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Weekly rainfall variability and probability analysis for resource planning at Hadagali, Karnataka

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■ ABSTRACT : Daily rainfall data of 35 years (1978-2012) of Hadagali were used for weekly analysis to study the variability and the probability level of occurrence. The highest mean weekly rainfall (42.5 mm) was received during 39th SMW. The CV was less than 150 per cent during 22-33, 35 and 37-42nd SMW, indicated that the rainfall was consistent during those weeks. The rainfall analysis showed that the crop could be recommended under dry land during 22-33, 35 and 37-42nd SMW as the rainfall was more consistent during these periods as compared to 18th to 21st SMW, which also fell under south west monsoon period. The study indicated that rainfall amount of more than 20 mm of rainfall could be expected during 38-40th SMW with 50 per cent probability, which hints for rain water harvesting.

■ KEY WORDS : Daily rainfall, Co-efficient of variation, Standard meteorological weeks, Variability, Probability

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Hadagali is situated in the Northern Dry Zone (agro-climatic zone) of Karnataka state in Ballari district and located at 15°00'57.46" N latitude and 75°56'09.97"E longitude with an elevation of 561 m above mean sea level. In agricultural planning, rainfall variability analysis aids to take farm decisions on time of sowing, inter culture operations, fertilizer application and other agricultural operations. Several studies (Subbulakshmi *et al*., 2005; Singh *et al*., 2009; Jat *et al.*, 2010; Nemichandrappa *et al*., 2010; Pawar *et al.*, 2015) reported the advantages of working out weekly rainfall probabilities for a station or for an agro-climatic region. Probability analysis can be used for predicting the occurrence of future events of rainfall from the available data with the help of statistical methods (Kumar and Kumar, 1989). Chattopadhyay and Ganesan (1995) studied the probability of occurrence of annual and seasonal rainfall, wet and dry spells on monthly and weekly basis during North–East monsoon season for various stations in Tamil Nadu. It has been observed that the number of wet spells was more from July to September in the stations of north coastal Tamil Nadu. During the north–east monsoon season wet weeks are mainly confined to the same stations. Analysis of rainfed crop production shows more productivity in North than in South coastal Tamil Nadu. The initial and conditional probability approach would be relatively good method for rainfall analysis, especially in the regions where rainfall is erratic or where short dry periods can be expected within the wet season. Gupta *et al*. (1975) suggested that the rainfall at 80 per cent probability can safely be taken as assured rainfall, while that of 50 per cent probability is the medium limit for taking dry risk. Wubengeda *et al*. (2014) employed the markov–chain model to study the probability of dry and wet spells for Dhera, region and weekly rainfall data was considered as standard for the probabilities of occurrences of dry and wet weeks. Initial and conditional probabilities at 20 mm threshold limit per week showed that the supplementary irrigation and moisture conservation practice need to be practiced between 38th and 40th week for short duration crops.

Objective:

Estimation of rainfall amount at various probability levels and weekly dry and wet spells.

METHODOLOGY

The daily rainfall data from 1978-2012 (35 years) were collected from Directorate of Economics and Statistics, M.S. Building, Bengaluru, Karnataka. The daily rainfall was aggregated into weekly and used for the analysis. Three types of probabilities *i.e.*, incomplete gamma distribution probability, initial and conditional probability indices were used for the study.

Incomplete gamma distribution probability :

One of the important problems in hydrology, deals with interpreting a past record of rainfall events, in terms of future probabilities of occurrences. There are many probability distributions that have been found to be useful for hydrologic frequency analysis. Hence, incomplete gamma distribution (IGD) was used (Manjunath *et al*., 2014). Biswas and Khambeta (1974) and computed the lowest amount of rainfall at different probability level by fitting gamma distribution probability model to week by week total rainfall of 82 stations in dry farming tract of Maharashtra. The amount of rainfall at different probability levels (10-90 %) called assured rainfall have been computed for each standard week by fitting incomplete gamma distribution model. Tables of assured rainfall at different probability levels gets using gamma probability tool. Probability analysis of rainfall offers a better scope for predicting the minimum assured rainfall to help in crop planning in rainfed regions.

Weekly initial and conditional probabilities (Markov–chain model) :

The success or failure of crops particularly under rainfed conditions is closely linked with the rainfall patterns. Simple criterion related to sequential phenomenon like dry and wet spell was used for analysing rainfall data to obtain specific information needed for crop planning and for carrying out agricultural operations. Rainfall of 20 mm per week is adequate for all the growth stages of all the crops grown. Thus, if in a given week the rainfall received is less than 20 mm that week can be designated as a dry week and *vice versa* (Pandharinath, 1991). On the basis of this criterion each week was categorised as a dry week and wet week and respective probabilities were calculated by Markov chain model procedure (Singh and Bhandari, 1998; Kichar *et al*., 2000; Panigrahi and Panda, 2002; Gouranga, 2003; Senthilvelan *et al*., 2012; Mangaraj *et al.*, 2013; Kar *et al.*, 2014).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Rainfall variability :

The highest mean weekly rainfall (42.5 mm) was received during 39th SMW (Table 1). The CV was less than 150 per cent during 22-33, 35 and 37-42nd SMW, indicated that the rainfall was consistent during those weeks. It was also observed that, within monsoon period, during 18th to 21st SMW, the rainfall was not sufficient to support the crop. The above rainfall analysis showed that the crop could be recommended under dry land during 22-33, 35 and 37-42nd SMW as the rainfall was more consistent during these periods as compared to 18th to 21st SMW, which also fell under south west monsoon period. So, sowing can be recommended after 21st SMW onwards.

