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## PROBABILITY ANALYSIS OF DRY AND WET SPELLS AT SANGLI DISTRICT

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**Abstract:-**The study is carried out for weekly rainfall for the period from 1981 to 2012 at ten stations of Sangli District. Markov chain probability model has been used extensively to determine the long-term frequency behaviour of wet and dry weather spells. The probabilities occurrence of two or more dry/wet weeks preceded by dry/wet weeks has been evaluated. The probabilities of two or more consecutive dry/wet weeks have been worked out. Some interesting findings are discussed.

**Keywords:** Markov chain model, Dry spells, Wet spells, Transitional probability, Initial probability.

### INTRODUCTION

In the present study, the weekly rainfall data from 1981 to 2012 were obtained from India Metrological Department, Pune, recorded at ten stations of Sangli district namely Shirala, Islampur, Kasegaon, Sangli, Miraj, Tasgaon, Jath, Kavathe Mahankal, Palus and Atpadi.

The Sangli District is one of the important district of Maharashtra state. It is situated between the latitudes 16°45'N and 17°33'N and longitudinal of 73°42' East and 74°40' East. Its east-west length is 205 km and north-south breadth is only 96 km. The total area of the district according to 2011 census is about 8572 Sq.km. The climate gets hotter and drier towards the east and humidity goes on increasing towards the west. The maximum temperature is 42° C while the minimum temperature is 14° C.

Transition probability matrix in Markov chain plays an important role in evaluating frequency behaviour of wet and dry weather spells. The Markov chain probability model [Pandharinath (1991)] has been used for drought and wet frequencies during rain periods. Robertson (1982) has used the 30 mm or more rainfall in 10 days duration as the criterion for deciding the spell as wet and less than 30 mm rainfall as a dry spell. Pandharinath (1991) and Das & Senapati (1992) have taken 20 mm or more rainfall in a week as a wet period and less than 20 mm a dry period. In the present study, based on Das and Senapati (1992), it is assumed that the week is wet if it receives 20 mm or more rainfall, otherwise dry.

### 2. DATA AND METHODOLOGY

Day wise rainfall data for 32 years, for the period 1981 to 2012 are collected from India Metrological Department, Pune, recorded at ten stations of Sangli district. Here, based on Das and Senapati (1992), it is assumed that the week is wet if it receives 20 mm or more rainfall, otherwise dry. Table 1 gives the standard meteorological weeks.

**Table 1 : Standard meteorological weeks**

MW	Calendar Month	Dates From-To	MW	Calendar Month	Dates From-To
1	January	01-07	27	July	02-08
2	"	08-14	28	"	09-15
3	"	15-21	29	"	16-22
4	"	22-28	30	"	23-29
5	"	29-04 February	31	"	30-05 August
6	February	05-11	32	August	06-12
7	"	12-18	33	"	13-19
8	"	19-25	34	"	20-26
9*	"	26-04 March	35	"	27-02 September
10	March	05-11	36	September	03-09
11	"	12-18	37	"	10-16
12	"	19-25	38	"	17-23
13	"	26-01 April	39	"	24-30
14	April	02-08	40	October	01-07
15	"	09-15	41	"	08-14
16	"	16-22	42	"	15-21
17	"	23-29	43	"	22-28
18	"	30-06 May	44	"	29-04 November
19	May	07-13	45	November	05-11
20	"	14-20	46	"	12-18
21	"	21-27	47	"	19-25
22	"	28-03 June	48	"	26-02 December
23	June	04-10	49	December	03-09
24	"	11-17	50	"	10-16
25	"	18-24	51	"	17-23
26	"	25-01 July	52**	"	24-31

\*MW. No. 9 is of 8 days in leap year.      \*\*MW. No. 52 is of 8 days

3. Probability Analysis of Dry and Wet Spells at Different Stations of Sangli District.

The formulae used in this study are

$P(d)=F(d)/N$ ,  
 $P(w)=F(w)/N$ ,  
 Where, P(d) = Probability of the week being dry.  
 F(d)=Frequency of dry weeks, N= Total number of years of data being used.  
 P(w)= Probability of the week being wet,  
 P(d) and P(w) are known as initial probabilities.  
 F(w)=Frequency of wet weeks

The consecutive dry and wet probabilities are defined as under

$P(2D)=P(dw1)*P(ddw2)$ ,  
 $P(3D)= P(dw1)*P(ddw2)*P(ddw3)$   
 Where, P(2D)= Probability of 2 consecutive dry weeks  
 P(dw1)= Probability of the first week being dry  
 P(ddw2)=Probability of the 2nd week consecutive dry week given the preceding week being dry  
 P(3D)=Probability of 3 consecutive dry week.  
 P(ddw3)=Probability of 3rd week being dry given the preceding week being dry.

