*Vol. 13, No. 2, pp. 193-202 (2013)*
**Journal of Agricultural Physics**
**ISSN 0973-032X**
**http://www.agrophysics.in**

**Research Article**

# Wet and Dry Spell Analysis for Crop Planning in Sub-Mountainous Punjab using Markov Chain Approach

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**ABSTRACT**

Wet and dry spell rainfall analysis was carried out for sub-mountainous region of Punjab to find out the initial and conditional probability of their occurrence using Markov chain approach. Weekly rainfall data from 1984 to 2010 was collected from meteorological observatory at Regional Research Station for *kandi* area, Ballowall Saunkhari. The probability of occurrence of wet spell was 73-100, 65-85, 46-81, 31-73 and 31-65% for wet limits of 10, 20, 30, 40 and 50 mm rainfall during Standard Meteorological Weeks (SMW) 26 to 35 whereas from SMW 39-52, it was 0-23, 0-15, 0-12, 0-8 and 0-8% and during SMW 1-22, it was 11- 42, 4-23, 0-19, 0-12 and 0-12%, respectively for the corresponding wet limits. The rainfall distribution for different crop seasons were also determined to adjust various crop phenophases and their planning based on moisture availability.

**Key words:** Wet and dry spell, Markov chain, Rainfall probability, Sub-mountainous region

## Introduction

The production potential of agriculture is based on rainfall in terms of its intensity and distribution, which are considered to be the principal elements in semi-arid regions. The variability of rainfall in Punjab is very high due to erratic behaviour of monsoon during *kharif* season and western disturbances during *rabi* season. The situation of water resources has been further deteriorated due to high water requirement of paddy and wheat crops, which occupy large area in the state during *kharif* and *rabi* season, respectively. Duration and degree of humid period plays a vital role in agricultural development and planning.

Ballowal Saunkhari ($31^0$6'5" N and $76^0$23'26" E) is situated in the sub-mountainous undulating agroclimatic region of Punjab at a height of 355 m above mean sea level. It receives 1009 and 154 mm of rains during *kharif* and *rabi* seasons, respectively (Kingra *et al*., 2004). Agriculture is highly dependent on rainfall and many decisions are made based on the amounts of rainfall occurring during crop seasons. Hence, knowledge and data base of dry and wet spell sequences of a particular region can help in better crop planning. The probability analysis of occurrence of wet and dry spells is essentially required for successful crop planning, development of suitable agro-techniques, recommendation of suitable crop varieties, design of water-harvesting tanks, earthen dams and other soil conservation structures (Singh *et al*., 2008).

Markov chain probability model has been extensively used to determine the long-term frequency behaviour of dry and wet spells (Victor and Sastry, 1979). Goyal (2013) also computed

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weekly rainfall probabilities using this approach and incomplete gamma distribution for Ludhiana. The week-wise analysis was done for initial and conditional probabilities at different rainfall intervals. Using this information in crop planning can be of great help in judicious and efficient use of rainwater, conservation of ground water and in increasing the productivity of crops. If the dry spell coincides with critical moisture requiring stages of the crop, it is damaging whereas during ripening stage, it may be beneficial. On the other hand, if wet spell coincides with the critical moisture requiring stages of the crop, it will be most beneficial for increasing productivity vis-à-vis conserving ground water. The practical utility of Markov chain probability model in agricultural planning for both long- and short-term periods has been aptly demonstrated (Choudhary, 2006; Senthilvelan *et al.,* 2012). Keeping these in view, the initial and conditional probabilities of rainfall occurrence for Ballowal Saunkhari were calculated on weekly basis using Markov chain approach.

## Materials and Methods

Data on weekly rainfall was collected for Ballowal Saunkhari for a period from 1984 to 2010. A week receiving 10, 20, 30, 40 and 50 mm rainfall or more was considered as wet, and that receiving less than these limits as dry.

### *Initial rainfall probability (%) (W)*

Initial probability indicates the minimum quantity of rainfall to be expected for a particular time series data. Initial rainfall probability of getting greater than specific limit of rainfall is given by

$$W = \frac{\text{Number of years during which } > specific\ rainfall\ limit\ during\ x\ week}{\text{Total number of years}}\ X\ 100$$

### *Conditional rainfall probability (%) (W/Wx)*

Conditional rainfall probability (%) of getting rainfall higher than specific limit during next week also, when rainfall was more than the specific limit during previous week

$$\frac{W}{Wx} = \frac{\text{No. of years during which next week received } > \text{specific limit of rainfall when this week also received } > \text{specific rainfall}}{\text{No. of years during which this week received} > \text{specific limit of rainfall}} \text{x } 100$$

### *Conditional rainfall probability (%) (W/D)*

Conditional rainfall probability (W/D) of getting <specific limit of rainfall during next week when this week has been dry *i.e.*, the rainfall was >specific limit; then

$$\frac{W}{D} = \frac{\text{No. of years during which next week received } < specific\ rainfall \text{ when this week received } > specific limit\ of\ rainfall}{\text{No. of years during which this week was wet i. e.} > specific\ limit\ of\ rainfall}\ X\ 100$$

Where, W = Wet week; D = Dry week; W/W = Wet week followed by wet week; W/D = Wet week followed by dry week

## Results and Discussion

### *Annual rainfall distribution*

Annual rainfall at Ballowal Saunkhari ranged from 617 (2009) to 2041 mm (1988) with an average value of 1062 mm and a standard deviation (SD) of 303 mm, indicating a highly erratic nature of rainfall (Fig. 1). Under such conditions, rainfall probability analysis becomes more important so that rainfall for the coming period can be estimated for crop planning.

