A MARKOV CHAIN MODEL FOR RAINFALL OCCURRENCE IN PAKISTAN

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SUMMARY: The rainfall probabilities for four locations; Faisalabad, Lahore, Islamabad and Murree in Pakistan, have been calculated by the method of Markov chains using the threshold values of 10 mm/decade. A program written in GWBASIC calculates these probabilities. The probabilities of dry spells for Faisalabad and Lahore are higher than the Islamabad and Murree for all the 36 decades of a year using the data of 45 years for Faisalabad, 39 for each Lahore and Islamabad and 44 years for Murree.

Key words: Rainfall probabilities, markov chains.

INTRODUCTION

Being and agricultural economy, crop yields play a vital role in the national income of Pakistan. A major determinant for better yields is timely rainfall as the growth responses of plants are often a compromise between photosynthesis and transpiration with an optimization of water use efficiency being the prime aim. The dry periods at the phonological stage can damage the crop and on the other hand are usually useful at the ripening state. The lack of rainfall in a certain area is the factor for declaring it a desert.

The rainfall data is generally available for most areas on monthly basis. There is need to know the probability of having a dry period or having a consecutive dry period of 2 or 3 decades during the growing season of a crop. This information would improve decisions about crops or varieties and the timings of the plantings of crops.

According to Gangopadhya and Sarkar (2), the rainfall has a direct relationship with the yield of wheat crop. Robertson (4) discussed the rainfall and water variability and again Robertson (5,6) and Gabriel and Neuman (1) used the method of Markov chains to calculate dry and wet spells. The Stern and Coe (9,10) gave a way to analyze and simulate the daily rainfall data; Stern *et al.* (11,12) combine the Fourier analysis, Markov chains and distribution function of daily rainfall amount. Salimi *et al.* (7,8) and Muhammad *et al.* (3) have calculated the rainfall probabilities and the probabilities of the number of rainy days.

In this article we calculate the rainfall probabilities for Faisalabad, Lahore, Islamabad and Murree using Markov chain method. A general purpose program is written in GWBASIC which is very easy to use.

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MATERIALS AND METHODS

The data collected by the Dept. of Agri. Meteorology Univ. of Agri. Faisalabad for four locations; Faisalabad, Lahore, Islamabad and Murree is used for this study. The rainfall data for Faisalabad is available for 45 years from 1944-88 and for 39 years from 1950-1988 for each Islamabad and Lahore and for 44 years for Murree from 1945-1988. The rainfall probabilities are calculated by the Markov method used by Robertson (6). Here P(D) denotes the probabilities of dry decade, P (DD) denotes the probability of dry decade preceded by a dry decade, P (W) denotes the probability of wet decade, P (WW) denotes the probability of wet decade preceded by a wet decade, 2Deca (D/W) denotes probability of 2 consecutive dry/wet decades starting with any decade and 3Deca (D/W) denotes the probability of 3 consecutive dry/wet decades starting with any decade. We have taken a threshold value of 10 mm/decade as the period with rainfall less than threshold value is considered as dry period and that with greater than or equal to the threshold value as the wet period. A simple program written in GWBASIC calculates all the above frequency probabilities and is given in appendix. The program is self explanatory and the data required to be entered is only the decade wise amount of rainfall.

RESULTS AND DISCUSSION

For four locations the threshold value of 10 mm/decade is used to calculate the frequency probabilities and results are reported in Table 1 to Table 4.

Table 1: Faisalabad: Probability of dry and wet spells. Threshold Value = 10 mm/Dec., Period: 1944-1988.