In a similar way P(w/d), probability of wet week preceded by dry week; P(d/d), probability of dry week preceded by another dry week; P(d/w), probability of dry week preceded by wet week; P(w/w), probability of wet week preceded by another wet week; P(2W), probability of 2 consecutive wet weeks; and P(3W)=probability of 3

consecutive wet weeks are computed. Here  $P(w/w)$ ,  $P(d/w)$ ,  $P(d/d)$  and  $P(w/d)$  are known as transitional probabilities.

For the comparison purpose here we find initial probabilities and transitional probabilities for Atpadi and Shirala stations only. On the same way we can find initial probabilities and transitional probabilities for all the stations of Sangli district.

**Table 2: Initial and transitional probabilities for Atpadi station**

<b>Atpadi</b>						
Week	Initial Probabilities (%)		Transitional Probabilities (%)			
	P(w)	P(d)	P(w/w)	P(d/w)	P(d/d)	P(w/d)
1	0.00	100.00	0.00	0.00	100.00	0.00
2	0.00	100.00	0.00	0.00	100.00	0.00
3	0.00	100.00	0.00	0.00	100.00	0.00
4	0.00	100.00	0.00	3.23	96.77	0.00
5	3.23	96.77	0.00	0.00	96.77	3.23
6	0.00	100.00	0.00	3.23	96.77	0.00
7	3.23	96.77	0.00	0.00	96.77	3.23
8	0.00	100.00	0.00	0.00	100.00	0.00
9	0.00	100.00	0.00	0.00	100.00	0.00
10	0.00	100.00	0.00	0.00	100.00	0.00
11	0.00	100.00	0.00	3.23	96.77	0.00
12	3.23	96.77	0.00	3.23	93.55	3.23
13	3.23	96.77	0.00	0.00	96.77	3.23
14	0.00	100.00	0.00	3.23	96.77	0.00
15	3.23	96.77	0.00	3.23	93.55	3.23
16	3.23	96.77	0.00	0.00	96.77	3.23
17	0.00	100.00	0.00	12.90	87.10	0.00
18	12.90	87.10	0.00	6.45	80.65	12.90
19	6.45	93.55	0.00	6.45	87.10	6.45
20	6.45	93.55	3.23	19.35	74.19	3.23
21	22.58	77.42	3.23	16.13	61.29	19.35
22	19.35	80.65	3.23	19.35	61.29	16.13
23	22.58	77.42	38.71	19.35	58.06	16.13
24	25.81	74.19	3.23	22.58	51.61	22.58
25	25.81	74.19	9.68	6.45	67.74	16.13
26	16.13	83.87	3.23	12.90	70.97	12.90
27	16.13	83.87	0.00	16.13	67.74	16.13
28	16.13	83.87	0.00	9.68	74.19	16.13
29	9.68	90.32	3.23	12.90	77.42	6.45
30	16.13	83.87	3.23	6.45	77.42	12.90
31	9.68	90.32	3.23	6.45	83.87	6.45
32	9.68	90.32	3.23	12.90	77.42	6.45
33	16.13	83.87	3.23	16.13	67.74	12.90
34	19.35	80.65	6.45	19.35	61.29	12.90
35	25.81	74.19	6.45	16.13	58.06	19.35