### *Monthly and seasonal rainfall distribution*

Monthly rainfall at Ballowal Saunkhari ranges from a minimum of 5.1 mm during November to 294.5 mm during July (Table 1). Out of the total annual rainfall of 1062 mm, 80% is received during monsoon (June to September) and remaining 20% during rest of the year. So far as the seasons are concerned, 915 mm rainfall is received during *kharif* (May to October) and 147 mm during *rabi* (November to April) with SDs of 287 and 60 mm, respectively. Again, high value of SD indicated the necessity of computation of rainfall probabilities during different parts of the year.

### *Weekly rainfall distribution*

Weekly rainfall distribution indicated that during 26 years period, number of weeks receiving < 10 mm of rainfall ranged 28-37 whereas weeks receiving > 50 mm of rainfall were 3-11 in number (Table 2). On an average, 34 weeks received < 10 mm rainfall, 4 weeks 10 to 20, 3 weeks 20 to 30, 2.5 weeks 30 to 40, 1.5

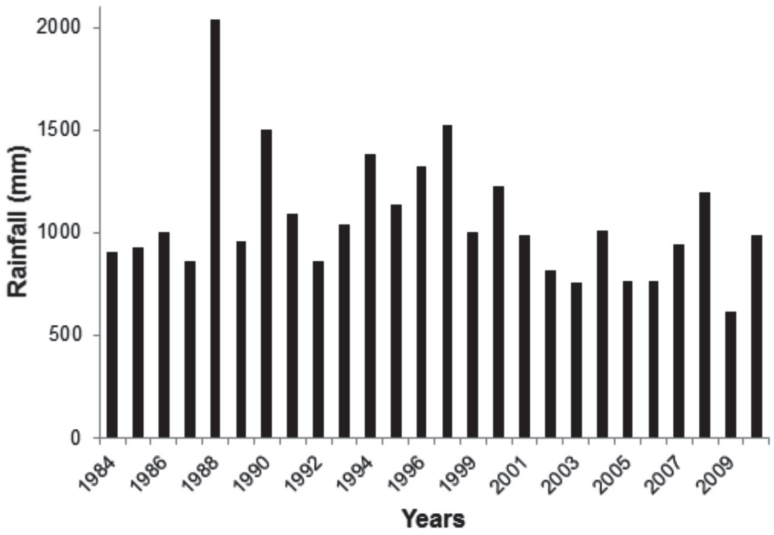


**Fig. 1.** Annual rainfall distribution at Ballowal Saunkhari

**Table 1.** Monthly and seasonal rainfall at Ballowal Saunkhari

| Month / Season | Average rainfall (mm) | Standard deviation | Month / Season | Average rainfall | Standard deviation (mm) |
|---|---|---|---|---|---|
| *Rabi* | 146.6 | 60.4 | *Kharif* | 915.3 | 287.2 |
| November | 5.1 | 8.3 | May | 32.3 | 30.4 |
| December | 20.4 | 32.0 | Jun | 101.2 | 85.4 |
| January | 33.3 | 31.2 | Jul | 294.5 | 168.1 |
| February | 40.9 | 34.4 | Aug | 293.8 | 118.4 |
| March | 29.2 | 24.8 | Sep | 164.2 | 131.8 |
| April | 17.7 | 14.4 | Oct | 29.3 | 52.9 |

weeks 40 to 50 and 7 weeks received rainfall > 50mm.

### *Initial and conditional rainfall probability analysis*

The initial and conditional probabilities for five rainfall limits (10, 20, 30, 40 and 50 mm) computed by Markov chain model are given in Tables 3 to 7. Rainfall in the region is highly erratic, so five limits were taken for detailed analysis of occurrence of dry and wet spells under variable rainfall conditions. The initial probability of occurrence of wet spell ranged as 11-42, 4-23, 0-19, 0-12 and 0-12% for 10, 20, 30, 40 and 50 mm limits, respectively during SMW 1-22. The range was 73-100, 65-85, 46-81, 31-73 and 31-65% during SMW 26-35, and suddenly decreased. It probability of occurrence varied as 0-23, 0-15, 0-12, 0-8 and 0-8% for the corresponding wet limits during SMW 39 to 52.

On the contrary, the initial probability of occurrence of dry spell was very high during SMW 1-22 ranging from 58-89, 77-99, 81-100, 89-100 and 89-100% for same rainfall limits as above, whereas from SMW 27-35, it was very low ranging from 0-27, 15-35, 19-54, 27-69 and 35-69% and again increased thereafter ranging as 77-100, 85-100, 89-100, 92-100 and 92-100% for the corresponding rainfall limits during SMW 39 to 52, being nearly 100% for seven weeks (SMW 43-46, 48-50). Thus, the chance of dry spell was more prominent than the wet spell throughout the year except for a few weeks during monsoon period.