Decade	P(D)	P(DD)	2 Deca	3 Deca	P(W)	P(WW)	2 Deca	3 Deca
JAN 1	0.76	0.90	0.56	0.45	0.24	0.20	0.03	0.00
JAN 2	0.83	0.74	0.67	0.60	0.17	0.14	0.00	0.00
JAN 3	0.88	0.81	0.78	0.71	0.12	0.00	0.03	0.00
FEB 1	0.90	0.89	0.82	0.69	0.10	0.25	0.01	0.00
FEB 2	0.83	0.91	0.69	0.58	0.17	0.14	0.03	0.00
FEB 3	0.88	0.83	0.74	0.64	0.12	0.20	0.00	0.00
MAR 1	0.78	0.84	0.68	0.51	0.22	0.00	0.10	0.03
MAR 2	0.73	0.83	0.55	0.39	0.27	0.45	0.08	0.04
MAR 3	0.68	0.75	0.48	0.40	0.32	0.31	0.14	0.02
APR 1	0.83	0.71	0.57	0.68	0.17	0.43	0.02	0.00
APR 2	0.83	0.82	0.69	0.60	0.17	0.14	0.03	0.00
APR 3	0.88	0.83	0.76	0.69	0.12	0.20	0.00	0.00
MAY 1	0.90	0.86	0.82	0.59	0.10	0.00	0.01	0.00
MAY 2	0.76	0.90	0.55	0.51	0.24	0.10	0.00	0.00
MAY 3	0.88	0.72	0.82	0.63	0.12	0.00	0.04	0.01
JUN 1	0.78	0.94	0.60	0.46	0.22	0.33	0.04	0.01
JUN 2	0.73	0.77	0.56	0.43	0.27	0.18	0.10	0.03
JUN 3	0.73	0.77	0.57	0.31	0.27	0.36	0.08	0.04
JUL 1	0.54	0.77	0.29	0.09	0.46	0.32	0.22	0.16
JUL 2	0.27	0.55	0.08	0.03	0.73	0.47	0.55	0.40
JUL 3	0.32	0.31	0.12	0.04	0.68	0.75	0.49	0.29
AUG 1	0.39	0.38	0.14	0.06	0.61	0.72	0.36	0.26
AUG 2	0.34	0.36	0.14	0.07	0.66	0.59	0.47	0.24
AUG 3	0.49	0.40	0.23	0.14	0.51	0.71	0.26	0.09
SEP 1	0.62	0.48	0.36	0.27	0.39	0.50	0.13	0.01
SEP2	0.78	0.59	0.59	0.46	0.22	0.33	0.02	0.01
SEP 3	0.78	0.75	0.62	0.57	0.22	0.11	0.07	0.00
OCT 1	0.93	0.79	0.86	0.81	0.07	0.33	0.00	0.00
OCT 2	0.95	0.92	0.90	0.86	0.05	0.00	0.00	0.00
OCT 3	0.93	0.95	0.88	0.86	0.07	0.00	0.07	0.00
NOV 1	0.98	0.95	0.95	0.93	0.02	0.01	0.00	0.00
NOV 2	0.98	0.98	0.95	0.95	0.02	0.00	0.00	0.00
NOV 3	0.98	0.98	0.95	0.87	0.02	0.00	0.00	0.00
DEC 1	0.93	0.97	0.85	0.78	0.07	0.00	0.00	0.00
DEC 2	0.90	0.92	0.83	0.75	0.10	0.00	0.02	0.00
DEC 3	0.88	0.92	0.79	0.58	0.12	0.20	0.02	0.00

Table 2: Lahore: Probability of dry and wet spells. Threshold Value = 10 mm/Dec., Period: 1950-1988.