36	22.58	77.42	12.90	29.03	48.39	9.68
37	41.94	58.06	25.81	16.13	41.94	16.13
38	41.94	58.06	29.03	32.26	25.81	12.90
39	61.29	38.71	32.26	29.03	9.68	29.03
40	61.29	38.71	25.81	9.68	29.03	35.48
41	35.48	64.52	12.90	9.68	54.84	22.58
42	22.58	77.42	6.45	12.90	64.52	16.13
43	19.35	80.65	3.23	3.23	77.42	16.13
44	6.45	93.55	0.00	3.23	90.32	6.45
45	3.23	96.77	0.00	6.45	90.32	3.23
46	6.45	93.55	0.00	0.00	93.55	6.45
47	0.00	100.00	0.00	3.23	96.77	0.00
48	3.23	96.77	0.00	3.23	93.55	3.23
49	3.23	96.77	0.00	3.23	93.55	3.23
50	3.23	96.77	0.00	0.00	96.77	3.23
51	0.00	100.00	0.00	3.23	96.77	0.00
52	3.23	96.77	0.00	0.00	96.77	3.23

Table 3: Initial and transitional probabilities for Shirala station

Shirala						
Week	Initial Probabilities (%)		Transitional Probabilities (%)			
	P(w)	P(d)	P(w/w)	P(d/w)	P(d/d)	P(w/d)
1	3.23	96.77	0.00	6.45	90.32	3.23
2	6.45	93.55	0.00	0.00	93.55	6.45
3	0.00	100.00	0.00	0.00	100.00	0.00
4	0.00	100.00	0.00	0.00	100.00	0.00
5	0.00	100.00	0.00	0.00	100.00	0.00
6	0.00	100.00	0.00	0.00	100.00	0.00
7	0.00	100.00	0.00	0.00	100.00	0.00
8	0.00	100.00	0.00	0.00	100.00	0.00
9	0.00	100.00	0.00	3.23	96.77	0.00
10	3.23	96.77	0.00	0.00	96.77	3.23
11	0.00	100.00	0.00	3.23	96.77	0.00
12	3.23	96.77	0.00	3.23	93.55	3.23
13	3.23	96.77	0.00	3.23	93.55	3.23
14	3.23	96.77	0.00	3.23	93.55	3.23
15	3.23	96.77	3.23	0.00	96.77	0.00
16	3.23	96.77	3.23	12.90	83.87	0.00
17	16.13	83.87	3.23	9.68	74.19	12.90
18	12.90	87.10	0.00	6.45	80.65	12.90
19	6.45	93.55	0.00	9.68	83.87	6.45
20	9.68	90.32	3.23	22.58	67.74	6.45

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21	25.81	74.19	12.90	19.35	54.84	12.90
22	32.26	67.74	16.13	19.35	48.39	16.13
23	35.48	64.52	22.58	41.94	22.58	12.90
24	64.52	35.48	48.39	22.58	12.90	16.13
25	70.97	29.03	41.94	12.90	16.13	29.03
26	54.84	45.16	41.94	19.35	25.81	12.90
27	61.29	38.71	41.94	12.90	25.81	19.35
28	54.84	45.16	45.16	35.48	9.68	9.68
29	80.65	19.35	58.06	19.35	0.00	22.58
30	77.42	22.58	54.84	12.90	9.68	22.58
31	67.74	32.26	48.39	19.35	12.90	19.35
32	67.74	32.26	54.84	19.35	12.90	12.90
33	74.19	25.81	38.71	16.13	9.68	35.48
34	54.84	45.16	25.81	16.13	29.03	29.03
35	41.94	58.06	35.48	16.13	41.94	6.45
36	51.61	48.39	19.35	9.68	38.71	32.26
37	29.03	70.97	16.13	32.26	38.71	12.90
38	48.39	51.61	29.03	19.35	32.26	19.35
39	48.39	51.61	32.26	19.35	32.26	16.13
40	51.61	48.39	25.81	25.81	22.58	25.81
41	51.61	48.39	12.90	9.68	38.71	38.71
42	22.58	77.42	3.23	9.68	67.74	19.35
43	12.90	87.10	3.23	6.45	80.65	9.68
44	9.68	90.32	3.23	12.90	77.42	6.45
45	16.13	83.87	3.23	6.45	77.42	12.90
46	9.68	90.32	0.00	0.00	90.32	9.68
47	0.00	100.00	0.00	3.23	96.77	0.00
48	3.23	96.77	3.23	0.00	96.77	0.00
49	3.23	96.77	0.00	3.23	93.55	3.23
50	3.23	96.77	0.00	0.00	96.77	3.23
51	0.00	100.00	0.00	0.00	100.00	0.00
52	0.00	100.00	0.00	3.23	96.77	0.00

Table 4 and Table 5 gives the consecutive Dry and Wet probability analysis of Atpadi and Shirala station.