**Table 2.** Distribution of weekly rainfall at Ballowal Saunkhari (1984–2010)

| Year | Weekly rainfall (mm) | | | | | |
|---|---|---|---|---|---|---|
| | (0 - 10) | > (10 - 20) | > (20 - 30) | > (30 - 40) | > (40 - 50) | >50 |
| 1984 | 35 | 5 | - | 1 | 2 | 9 |
| 1985 | 35 | 2 | 2 | 6 | 1 | 6 |
| 1986 | 37 | 6 | 1 | 1 | - | 7 |
| 1987 | 36 | 3 | 3 | - | 3 | 7 |
| 1988 | 33 | 5 | 2 | 2 | 1 | 9 |
| 1989 | 35 | 4 | 2 | 4 | 1 | 6 |
| 1990 | 28 | 8 | 4 | 1 | 3 | 8 |
| 1991 | 32 | 6 | 2 | 3 | 2 | 7 |
| 1992 | 35 | 3 | 2 | 6 | 2 | 4 |
| 1993 | 35 | 6 | 4 | 1 | 3 | 3 |
| 1994 | 38 | 1 | 2 | 2 | - | 9 |
| 1995 | 38 | 2 | 2 | 2 | 2 | 6 |
| 1996 | 30 | 5 | 2 | 3 | 1 | 11 |
| 1998 | 32 | 3 | 2 | 3 | 1 | 11 |
| 1999 | 36 | 1 | 5 | 3 | 1 | 6 |
| 2000 | 32 | 4 | 5 | 3 | - | 8 |
| 2001 | 35 | - | 4 | 4 | 2 | 7 |
| 2002 | 35 | 6 | 2 | 4 | - | 5 |
| 2003 | 34 | 5 | 6 | 1 | 2 | 4 |
| 2004 | 34 | 4 | 2 | 5 | 2 | 5 |
| 2005 | 33 | 4 | 7 | 2 | 2 | 4 |
| 2006 | 35 | 6 | 3 | 1 | 1 | 6 |
| 2007 | 32 | 6 | 1 | 3 | 4 | 6 |
| 2008 | 36 | 4 | 4 | - | 1 | 7 |
| 2009 | 37 | 6 | 2 | 1 | 1 | 5 |
| 2010 | 34 | 3 | - | 3 | 2 | 10 |

The conditional probability of wet spell followed by another wet spell was very high during SMW 25-35 (74-100, 68-95, 47-83, 50-87 and 50-77% for 10, 20, 30, 40 and 50 mm rainfall limits, respectively). However, the conditional probability of wet spell followed by a dry spell was the least during this period. Probability of dry spell followed by next dry spell was very high throughout the year except for the monsoon (SMW 27-35); during monsoon, it was comparatively low (16-67, 33-57, 29-50, 0-57 and 18-63% for rainfall limits of 10, 20, 30, 40 and 50 mm. On the contrary, two dry spells one after the other during rest of the year might have 100% probability of occurrence (24-100, 32-100, 29-100, 39-100 and 67-100 for the corresponding rainfall limits). Similarly, probability of occurrence of dry followed by a wet spell was comparatively higher during the monsoon and was low during rest of the year. Similarly, the probability of occurrence of wet spell-dry spell was less during monsoon and high during rest of the year.

A critical look on the above results indicated that sowing of *kharif* crops may be started from SMW 27 in the sub-mountainous region of Punjab as the week is followed by south-west monsoon rainfall which is beneficial for early establishment of the crop. In this region, chances of dry spell occurrence are more prominent than that of wet spell. Singh *et al*. (2004) computed the dry and wet spell sequences for south-western region of Punjab. Similarly, Khichar *et al*. (2000) used the

**Table 3.** Initial and conditional probability (%) of wet (>10mm) and dry (<10mm rainfall) weeks at Ballowal Saunkhari (1984–2010) by Markov chain method