Decade	P(D)	P(DD)	2 Deca	3 Deca	P(W)	P(WW)	2 Deca	3 Deca
JAN 1	0.83	0.83	0.68	0.52	0.17	0.33	0.02	0.00
JAN 2	0.77	0.81	0.60	0.42	0.23	0.13	0.05	0.05
JAN 3	0.63	0.77	0.45	0.38	0.37	0.23	0.37	0.00
FEB 1	0.89	0.71	0.75	0.56	0.11	0.00	0.00	0.00
FEB 2	0.74	0.85	0.55	0.42	0.26	0.00	0.06	0.01
FEB 3	0.77	0.74	0.59	0.43	0.23	0.25	0.05	0.01
MAR 1	0.71	0.76	0.52	0.36	0.29	0.20	0.09	0.04
MAR 2	0.63	0.73	0.44	0.31	0.37	0.31	0.19	0.09
MAR 3	0.66	0.70	0.46	0.35	0.34	0.50	0.17	0.03
APR 1	0.77	0.70	0.58	0.41	0.23	0.50	0.04	0.04
APR 2	0.69	0.75	0.48	0.47	0.31	0.18	0.31	0.00
APR 3	0.97	0.71	0.94	0.79	0.03	1.00	0.00	0.00
MAY 1	0.86	0.97	0.72	0.52	0.14	0.00	0.01	0.00
MAY 2	0.71	0.84	0.52	0.43	0.29	0.10	0.10	0.02
MAY 3	0.83	0.72	0.69	0.56	0.17	0.33	0.03	0.00
JUN 1	0.86	0.83	0.70	0.41	0.14	0.20	0.01	0.00
JUN 2	0.63	0.82	0.36	0.33	0.37	0.08	0.12	0.07
JUN 3	0.54	0.58	0.49	0.49	0.46	0.31	0.27	0.21
JUL 1	0.29	0.90	0.29	0.00	0.71	0.60	0.56	0.50
JUL 2	0.09	0.00	0.00	0.00	0.91	0.78	0.82	0.67
JUL 3	0.20	0.00	0.05	0.00	0.80	0.89	0.65	0.48
AUG 1	0.23	0.25	0.00	0.00	0.77	0.81	0.57	0.49
AUG 2	0.14	0.00	0.02	0.01	0.86	0.73	0.75	0.54
AUG 3	0.34	0.17	0.16	0.07	0.66	0.87	0.48	0.35
SEP 1	0.37	0.46	0.17	0.10	0.63	0.73	0.46	0.23
SEP2	0.57	0.45	0.33	0.27	0.43	0.73	0.21	0.00
SEP 3	0.83	0.59	0.67	0.57	0.17	0.50	0.00	0.00
OCT 1	0.89	0.81	0.75	0.55	0.11	0.00	0.00	0.00
OCT 2	0.74	0.85	0.55	0.53	0.26	0.00	0.00	0.00
OCT 3	0.97	0.74	0.94	0.92	0.03	0.00	0.00	0.00
NOV 1	0.97	0.97	0.94	0.92	0.03	0.00	0.00	0.00
NOV 2	0.97	0.97	0.94	0.91	0.03	0.00	0.00	0.00
NOV 3	0.97	0.97	0.94	0.91	0.03	0.00	0.00	0.00
DEC 1	0.91	0.97	0.88	0.79	0.09	0.00	0.03	0.01
DEC 2	0.86	0.97	0.77	0.63	0.14	0.40	0.04	0.01
DEC 3	0.80	0.89	0.66	0.54	0.20	0.29	0.07	0.01

Table 3: Islamabad: Probability of dry and wet spells. Threshold Value = 10 mm/Dec., Period: 1950-1988.

Decade	P(D)	P(DD)	2 Deca	3 Deca	P(W)	P(WW)	2 Deca	3 Deca
JAN 1	0.59	0.60	0.36	0.23	0.41	0.29	0.18	0.10
JAN 2	0.53	0.61	0.34	0.15	0.47	0.44	0.26	0.16
JAN 3	0.41	0.64	0.18	0.12	0.59	0.55	0.37	0.20
FEB 1	0.53	0.44	0.35	0.14	0.47	0.63	0.26	0.18
FEB 2	0.35	0.67	0.14	0.07	0.65	0.55	0.44	0.20
FEB 3	0.53	0.39	0.26	0.19	0.47	0.69	0.21	0.15
MAR 1	0.41	0.50	0.29	0.13	0.59	0.45	0.42	0.32
MAR 2	0.29	0.70	0.13	0.04	0.71	0.71	0.54	0.42
MAR 3	0.26	0.44	0.09	0.04	0.74	0.76	0.58	0.36
APR 1	0.44	0.33	0.21	0.13	0.56	0.79	0.34	0.13
APR 2	0.62	0.48	0.38	0.29	0.38	0.62	0.15	0.08
APR 3	0.62	0.62	0.46	0.26	0.38	0.38	0.22	0.08
MAY 1	0.59	0.75	0.34	0.19	0.41	0.57	0.16	0.05
MAY 2	0.62	0.57	0.35	0.18	0.38	0.38	0.12	0.02
MAY 3	0.62	0.57	0.32	0.22	0.38	0.31	0.07	0.02
JUN 1	0.68	0.52	0.46	0.33	0.32	0.18	0.11	0.06
JUN 2	0.56	0.68	0.39	0.13	0.44	0.33	0.26	0.12
JUN 3	0.50	0.71	0.17	0.04	0.50	0.59	0.23	0.19
JUL 1	0.18	0.33	0.04	0.02	0.82	0.46	0.69	0.62
JUL 2	0.12	0.25	0.06	0.00	0.88	0.83	0.80	0.75
JUL 3	0.06	0.50	0.00	0.00	0.94	0.91	0.89	0.89
AUG 1	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.97
AUG 2	0.03	0.00	0.00	0.00	0.97	0.00	0.94	0.87
AUG 3	0.06	0.00	0.00	0.00	0.94	0.97	0.87	0.74
SEP 1	0.21	0.00	0.09	0.01	0.79	0.93	0.68	0.50
SEP2	0.21	0.43	0.03	0.01	0.79	0.85	0.59	0.41
SEP 3	0.44	0.13	0.23	0.13	0.56	0.74	0.39	0.08
OCT 1	0.62	0.52	0.33	0.26	0.38	0.69	0.08	0.03
OCT 2	0.71	0.54	0.55	0.38	0.29	0.20	0.13	0.05
OCT 3	0.68	0.78	0.47	0.36	0.32	0.15	0.12	0.03
NOV 1	0.76	0.69	0.59	0.53	0.24	0.38	0.06	0.01
NOV 2	0.88	0.77	0.79	0.71	0.12	0.25	0.02	0.01
NOV 3	0.85	0.90	0.76	0.64	0.15	0.20	0.06	0.01
DEC 1	0.85	0.90	0.72	0.49	0.15	0.40	0.02	0.00
DEC 2	0.74	0.84	0.50	0.30	0.26	0.11	0.04	0.01
DEC 3	0.65	0.68	0.39	0.24	0.35	0.17	0.10	0.04