Incomplete gamma distribution probability :

The incomplete gamma distribution probability analysis for weekly rainfall indicated that, more than 20 mm of rainfall could be expected during 38, 39 and 40th SMW with 50 per cent probability (Table 1) which shows the potentiality for rain water harvesting. At 75 per cent probability atleast 3 mm per week was expected during 22nd– 40th SMW which indicates potentiality for crop growing in dryland areas. Whereas, with 25 per cent probability, the expected rainfall of more than 20 mm was observed from 22-26 and 28-42nd SMW (Table 1). Sarkar and Biswas (1988) reported that even 30 per cent

Table 1 : Weekly mean rainfall and rainfall at various probabilities (IGD) at Hadagali

SMW	Period	Mean (mm)	CV (%)	90%	75%	50%	25%	10%
1	Jan. 1 - 7	0.1	492.8	0.8	0.9	1.0	1.2	1.4
2	8 - 14	0.3	471.8	0.5	0.7	1.2	1.8	2.4
3	15 - 21	0.4	505.0	0.4	0.7	1.2	1.8	2.5
4	22 - 28	0.0	-	0.5	0.7	0.9	1.3	1.6
5	29 – Feb. 4	0.0	-	0.5	0.7	0.9	1.3	1.6
6	5 - 11	0.4	438.3	0.0	0.0	0.4	2.8	4.1
7	12 - 18	0.0	-	0.0	0.3	0.0	1.7	2.3
8	19 – 25	0.0	-	0.0	0.3	0.0	1.7	2.3
9	26 – Mar. 4	0.1	591.6	0.6	0.8	1.1	1.4	1.8
10	5 – 11	0.1	591.6	0.7	0.8	1.1	1.3	1.6
11	12 -18	0.5	412.4	0.4	0.7	1.3	2.0	2.8
12	19 – 25	4.7	532.9	0.1	0.5	2.4	7.5	15.8
13	26 – Apr. 1	1.0	412.6	0.3	0.7	1.5	2.7	4.4
14	2 – 8	5.4	218.6	0.2	0.9	3.3	8.7	16.8
15	9 – 15	7.7	158.5	0.3	1.3	4.6	11.7	22.5
16	16 – 22	12.0	204.8	0.2	1.4	6.1	17.3	34.8
17	23 – 29	13.4	184.7	0.3	1.5	6.7	19.1	38.7
18	30 May – 6	9.1	181.2	0.2	1.2	4.8	13.5	27.0
19	7 – 13	9.8	172.4	0.3	1.5	5.5	14.6	28.4
20	14 – 20	12.0	123.6	0.7	2.6	7.8	17.9	32.3
21	21 – 27	10.0	164.0	0.3	1.6	5.8	15.0	28.7
22	28 – Jun. 3	17.1	121.8	0.8	3.2	10.3	24.8	45.6
23	4 – 10	22.5	102.5	2.1	6.1	15.6	32.5	55.3
24	11 – 17	17.6	98.6	2.0	5.4	13.0	25.7	42.5
25	18 – 24	16.6	129.1	1.2	4.1	11.2	24.3	42.4
26	25 – July 1	13.6	122.5	1.2	3.7	9.6	20.3	34.7
27	Jul 2 – 8	11.5	123.9	1.0	3.2	8.2	17.3	29.6
28	9 – 15	22.8	95.2	2.8	7.3	16.9	32.9	53.9
29	16 – 22	14.6	76.8	3.1	6.3	12.3	21.3	32.4
30	23 – 29	17.3	103.8	2.4	5.9	13.2	25.3	40.7
31	30 – Aug. 5	19.4	94.0	2.9	6.9	15.0	28.2	45.0
32	6 – 12	24.1	133.0	2.0	6.1	16.3	34.7	59.9
33	13 – 19	15.7	114.5	2.1	5.3	12.0	23.1	37.4
34	20 – 26	19.4	151.3	1.0	3.9	12.1	28.1	50.9
35	27 – Sep. 2	25.3	137.6	1.8	6.0	16.7	36.4	63.8
36	Sep. 3 – 9	15.7	158.7	1.0	3.5	10.2	23.0	40.9
37	10 – 16	28.5	131.1	0.9	4.4	15.6	40.1	76.5
38	17 – 23	40.5	110.8	1.1	5.6	21.3	56.0	108.7
39	24 – 30	42.5	87.4	4.3	12.0	29.7	60.3	101.1
40	Oct. 1 – 7	40.7	124.2	2.1	8.0	24.7	57.4	104.1
41	8 – 14	21.1	164.7	0.5	2.8	11.1	29.8	58.3
42	15 – 21	14.9	141.1	0.6	2.5	8.7	21.7	41.0
43	22 – 28	12.7	202.7	0.3	1.6	6.6	18.4	36.6
44	29 – Nov. 4	8.7	196.8	0.4	1.6	5.4	13.3	24.8
45	5 – 11	12.5	208.4	0.3	1.5	6.4	18.1	36.3
46	12 – 18	14.5	231.1	0.1	1.1	6.0	19.8	43.1
47	19 – 25	2.5	329.4	0.2	0.6	2.0	4.8	8.9
48	26 Dec. – 2	6.7	424.1	0.1	0.5	3.0	9.9	21.6
49	3 – 9	1.8	412.5	0.2	0.6	1.7	3.8	6.8
50	10 – 16	2.4	430.6	0.1	0.5	1.9	4.6	8.7
51	17 – 23	0.0	-	0.5	0.7	0.9	1.3	1.6
52	24 – 31	1.4	405.9	0.2	0.6	1.6	3.3	5.7