| SMW | Initial probability | | | | Conditional probability | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F(D) | P(D) (%) | F(W) | P(W) (%) | F(D/D) | P(D/D) (%) | F(D/W) | P(D/W) (%) | F(W/D) | P(W/D) (%) | F(W/W) | P(W/W) (%) |
| 1 | 21 | 80.8 | 5 | 19.2 | 12 | 57.1 | 9 | 42.9 | 5 | 100.0 | 0 | 0 |
| 2 | 17 | 65.4 | 9 | 34.6 | 14 | 82.4 | 3 | 17.6 | 7 | 77.8 | 2 | 22.2 |
| 3 | 21 | 80.8 | 5 | 19.2 | 17 | 81.0 | 4 | 19.0 | 4 | 80.0 | 1 | 20.0 |
| 4 | 21 | 80.8 | 5 | 19.2 | 20 | 95.2 | 1 | 4.8 | 2 | 40.0 | 3 | 60.0 |
| 5 | 22 | 84.6 | 4 | 15.4 | 13 | 59.1 | 9 | 40.9 | 2 | 50.0 | 2 | 50.0 |
| 6 | 15 | 57.7 | 11 | 42.3 | 9 | 60.0 | 6 | 40.0 | 7 | 63.6 | 4 | 36.4 |
| 7 | 16 | 61.5 | 10 | 38.5 | 15 | 93.8 | 1 | 6.3 | 6 | 60.0 | 4 | 40.0 |
| 8 | 21 | 80.8 | 5 | 19.2 | 16 | 76.2 | 5 | 23.8 | 3 | 60.0 | 2 | 40.0 |
| 9 | 19 | 73.1 | 7 | 26.9 | 16 | 84.2 | 3 | 15.8 | 4 | 57.1 | 3 | 42.9 |
| 10 | 20 | 76.9 | 6 | 23.1 | 16 | 80.0 | 4 | 20.0 | 3 | 50.0 | 3 | 50.0 |
| 11 | 19 | 73.1 | 7 | 26.9 | 11 | 57.9 | 8 | 42.1 | 5 | 71.4 | 2 | 28.6 |
| 12 | 16 | 61.5 | 10 | 38.5 | 13 | 81.3 | 3 | 18.8 | 8 | 80.0 | 2 | 20.0 |
| 13 | 21 | 80.8 | 5 | 19.2 | 17 | 81.0 | 4 | 19.0 | 5 | 100.0 | 0 | 0.0 |
| 14 | 22 | 84.6 | 4 | 15.4 | 19 | 86.4 | 3 | 13.6 | 4 | 100.0 | 0 | 0.0 |
| 15 | 23 | 88.5 | 3 | 11.5 | 20 | 87.0 | 3 | 13.0 | 3 | 100.0 | 0 | 0.0 |
| 16 | 23 | 88.5 | 3 | 11.5 | 20 | 87.0 | 3 | 13.0 | 3 | 100.0 | 0 | 0.0 |
| 17 | 23 | 88.5 | 3 | 11.5 | 18 | 78.3 | 5 | 21.7 | 2 | 66.7 | 1 | 33.3 |
| 18 | 20 | 76.9 | 6 | 23.1 | 19 | 95.0 | 1 | 5.0 | 2 | 33.3 | 4 | 66.7 |
| 19 | 21 | 80.8 | 5 | 19.2 | 16 | 76.2 | 5 | 23.8 | 3 | 60.0 | 2 | 40.0 |
| 20 | 19 | 73.1 | 7 | 26.9 | 15 | 78.9 | 4 | 21.1 | 7 | 100.0 | 0 | 0.0 |
| 21 | 22 | 84.6 | 4 | 15.4 | 17 | 77.3 | 5 | 22.7 | 3 | 75.0 | 1 | 25.0 |
| 22 | 20 | 76.9 | 6 | 23.1 | 12 | 60.0 | 8 | 40.0 | 3 | 50.0 | 3 | 50.0 |
| 23 | 15 | 57.7 | 11 | 42.3 | 8 | 53.3 | 7 | 46.7 | 6 | 54.5 | 5 | 45.5 |
| 24 | 14 | 53.8 | 12 | 46.2 | 12 | 85.7 | 2 | 14.3 | 5 | 41.7 | 7 | 58.3 |
| 25 | 17 | 65.4 | 9 | 34.6 | 4 | 23.5 | 13 | 76.5 | 2 | 22.2 | 7 | 77.8 |
| 26 | 6 | 23.1 | 20 | 76.9 | 2 | 33.3 | 4 | 66.7 | 4 | 20.0 | 16 | 80.0 |
| 27 | 6 | 23.1 | 20 | 76.9 | 1 | 16.7 | 5 | 83.3 | 3 | 15.0 | 17 | 85.0 |
| 28 | 4 | 15.4 | 22 | 84.6 | 1 | 25.0 | 3 | 75.0 | 3 | 13.6 | 19 | 86.4 |
| 29 | 4 | 15.4 | 22 | 84.6 | 0 | 0.0 | 4 | 100.0 | 0 | 0.0 | 22 | 100.0 |
| 30 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 2 | 7.7 | 24 | 92.3 |
| 31 | 2 | 7.7 | 24 | 92.3 | 1 | 50.0 | 1 | 50.0 | 3 | 12.5 | 21 | 87.5 |
| 32 | 4 | 15.4 | 22 | 84.6 | 0 | 0.0 | 4 | 100.0 | 3 | 13.6 | 19 | 86.4 |
| 33 | 3 | 11.5 | 23 | 88.5 | 2 | 66.7 | 1 | 33.3 | 5 | 21.7 | 18 | 78.3 |
| 34 | 7 | 26.9 | 19 | 73.1 | 1 | 14.3 | 6 | 85.7 | 5 | 26.3 | 14 | 73.7 |
| 35 | 6 | 23.1 | 20 | 76.9 | 2 | 33.3 | 4 | 66.7 | 5 | 25.0 | 15 | 75.0 |
| 36 | 7 | 26.9 | 19 | 73.1 | 5 | 71.4 | 2 | 28.6 | 7 | 36.8 | 12 | 63.2 |
| 37 | 12 | 46.2 | 14 | 53.8 | 5 | 41.7 | 7 | 58.3 | 8 | 57.1 | 6 | 42.9 |
| 38 | 13 | 50.0 | 13 | 50.0 | 12 | 92.3 | 1 | 7.7 | 8 | 61.5 | 5 | 38.5 |
| 39 | 20 | 76.9 | 6 | 23.1 | 16 | 80.0 | 4 | 20.0 | 5 | 83.3 | 1 | 16.7 |
| 40 | 21 | 80.8 | 5 | 19.2 | 20 | 95.2 | 1 | 4.8 | 2 | 40.0 | 3 | 60.0 |
| 41 | 22 | 84.6 | 4 | 15.4 | 18 | 81.8 | 4 | 18.2 | 4 | 100.0 | 0 | 0.0 |
| 42 | 22 | 84.6 | 4 | 15.4 | 21 | 95.5 | 1 | 4.5 | 4 | 100.0 | 0 | 0.0 |
| 43 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 44 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 45 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 46 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 47 | 23 | 88.5 | 3 | 11.5 | 23 | 100.0 | 0 | 0.0 | 3 | 0.0 | 0 | 0.0 |
| 48 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 49 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 50 | 25 | 96.2 | 1 | 3.8 | 21 | 84.0 | 4 | 16.0 | 1 | 100.0 | 0 | 0.0 |
| 51 | 22 | 84.6 | 4 | 15.4 | 17 | 77.3 | 5 | 22.7 | 3 | 75.0 | 1 | 25.0 |
| 52 | 20 | 76.9 | 6 | 23.1 | 16 | 80.0 | 4 | 20.0 | 6 | 100.0 | 0 | 0.0 |