Table 4: Murree: Probability of dry and wet spells. Threshold Value = 10 mm/Dec., Period: 1945-1988.

Decade	P(D)	P(DD)	2 Deca	3 Deca	P(W)	P(WW)	2 Deca	3 Deca
JAN 1	0.46	0.53	0.14	0.09	0.54	0.35	0.19	0.10
JAN 2	0.54	0.30	0.35	0.22	0.46	0.35	0.24	0.18
JAN 3	0.38	0.64	0.24	0.09	0.62	0.52	0.45	0.34
FEB 1	0.30	0.64	0.11	0.09	0.70	0.73	0.53	0.41
FEB 2	0.35	0.38	0.27	0.08	0.65	0.75	0.51	0.40
FEB 3	0.24	0.78	0.07	0.02	0.76	0.79	0.59	0.36
MAR 1	0.38	0.29	0.13	0.05	0.62	0.78	0.38	0.29
MAR 2	0.24	0.33	0.10	0.00	0.76	0.61	0.59	0.50
MAR 3	0.14	0.40	0.00	0.00	0.86	0.78	0.73	0.60
APR 1	0.14	0.00	0.00	0.00	0.86	0.84	0.72	0.59
APR 2	0.22	0.00	0.06	0.02	0.78	0.83	0.64	0.38
APR 3	0.41	0.27	0.16	0.05	0.59	0.82	0.35	0.27
MAY 1	0.27	0.40	0.09	0.03	0.73	0.59	0.56	0.33
MAY 2	0.41	0.33	0.15	0.04	0.59	0.77	0.35	0.28
MAY 3	0.22	0.38	0.06	0.02	0.78	0.59	0.63	0.44
JUN 1	0.30	0.27	0.08	0.01	0.70	0.81	0.49	0.31
JUN 2	0.30	0.27	0.03	0.01	0.70	0.69	0.45	0.35
JUN 3	0.24	0.11	0.07	0.00	0.76	0.64	0.58	0.47
JUL 1	0.19	0.29	0.00	0.00	0.81	0.77	0.65	0.64
JUL 2	0.03	0.00	0.00	0.00	0.97	0.81	0.95	0.95
JUL 3	0.00	0.00	0.00	0.00	1.00	0.97	1.00	1.00
AUG 1	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
AUG 2	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.97
AUG 3	0.03	0.00	0.00	0.00	0.97	1.00	0.95	0.95
SEP 1	0.00	0.00	0.00	0.00	1.00	0.97	1.00	0.88
SEP2	0.16	0.00	0.08	0.01	0.84	1.00	0.74	0.65
SEP 3	0.11	0.50	0.01	0.00	0.89	0.88	0.78	0.61
OCT 1	0.32	0.08	0.14	0.06	0.68	0.88	0.53	0.20
OCT 2	0.51	0.42	0.22	0.12	0.49	0.78	0.18	0.07
OCT 3	0.57	0.43	0.31	0.18	0.43	0.38	0.17	0.07
NOV 1	0.59	0.55	0.35	0.28	0.41	0.40	0.16	0.07
NOV 2	0.73	0.59	0.59	0.44	0.27	0.40	0.12	0.05
NOV 3	0.70	0.81	0.53	0.39	0.30	0.45	0.13	0.03
DEC 1	0.76	0.75	0.56	0.43	0.24	0.44	0.05	0.02
DEC 2	0.73	0.74	0.56	0.30	0.27	0.20	0.09	0.03
DEC 3	0.59	0.77	0.31	0.09	0.41	0.33	0.14	0.05