Table4: Consecutive Dry and Wet probability analysis of Atpadi station

Atpadi				
Week No.	Consecutive Dry Probability (%)		Consecutive Wet Probability (%)	
	P(2D)	P(3D)	P(2W)	P(3W)
1	100.00	100.00	0.00	0.00
2	100.00	100.00	0.00	0.00
3	100.00	96.77	0.00	0.00
4	96.77	96.77	0.00	0.00
5	96.77	93.55	0.00	0.00

Probability Analysis Of Dry And Wet Spells At Sangli District

6	96.77	96.77	0.00	0.00
7	96.77	96.77	0.00	0.00
8	100.00	100.00	0.00	0.00
9	100.00	100.00	0.00	0.00
10	100.00	96.77	0.00	0.00
11	96.77	93.55	0.00	0.00
12	93.55	93.55	0.00	0.00
13	96.77	93.55	0.00	0.00
14	96.77	93.55	0.00	0.00
15	93.55	93.55	0.00	0.00
16	96.77	83.87	0.00	0.00
17	87.10	80.65	0.00	0.00
18	80.65	77.42	0.00	0.00
19	87.10	70.97	0.00	0.00
20	74.19	61.29	3.23	0.00
21	61.29	45.16	3.23	3.23
22	61.29	51.61	3.23	3.23
23	58.06	41.94	6.45	0.00
24	51.61	45.16	3.23	0.00
25	67.74	54.84	9.68	3.23
26	70.97	58.06	3.23	0.00
27	67.74	61.29	0.00	0.00
28	74.19	61.29	0.00	0.00
29	77.42	74.19	3.23	0.00
30	77.42	70.97	3.23	0.00
31	83.87	70.97	3.23	3.23
32	77.42	61.29	3.23	0.00
33	67.74	51.61	3.23	0.00
34	61.29	48.39	6.45	0.00
35	58.06	32.26	6.45	3.23
36	48.39	35.48	12.90	6.45
37	41.94	22.58	25.81	19.35
38	25.81	6.45	29.03	16.13
39	9.68	6.45	32.26	16.13
40	29.03	25.81	25.81	9.68
41	54.84	45.16	12.90	3.23
42	64.52	61.29	6.45	0.00
43	77.42	74.19	3.23	0.00
44	90.32	83.87	0.00	0.00
45	90.32	90.32	0.00	0.00
46	93.55	90.32	0.00	0.00
47	96.77	93.55	0.00	0.00
48	93.55	90.32	0.00	0.00
49	93.55	93.55	0.00	0.00
50	96.77	93.55	0.00	0.00
51	96.77	96.77	0.00	0.00
52	96.77	93.55	0.00	0.00

**Table 5: Consecutive Dry and Wet probability analysis of Shirala station**

Shirala				
Week No.	Consecutive Dry Probability (%)		Consecutive Wet Probability (%)	
	P(2D)	P(3D)	P(2W)	P(3W)
1	90.32	90.32	0.00	0.00
2	93.55	93.55	0.00	0.00
3	100.00	100.00	0.00	0.00
4	100.00	100.00	0.00	0.00
5	100.00	100.00	0.00	0.00
6	100.00	100.00	0.00	0.00
7	100.00	100.00	0.00	0.00
8	100.00	96.77	0.00	0.00
9	96.77	96.77	0.00	0.00
10	96.77	93.55	0.00	0.00
11	96.77	93.55	0.00	0.00
12	93.55	90.32	0.00	0.00
13	93.55	90.32	0.00	0.00
14	93.55	93.55	0.00	0.00
15	96.77	83.87	3.23	3.23
16	83.87	74.19	3.23	0.00
17	74.19	67.74	3.23	0.00
18	80.65	70.97	0.00	0.00
19	83.87	64.52	0.00	0.00
20	67.74	51.61	3.23	3.23
21	54.84	35.48	12.90	9.68
22	48.39	16.13	16.13	9.68
23	22.58	6.45	22.58	16.13
24	12.90	6.45	48.39	29.03
25	16.13	9.68	41.94	29.03
26	25.81	16.13	41.94	29.03
27	25.81	6.45	41.94	32.26
28	9.68	0.00	45.16	25.81
29	0.00	0.00	58.06	41.94
30	9.68	3.23	54.84	41.94
31	12.90	3.23	48.39	45.16
32	12.90	3.23	54.84	25.81
33	9.68	6.45	38.71	12.90
34	29.03	25.81	25.81	19.35
35	41.94	32.26	35.48	9.68
36	38.71	16.13	19.35	12.90
37	38.71	25.81	16.13	6.45
38	32.26	19.35	29.03	12.90
39	32.26	12.90	32.26	16.13
40	22.58	19.35	25.81	6.45