**Table 4.** Initial and conditional probability (%) of wet (>20mm) and dry (<20mm rainfall) weeks at Ballowal Saunkhari (1984-2010) by Markov chain method

| SMW | Initial probability | | | | | | Conditional probability | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F(D) | P(D) (%) | F(W) | P(W) (%) | F(D/D) | P(D/D) (%) | F(D/W) | P(D/W) (%) | F(W/D) | P(W/D) (%) | F(W/W) | P(W/W) (%) |
| 1 | 22 | 84.6 | 4 | 15.4 | 18 | 81.8 | 4 | 18.2 | 4 | 100.0 | 0 | 0 |
| 2 | 22 | 84.6 | 4 | 15.4 | 20 | 90.9 | 2 | 9.1 | 3 | 75.0 | 1 | 25.0 |
| 3 | 23 | 88.5 | 3 | 11.5 | 22 | 95.7 | 1 | 4.3 | 2 | 66.7 | 1 | 33.3 |
| 4 | 24 | 92.3 | 2 | 7.7 | 22 | 91.7 | 2 | 8.3 | 1 | 50.0 | 1 | 50.0 |
| 5 | 23 | 88.5 | 3 | 11.5 | 19 | 82.6 | 4 | 17.4 | 2 | 66.7 | 1 | 33.3 |
| 6 | 21 | 80.8 | 5 | 19.2 | 16 | 76.2 | 5 | 23.8 | 4 | 80.0 | 1 | 20.0 |
| 7 | 20 | 76.9 | 6 | 23.1 | 17 | 85.0 | 3 | 15.0 | 5 | 83.3 | 1 | 16.7 |
| 8 | 22 | 84.6 | 4 | 15.4 | 20 | 90.9 | 2 | 9.1 | 3 | 75.0 | 1 | 25.0 |
| 9 | 23 | 88.5 | 3 | 11.5 | 21 | 91.3 | 2 | 8.7 | 3 | 100.0 | 0 | 0.0 |
| 10 | 24 | 92.3 | 2 | 7.7 | 22 | 91.7 | 2 | 8.3 | 2 | 100.0 | 0 | 0.0 |
| 11 | 24 | 92.3 | 2 | 7.7 | 20 | 83.3 | 4 | 16.7 | 1 | 50.0 | 1 | 50.0 |
| 12 | 21 | 80.8 | 5 | 19.2 | 19 | 90.5 | 2 | 9.5 | 5 | 100.0 | 0 | 0.0 |
| 13 | 24 | 92.3 | 2 | 7.7 | 21 | 87.5 | 3 | 12.5 | 2 | 100.0 | 0 | 0.0 |
| 14 | 23 | 88.5 | 3 | 11.5 | 21 | 91.3 | 2 | 8.7 | 3 | 100.0 | 0 | 0.0 |
| 15 | 24 | 92.3 | 2 | 7.7 | 22 | 91.7 | 2 | 8.3 | 2 | 100.0 | 0 | 0.0 |
| 16 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0.0 |
| 17 | 25 | 96.2 | 1 | 3.8 | 21 | 84.0 | 4 | 16.0 | 1 | 100.0 | 0 | 0.0 |
| 18 | 22 | 84.6 | 4 | 15.4 | 22 | 100.0 | 0 | 0.0 | 3 | 75.0 | 1 | 25.0 |
| 19 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 20 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0.0 |
| 21 | 25 | 96.2 | 1 | 3.8 | 21 | 84.0 | 4 | 16.0 | 1 | 100.0 | 0 | 0.0 |
| 22 | 22 | 84.6 | 4 | 15.4 | 14 | 63.6 | 8 | 36.4 | 2 | 50.0 | 2 | 50.0 |
| 23 | 16 | 61.5 | 10 | 38.5 | 10 | 62.5 | 6 | 37.5 | 7 | 70.0 | 3 | 30.0 |
| 24 | 17 | 65.4 | 9 | 34.6 | 15 | 88.2 | 2 | 11.8 | 4 | 44.4 | 5 | 55.6 |
| 25 | 19 | 73.1 | 7 | 26.9 | 6 | 31.6 | 13 | 68.4 | 2 | 28.6 | 5 | 71.4 |
| 26 | 8 | 30.8 | 18 | 69.2 | 3 | 37.5 | 5 | 62.5 | 3 | 16.7 | 15 | 83.3 |
| 27 | 6 | 23.1 | 20 | 76.9 | 2 | 33.3 | 4 | 66.7 | 4 | 20.0 | 16 | 80.0 |
| 28 | 6 | 23.1 | 20 | 76.9 | 2 | 33.3 | 4 | 66.7 | 3 | 15.0 | 17 | 85.0 |
| 29 | 6 | 23.1 | 20 | 76.9 | 3 | 50.0 | 3 | 50.0 | 1 | 5.0 | 19 | 95.0 |
| 30 | 4 | 15.4 | 22 | 84.6 | 0 | 0.0 | 4 | 0.0 | 4 | 18.2 | 18 | 81.8 |
| 31 | 4 | 15.4 | 22 | 84.6 | 1 | 25.0 | 3 | 75.0 | 6 | 27.3 | 16 | 72.7 |
| 32 | 7 | 26.9 | 19 | 73.1 | 0 | 0.0 | 7 | 100.0 | 4 | 21.1 | 15 | 78.9 |
| 33 | 4 | 15.4 | 22 | 84.6 | 2 | 50.0 | 2 | 50.0 | 7 | 31.8 | 15 | 68.2 |
| 34 | 9 | 34.6 | 17 | 65.4 | 2 | 22.2 | 7 | 77.8 | 5 | 29.4 | 12 | 70.6 |
| 35 | 7 | 26.9 | 19 | 73.1 | 4 | 57.1 | 3 | 42.9 | 6 | 31.6 | 13 | 68.4 |
| 36 | 10 | 38.5 | 16 | 61.5 | 6 | 60.0 | 4 | 40.0 | 10 | 62.5 | 6 | 37.5 |
| 37 | 16 | 61.5 | 10 | 38.5 | 7 | 43.8 | 9 | 56.3 | 7 | 70.0 | 3 | 30.0 |
| 38 | 14 | 53.8 | 12 | 46.2 | 13 | 92.9 | 1 | 7.1 | 9 | 75.0 | 3 | 25.0 |
| 39 | 22 | 84.6 | 4 | 15.4 | 19 | 86.4 | 3 | 13.6 | 3 | 75.0 | 1 | 25.0 |
| 40 | 22 | 84.6 | 4 | 15.4 | 21 | 95.5 | 1 | 4.5 | 2 | 50.0 | 2 | 50.0 |
| 41 | 23 | 88.5 | 3 | 11.5 | 20 | 87.0 | 3 | 13.0 | 3 | 100.0 | 0 | 0.0 |
| 42 | 23 | 88.5 | 3 | 11.5 | 22 | 95.7 | 1 | 4.3 | 3 | 100.0 | 0 | 0.0 |
| 43 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 44 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 45 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 46 | 26 | 100.0 | 0 | 0.0 | 24 | 92.3 | 2 | 7.7 | 0 | 0.0 | 0 | 0.0 |
| 47 | 24 | 92.3 | 2 | 7.7 | 24 | 100.0 | 0 | 0.0 | 2 | 0.0 | 0 | 0.0 |
| 48 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 49 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 50 | 26 | 100.0 | 0 | 0.0 | 23 | 88.5 | 3 | 11.5 | 0 | 0.0 | 0 | 0.0 |
| 51 | 23 | 88.5 | 3 | 11.5 | 19 | 82.6 | 4 | 17.4 | 3 | 100.0 | 0 | 0.0 |
| 52 | 22 | 84.6 | 4 | 15.4 | 18 | 81.8 | 4 | 18.2 | 4 | 100.0 | 0 | 0.0 |