Appendix

```
10  REM Please enter the data using data statements in the following order
20  REM First data statement should contain the following information
30  REM Station name, no. of years the data you have, period, threshold value
40  REM The second data statement should contain the name of twelwe months
50  REM
60  REM Example: Faisalabad, 40, 1941-80, 5
70  REM Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
80  REM Where Faisalabad is station name, 40 is no. of years the data we have
90  REM 1941-80 is period the data we have
100 REM 5 is the threshold value.
110 REM
115 REM Then enter the total rainfall in the last decade of December
117 REM for each year
120 REM After that enter the total rainfall in the first, second and third decade
130 REM of January for each year
140 REM Then enter the total rainfall in the first, second and third decade
145 REM of February for each year
150 REM then for March, April, ..... and upto the third decade of December
160 REM the last data statement should again contain the total rainfall
170 REM in the first decade of January for each year.
175 REM
180 REM Please note that there must be equal number of values for each decade
190 REM ÿIf the data is missing for any year either that year should be omitted
200 REM or estimated values may be entered for the missing data.
210 REM ********* Assigning initial value to variables used *******
220 M=1
230 MM=0
240 K=0
250 AA=0
260 CLS
270 Locate 8, 14 : Print “Probability of dry and wet spells”
280 Locate 10, 20 : Print “1. Display output”
290 Locate 11, 20 : Print “2. Print output”
300 Locate 12, 20 : Print “0. Quit”
310 Locate 14, 18 : Color 31 : Input “Your choice: “; CH : Color 7, 0
320 If CH = 0 then end
330 REM ****** Main routine *****
340 Read LS, N, PS, Thold
350 DIM A (N), B (N), FW (36), FD (36), FWW (36), FDD (36), PD (36), PW (36), PWW (36)
360 DIM PDD (36), Months (12)
370 For I=1 to 12
380 Read months (I), Reading name of months
390 Next I
400 For I = 1 to N
410 Read A (I), Reading data for each decade
420 Next I
430 FW = 0
440 FD = 0
450 FWW = 0
460 FDD = 0
470 For I = 1 to N
480 Read B (I)
490 Next I
500 For I = 1 to N
510 If B(I) > = Thold then FW = FW + 1 else FD = FD + 1
520 If B(I) > = Thold and A (I) > = Thold then go to 550 else go to 540
530 FWW = FWW + 1
540 If B(I) < Thold and A (I) < Thold then go to 550 else go to 560
550 FDD = FDD + 1
560 Next I
570 K = K + 1
580 FW (K) = FW
590 FD (K) = FD
600 FWW (K) = FWW
610 FDD (K) = FDD
620 PD (K) = FD/N
630 PDD (K) = FDD/FD
640 PW (K) = FW/N
650 If FW = 0 then PWW (K) = 0 else PWW (K) = FWW/FW
660 For I = 1 to N
670 A (I) = B (I)
680 Next I
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690  AA = AA + 1
700  If AA = 3 then go to 720 '36
710  Go to 430
720  K = 0
725  If CH = 2 then 850
730  Print "Probability of dry and wet spells"
740  Print "~~~~~~~~~~~~~~~~~~~~~~~~~~~~~"
750  Print "Threshold value = "; Thold
760  Print
770  Print "Location :"; LS;
780  Print Tab (64); "Period:" ; PS
790  Print "-------------------------------------------------------------------------------------------------------------------------------------------------------";
800  Print "---------------"
810  Print "Dec | F (D) | F (DD) | P (D) | P (DD) | 2 DEC | 3 DEC | F (W) | F (WW) | P(W) | P (WW)" ;
820  Print " | 2 DEC | 3 DEC" :
830  Print "-------------------------------------------------------------------------------------------------------------------------------------------------------";
845  Print "---------------"
842  Go to 970
845  REM ****** Print *******