**Probability Analysis Of Dry And Wet Spells At Sangli District**

41	38.71	35.48	12.90	3.23
42	67.74	64.52	3.23	0.00
43	80.65	67.74	3.23	3.23
44	77.42	74.19	3.23	0.00
45	77.42	77.42	3.23	0.00
46	90.32	87.10	0.00	0.00
47	96.77	96.77	0.00	0.00
48	96.77	93.55	3.23	0.00
49	93.55	93.55	0.00	0.00
50	96.77	96.77	0.00	0.00
51	100.00	96.77	0.00	0.00
52	96.77	90.32	0.00	0.00

**4. RESULT AND CONCLUSION**

We make the comparison of probabilities of dry week, wet week, wet given wet, wet given dry, dry given wet and dry given dry weeks between Shirala and Atpadi station. Above table shows the probability of occurrence of dry week is very high until the end of 23rd week. The range of probability of occurrence of dry week from 1st to 23rd week is from 64.52 % to 100% for Shirala station. At the same time for Atpadi station the same probability of occurrence of dry week from 1st to 23rd week is from 77.42 % to 100%. The probability of occurrence of dry week preceded by another dry week and that of dry week by another wet week from 1st to 23rd week vary from 22.58 % to 100% and 0% to 41.94% for Shirala station. The same probability for Atpadi station varies from 58.06% to 100% and 0% to 22.58% respectively.

From 24th to 41st week the probability of wet week increases. It varies from 29.03% to 80.65% for Shirala station. The same probability for Atpadi station varies from 9.68% to 61.29%. In the same period the probabilities of dry week varies from 19.35% to 70.97 for Shirala station. The same probability for Atpadi station varies from 38.71% to 90.32%. The probability of occurrence of dry week preceded by another dry week and that of dry week by another wet week from 24th to 41st week vary from 0 % to 41.94% and 9.68% to 32.26% for Shirala station. The same probability for Atpadi station varies from 9.68% to 8.087% and 6.45% to 32.26% respectively.

The analysis of consecutive dry and wet spells (Table 4 and Table 5) reveals that there are 58.06% to 100% chances that two consecutive dry weeks will occur within the first 23rd weeks of the year for Atpadi station and the same probability for Shirala station is 22.58% to 100%. Similarly, the probability of occurrence of three consecutive dry weeks is very high from 41.94% to 100% in the first 23rd weeks of the year for Atpadi station and the same probability for Shirala station is 6.45% to 100%. The corresponding values of 2 and 3 consecutive wet weeks from 1st to 23rd week are very low 0% to 6.45% and 0% to 3.23% for Atpadi station. The same probabilities for Shirala station are 0% to 22.58% and 0% to 16.13%.

From 24th to 41st week, the chances of occurring 2 and 3 consecutive dry weeks are only within 9.68% to 83.87% and 6.45% to 74.19% respectively for the Atpadi station. The same probability for Shirala station is within 0% to 38.71% and 0% to 35.48%. Further, the weeks will get sufficient rain with 2 consecutive wet weeks with the chance of 0% to 32.26%, whereas 3 consecutive wet weeks will have chance of deficit rain within 0% to 19.35% for Atpadi station. The same probability for Shirala station is within 12.90% to 58.06% and 3.23% to 45.16% during 24th to 41st week. The study further reveals that the weeks 42nd onwards would remain under stress due to the chance that occurrences of 2 and 3 consecutive dry weeks are very high in the range of 64.52% to 96.77% and 61.29% to 96.77% for Atpadi station. The same probability for Shirala station is within 67.74% to 100% and 64.52% to 96.77%.

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