**Table 5.** Initial and conditional probability (%) of wet (>30mm) and dry (<30mm rainfall) weeks at Ballowal Saunkhari (1984–2010) by Markov chain method

| SMW | Initial probability | | | | | | Conditional probability | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F(D) | P(D) (%) | F(W) | P(W) (%) | F(D/D) | P(D/D) (%) | F(D/W) | P(D/W) (%) | F(W/D) | P(W/D) (%) | F(W/W) | P(W/W) (%) |
| 1 | 24 | 92.3 | 2 | 7.7 | 21 | 87.5 | 3 | 12.5 | 2 | 100.0 | 0 | 0 |
| 2 | 23 | 88.5 | 3 | 11.5 | 20 | 87.0 | 3 | 13.0 | 3 | 100.0 | 0 | 0.0 |
| 3 | 23 | 88.5 | 3 | 11.5 | 22 | 95.7 | 1 | 4.3 | 2 | 66.7 | 1 | 33.3 |
| 4 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 1 | 50.0 | 1 | 50.0 |
| 5 | 24 | 92.3 | 2 | 7.7 | 22 | 91.7 | 2 | 8.3 | 1 | 50.0 | 1 | 50.0 |
| 6 | 23 | 88.5 | 3 | 11.5 | 19 | 82.6 | 4 | 17.4 | 2 | 66.7 | 1 | 33.3 |
| 7 | 21 | 80.8 | 5 | 19.2 | 18 | 85.7 | 3 | 14.3 | 4 | 80.0 | 1 | 20.0 |
| 8 | 22 | 84.6 | 4 | 15.4 | 21 | 95.5 | 1 | 4.5 | 3 | 75.0 | 1 | 25.0 |
| 9 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0.0 |
| 10 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 11 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0.0 |
| 12 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 13 | 24 | 92.3 | 2 | 7.7 | 24 | 100.0 | 0 | 0.0 | 2 | 100.0 | 0 | 0.0 |
| 14 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 15 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 16 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 17 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 18 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 0 | 0.0 | 1 | 100.0 |
| 19 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 20 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0.0 |
| 21 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 22 | 24 | 92.3 | 2 | 7.7 | 18 | 75.0 | 6 | 25.0 | 0 | 0.0 | 2 | 100.0 |
| 23 | 18 | 69.2 | 8 | 30.8 | 12 | 66.7 | 6 | 33.3 | 7 | 87.5 | 1 | 12.5 |
| 24 | 19 | 73.1 | 7 | 26.9 | 16 | 84.2 | 3 | 15.8 | 4 | 57.1 | 3 | 42.9 |
| 25 | 20 | 76.9 | 6 | 23.1 | 11 | 55.0 | 9 | 45.0 | 3 | 50.0 | 3 | 50.0 |
| 26 | 14 | 53.8 | 12 | 46.2 | 4 | 28.6 | 10 | 71.4 | 3 | 25.0 | 9 | 75.0 |
| 27 | 7 | 26.9 | 19 | 73.1 | 2 | 28.6 | 5 | 71.4 | 6 | 31.6 | 13 | 68.4 |
| 28 | 8 | 30.8 | 18 | 69.2 | 4 | 50.0 | 4 | 50.0 | 4 | 22.2 | 14 | 77.8 |
| 29 | 8 | 30.8 | 18 | 69.2 | 3 | 37.5 | 5 | 62.5 | 3 | 16.7 | 15 | 83.3 |
| 30 | 6 | 23.1 | 20 | 76.9 | 0 | 0.0 | 6 | 0.0 | 5 | 25.0 | 15 | 75.0 |
| 31 | 5 | 19.2 | 21 | 80.8 | 3 | 60.0 | 2 | 40.0 | 6 | 28.6 | 15 | 71.4 |
| 32 | 9 | 34.6 | 17 | 65.4 | 1 | 11.1 | 8 | 88.9 | 5 | 29.4 | 12 | 70.6 |
| 33 | 6 | 23.1 | 20 | 76.9 | 3 | 50.0 | 3 | 50.0 | 8 | 40.0 | 12 | 60.0 |
| 34 | 11 | 42.3 | 15 | 57.7 | 5 | 45.5 | 6 | 54.5 | 8 | 53.3 | 7 | 46.7 |
| 35 | 13 | 50.0 | 13 | 50.0 | 6 | 46.2 | 7 | 53.8 | 6 | 46.2 | 7 | 53.8 |
| 36 | 12 | 46.2 | 14 | 53.8 | 10 | 83.3 | 2 | 16.7 | 10 | 71.4 | 4 | 28.6 |
| 37 | 20 | 76.9 | 6 | 23.1 | 12 | 60.0 | 8 | 40.0 | 4 | 66.7 | 2 | 33.3 |
| 38 | 16 | 61.5 | 10 | 38.5 | 16 | 100.0 | 0 | 0.0 | 8 | 80.0 | 2 | 20.0 |
| 39 | 24 | 92.3 | 2 | 7.7 | 22 | 91.7 | 2 | 8.3 | 1 | 50.0 | 1 | 50.0 |
| 40 | 23 | 88.5 | 3 | 11.5 | 22 | 95.7 | 1 | 4.3 | 1 | 33.3 | 2 | 66.7 |
| 41 | 23 | 88.5 | 3 | 11.5 | 21 | 91.3 | 2 | 8.7 | 3 | 100.0 | 0 | 0.0 |
| 42 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0.0 |
| 43 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 44 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 45 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 46 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 47 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 48 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 49 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 50 | 26 | 100.0 | 0 | 0.0 | 24 | 92.3 | 2 | 7.7 | 0 | 0.0 | 0 | 0.0 |
| 51 | 24 | 92.3 | 2 | 7.7 | 21 | 87.5 | 3 | 12.5 | 2 | 100.0 | 0 | 0.0 |
| 52 | 23 | 88.5 | 3 | 11.5 | 21 | 91.3 | 2 | 8.7 | 3 | 100.0 | 0 | 0.0 |