850  LPrint "Probability of dry and wet spells"
860  LPrint "~~~~~~~~~~~~~~~~~~~~~~~~~~~~~"
870  LPrint "Threshold value = "; Thold
880  LPrint
890  LPrint "Location :"; LS;
900  LPrint Tab (64); "Period:" ; PS
910  LPrint "-------------------------------------------------------------------------------------------------------------------------------------------------------";
920  LPrint "---------------"
930  LPrint "Dec | F (D) | F (DD) | P (D) | P (DD) | 2 DEC | 3 DEC | F (W) | F (WW) | P(W) | P (WW)" ;
940  LPrint " | 2 DEC | 3 DEC" :
950  LPrint "-------------------------------------------------------------------------------------------------------------------------------------------------------";
960  LPrint "---------------"
970  K = K + 1
980  K1 = K + 1
990  K2 = K + 2
1000 If K1 > 36 then K1 = 1
1010 If K2 > 36 + 1 then K2 = 1
1020 If K2 > 36 + 2 then K2 = 2
1030 If  M = 1 then MM =MM + 1
1040 DDEC2 = PD (K) * PDD (K1)
1050 DDEC3 = PD (K) * PDD (K) * PDD (K2)
1060 WDEC2 = PW (K) * PWW (K1)
1070 WDEC3 = PW (K) * PWW (K1) * PWW (K2)
1075 If CH = 2 then 1135
1080 Print months (MM); M;
1090 Print using " ## "; FD (K); FDD (K);
1100 Print using " ###.## "; PD (K); PDD (K); DDEC2; DDEC3;
1110 Print "  " ;
1120 Print using " ## "; FW (K); FWW (K);
1130 Print using " ###.## "; PW (K); PWW (K); WDEC2; WDEC3;
1132 Go to 1200
1135 REM ********** Print **********
1140 LPrint months (MM); M;
1150 LPrint using " ## "; FD (K); FDD (K);
1160 LPrint using " ###.## "; PD (K); PDD (K); DDEC2; DDEC3;
1170 LPrint "  " ;
1180 LPrint using " ## "; FW (K); FWW (K);
1190 LPrint using " ###.## "; PW (K); PWW (K); WDEC2; WDEC3;
1200 M = M + 1
1210 If M > 3 then M = 1
1220 If K = 36 then 1270
1230 Go to 970
1270 End
1280 REM ********** Data **********
1290 Data Faisalabad, 40, 1941-80, 1
1300 Data Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
1310 Data 0, 0, 0, 0, 0, 0, 0, 0, 1.5, 0, 9.4, 0, 0, 0, 0, 11.4, .5, 0, 5.6, 0, 0, 0, 63.0
1320 Data 0, 0, 0, 0, 0, 0, 0, 0, 6.1, 0, 2.5, 0, 9.4, 9, 0, 0, 0, 3.3
1330 Data 17.8, 0, 0, 0, 0, 0, 0, 0, .8, 2.8, 1.0, 1.5, 16, 9.4, 0, 18.2, 0, 6.9, 0, 0, 33.5, 0, 0, 0, 1.3
1340 Data 7.6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 6, 15.7, 13.8, 0, 0
1350 Data 0, 0, 0, 0, 0, 10.9, 2.5, 0, 4.3, 0, 0, 0, 3, 0, 9.1, .5, 0, 0, 0, 0, 2.5, 0, 0, .5, 0, 0, 0, 0, 0
1360 Data .1, 3.5, 2.3, 0, 0, 19, 0, 0, 0, 0, 0
1370 Data 2.3, 0, 0, 0, 0, 8.4, 0, 0, 0, 7.6, .8, 0, 4.8, 0, 5.1, 1.3, 5.1, 3.3, 0, 2, 0, 0, 0, 2.5
1380 Data 0, 3.3, 3.8, 1, 0, 1, 3.3, 0, 19, 6, 17, 3, 17, 0, 5, 2.4
```

From Table 1 it is clear that for Faisalabad in the first week of January, the probability of the being dry is 0.76 or 76% and the probability of being dry followed by a dry decade is 90%. The same probabilities for Lahore in Table 2 are 83% and 83% respectively, for Islamabad in Table 3 are 0.59 or 59% and 60% respectively and for Murree in Table 4 are 46% and 53% respectively. It shows that in January there are more dry decades in Faisalabad and Lahore than Islamabad and Murree for threshold value of 10 mm/decade.

The probability of being dry is minimum in July and August in all the places but for Faisalabad and Lahore it is relatively higher as compared with Islamabad and Murree. The Tables indicate that Islamabad and Murree enjoy more rains than the Faisalabad and Lahore throughout the year.

These probabilities may help the agronomists and agricultural scientists to help decide the cultivation and timings for different new crops to be introduced.

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