Table 2 : Weekly initial and conditional probabilities for getting 20 mm of rainfall in Hadagali

SMW	Period	Initial Prob.		Conditional Prob.			
		P(W)	P(D)	P(W/W)	P(D/W)	P(D/D)	P(W/D)
1	Jan. 1 - 7	0	100	0	100	100	0
2	8 - 14	0	100	0	100	100	0
3	15 - 21	0	100	0	100	100	0
4	22 - 28	0	100	0	100	100	0
5	29 – Feb. 4	0	100	0	100	100	0
6	5 - 11	0	100	0	100	100	0
7	12 - 18	0	100	0	100	100	0
8	19 – 25	0	100	0	100	100	0
9	26 – Mar. 4	0	100	0	100	100	0
10	5 – 11	0	100	0	100	100	0
11	12 -18	0	100	0	100	100	0
12	19 – 25	3	97	0	100	97	3
13	26 – Apr. 1	3	97	0	100	97	3
14	2 – 8	11	89	0	100	88	12
15	9 – 15	20	80	25	75	81	19
16	16 – 22	17	83	14	86	82	18
17	23 – 29	20	80	50	50	86	14
18	30 May – 6	20	80	43	57	86	14
19	7 – 13	20	80	14	86	79	21
20	14 – 20	23	77	43	57	82	18
21	21 – 27	14	86	13	88	85	15
22	28 – Jun. 3	37	63	0	100	57	43
23	4 – 10	46	54	31	69	45	55
24	11 – 17	37	63	31	69	58	42
25	18 – 24	26	74	46	54	86	14
26	25 – July 1	23	77	33	67	81	19
27	Jul. 2 – 8	26	74	38	63	78	22
28	9 – 15	46	54	56	44	58	42
29	16 – 22	29	71	38	63	79	21
30	23 – 29	31	69	30	70	68	32
31	30 – Aug. 5	34	66	36	64	67	33
32	6 – 12	40	60	33	67	57	43
33	13 – 19	26	74	36	64	81	19
34	20 – 26	23	77	22	78	77	23
35	27 – Sep. 2	34	66	38	63	67	33
36	Sep. 3 – 9	20	80	33	67	87	13
37	10 – 16	43	57	71	29	64	36
38	17 – 23	51	49	67	33	60	40
39	24 – 30	66	34	78	22	47	53
40	Oct. 1 – 7	51	49	48	52	42	58
41	8 – 14	29	71	28	72	71	29
42	15 – 21	26	74	50	50	84	16
43	22 – 28	20	80	11	89	77	23
44	29 – Nov. 4	17	83	0	100	79	21
45	5 – 11	14	86	17	83	86	14
46	12 – 18	26	74	40	60	77	23
47	19 – 25	6	94	11	89	96	4
48	26 Dec. – 2	6	94	0	100	94	6
49	3 – 9	6	94	0	100	94	6
50	10 – 16	6	94	0	100	94	6
51	17 – 23	0	100	0	100	100	0
52	24 – 31	3	97	0	100	97	3

probability rainfall can be taken as weekly assured rainfall for computing moisture index if the annual rainfall is less than 400 mm.

Weekly initial and conditional probability :

Weekly initial wet (P (W) and conditional (P (W/W) (previous week wet followed by this week wet) probabilities for getting more than 20 mm rainfall were worked out and presented in Table 2. The initial wet week rainfall probabilities indicated that, there was no any week having initial probability more than 70 per cent. The chance of getting weekly rainfall of 20 mm with more than 50 per cent probability was observed during 38-40th SMW. Similarly, wet week followed by wet week probability was observed to be more than 65 per cent during 37-39th SMW which shows potentiality for rain water harvesting and has similar results obtained through incomplete gamma distribution probability also during that period. During crop growing season (23-40th SMW) the probability of dry week (P (D)) was found to be more than 50 per cent except 38-40th SMW. This hints for importance of *in-situ* moisture conservation practices to be followed even during potential crop growing period in dryland regions.

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