**Table 6.** Initial and conditional probability (%) of wet (>40mm) and dry (<40mm rainfall) weeks at Ballowal Saunkhari (1984–2010) by Markov chain method

| SMW | Initial probability | | | | | | Conditional probability | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F(D) | P(D) (%) | F(W) | P(W) (%) | F(D/D) | P(D/D) (%) | F(D/W) | P(D/W) (%) | F(W/D) | P(W/D) (%) | F(W/W) | P(W/W) (%) |
| 1 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0 |
| 2 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 3 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 4 | 24 | 92.3 | 2 | 7.7 | 24 | 100.0 | 0 | 0.0 | 2 | 100.0 | 0 | 0.0 |
| 5 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 6 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 0 | 0.0 | 1 | 100.0 |
| 7 | 23 | 88.5 | 3 | 11.5 | 21 | 91.3 | 2 | 8.7 | 2 | 66.7 | 1 | 33.3 |
| 8 | 23 | 88.5 | 3 | 11.5 | 22 | 95.7 | 1 | 4.3 | 3 | 100.0 | 0 | 0.0 |
| 9 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 10 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 11 | 24 | 92.3 | 2 | 7.7 | 24 | 100.0 | 0 | 0.0 | 2 | 100.0 | 0 | 0.0 |
| 12 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 13 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 14 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 15 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 16 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 17 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 18 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 0 | 0.0 | 1 | 100.0 |
| 19 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 20 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 21 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 22 | 26 | 100.0 | 0 | 0.0 | 22 | 84.6 | 4 | 15.4 | 0 | 0.0 | 0 | 0.0 |
| 23 | 22 | 84.6 | 4 | 15.4 | 16 | 72.7 | 6 | 27.3 | 3 | 75.0 | 1 | 25.0 |
| 24 | 19 | 73.1 | 7 | 26.9 | 16 | 84.2 | 3 | 15.8 | 4 | 57.1 | 3 | 42.9 |
| 25 | 20 | 76.9 | 6 | 23.1 | 15 | 75.0 | 5 | 25.0 | 3 | 50.0 | 3 | 50.0 |
| 26 | 18 | 69.2 | 8 | 30.8 | 7 | 38.9 | 11 | 61.1 | 4 | 50.0 | 4 | 50.0 |
| 27 | 11 | 42.3 | 15 | 57.7 | 4 | 36.4 | 7 | 63.6 | 7 | 46.7 | 8 | 53.3 |
| 28 | 10 | 38.5 | 16 | 61.5 | 5 | 50.0 | 6 | 60.0 | 6 | 37.5 | 9 | 56.3 |
| 29 | 11 | 42.3 | 15 | 57.7 | 6 | 54.5 | 5 | 45.5 | 2 | 13.3 | 13 | 86.7 |
| 30 | 8 | 30.8 | 18 | 69.2 | 0 | 0.0 | 8 | 0.0 | 6 | 33.3 | 12 | 66.7 |
| 31 | 7 | 26.9 | 19 | 73.1 | 5 | 71.4 | 2 | 28.6 | 7 | 36.8 | 12 | 63.2 |
| 32 | 13 | 50.0 | 13 | 50.0 | 5 | 38.5 | 8 | 61.5 | 4 | 30.8 | 9 | 69.2 |
| 33 | 9 | 34.6 | 17 | 65.4 | 6 | 66.7 | 3 | 33.3 | 8 | 47.1 | 9 | 52.9 |
| 34 | 14 | 53.8 | 12 | 46.2 | 8 | 57.1 | 6 | 42.9 | 6 | 50.0 | 6 | 50.0 |
| 35 | 14 | 53.8 | 12 | 46.2 | 8 | 57.1 | 6 | 42.9 | 5 | 41.7 | 7 | 58.3 |
| 36 | 13 | 50.0 | 13 | 50.0 | 12 | 92.3 | 1 | 7.7 | 11 | 84.6 | 2 | 15.4 |
| 37 | 23 | 88.5 | 3 | 11.5 | 17 | 73.9 | 6 | 26.1 | 2 | 66.7 | 1 | 33.3 |
| 38 | 19 | 73.1 | 7 | 26.9 | 19 | 100.0 | 0 | 0.0 | 6 | 85.7 | 1 | 14.3 |
| 39 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 40 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 0 | 0.0 | 1 | 100.0 |
