.37	0.38	0.36	0.20	0.21	0.19	0.17	0.10	0.20
39	47.5	0.50	0.36	0.58	0.30	0.33	0.29	0.23	0.40	0.20
40	38.4	0.37	0.33	0.40	0.33	0.22	0.38	0.20	0.14	0.22
41	24.9	0.33	0.36	0.32	0.20	0.20	0.20	0.10	0.33	0.04
42	16.8	0.17	0.30	0.10	0.10	0.33	0.04	0.07	0.00	0.07
43	2.9	0.03	0.00	0.04	0.03	0.00	0.04	0.00	0.00	0.00

Agrometeorol., 5 (1): 138-140.

Nath, K.K and Deka, R.L.(2002). Perturbations of climatic elements of Jorhat, Assam. *J. Agrometeorol.*, 4(1): 87-91.

Pandey, S.C., Singh, R.D. and Gupta, H.S.(2002). Analysis of meteorological drought based on rainfall data of Hawalbagh, Almora, *Indian J. Soil Cons.*98 (2): 186- 189.

Singh, R.S., Ramakrishna, Y.S. and Purohit, R.S. (1991). Rainfall characteristic analysis of Kutch (Gujarat) region of India. Annals Arid zone .30(2) 93-100.

Srivastava, A; Sastri, A.S.R.A.S. and Naidu, D. (2000). A note on drought and rice productivity in Chattisgarh state *J. Agrometeorol.*, 42(1): 75-81.

Thornthwaite, C.W. and Mather, J.R. (1955). The water balance. Publication in Climatology; Drexel Institute of Technology. Vol.8.No.1.

Vairavan, K.Singh, Durai, R, Kannam Kand Goneche, C. (2002). Sustainable agricultural planning with Agrometeorology observation. *Madras Agric. J* 89 (1-3): 151-154.

Virmani, S.M., M.V.K. Sivakumar and S.R.Reddy. (1982). Rainfall probability estimates of selected location of semi-arid India.2nd Edn.ICRICAT. Res. Bull. No1.

Virmani, S.M., M.V.K. Sivakumar and S.R.Reddy. (1980). Climatological feature of SAT in relation to the farming systems research programme. In Proc. Int. workshop on Agroclimatology Research needs of the Semi-arid tropics; 1978 held at ICRICAT, Hyderabad, Nov.22-24, PP 5-16.