| 41 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 42 | 24 | 92.3 | 2 | 7.7 | 24 | 100.0 | 0 | 0.0 | 2 | 100.0 | 0 | 0.0 |
| 43 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 44 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 45 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 46 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 47 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 48 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 49 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 50 | 26 | 100.0 | 0 | 0.0 | 24 | 92.3 | 2 | 7.7 | 0 | 0.0 | 0 | 0.0 |
| 51 | 24 | 92.3 | 2 | 7.7 | 22 | 91.7 | 2 | 8.3 | 2 | 100.0 | 0 | 0.0 |
| 52 | 24 | 92.3 | 2 | 7.7 | 22 | 91.7 | 2 | 8.3 | 2 | 100.0 | 0 | 0.0 |

**Table 7.** Initial and conditional probability (%) of wet (>50mm) and dry (<50mm rainfall) weeks at Ballowal Saunkhari (1984–2010) by Markov chain method

| SMW | Initial probability | | | | | | Conditional probability | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F(D) | P(D) (%) | F(W) | P(W) (%) | F(D/D) | P(D/D) (%) | F(D/W) | P(D/W) (%) | F(W/D) | P(W/D) (%) | F(W/W) | P(W/W) (%) |
| 1 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0 |
| 2 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 3 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 4 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 5 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 6 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 7 | 26 | 100.0 | 0 | 0.0 | 23 | 88.5 | 3 | 11.5 | 0 | 0.0 | 0 | 0.0 |
| 8 | 23 | 88.5 | 3 | 11.5 | 23 | 100.0 | 0 | 0.0 | 3 | 100.0 | 0 | 0.0 |
| 9 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 10 | 25 | 96.2 | 1 | 3.8 | 24 | 96.0 | 1 | 4.0 | 1 | 100.0 | 0 | 0.0 |
| 11 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 12 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 13 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 14 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 15 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 16 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 17 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 18 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 19 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 0 | 0.0 | 1 | 0.0 | 0 | 0.0 |
| 20 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 21 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 22 | 26 | 100.0 | 0 | 0.0 | 22 | 84.6 | 4 | 15.4 | 0 | 0.0 | 0 | 0.0 |
| 23 | 22 | 84.6 | 4 | 15.4 | 16 | 72.7 | 6 | 27.3 | 3 | 75.0 | 1 | 25.0 |
| 24 | 19 | 73.1 | 7 | 26.9 | 17 | 89.5 | 2 | 10.5 | 5 | 71.4 | 2 | 28.6 |
| 25 | 22 | 84.6 | 4 | 15.4 | 19 | 86.4 | 3 | 13.6 | 2 | 50.0 | 2 | 50.0 |
| 26 | 18 | 69.2 | 8 | 30.8 | 12 | 66.7 | 6 | 33.3 | 5 | 62.5 | 3 | 37.5 |
| 27 | 17 | 65.4 | 9 | 34.6 | 8 | 47.1 | 9 | 52.9 | 5 | 55.6 | 4 | 44.4 |
| 28 | 13 | 50.0 | 13 | 50.0 | 6 | 46.2 | 7 | 53.8 | 7 | 53.8 | 6 | 46.2 |
| 29 | 13 | 50.0 | 13 | 50.0 | 8 | 61.5 | 5 | 38.5 | 3 | 23.1 | 10 | 76.9 |
| 30 | 11 | 42.3 | 15 | 57.7 | 2 | 18.2 | 9 | 0.0 | 7 | 46.7 | 8 | 53.3 |
| 31 | 9 | 34.6 | 17 | 65.4 | 5 | 55.6 | 4 | 44.4 | 8 | 47.1 | 9 | 52.9 |
| 32 | 13 | 50.0 | 13 | 50.0 | 8 | 61.5 | 5 | 38.5 | 4 | 30.8 | 9 | 69.2 |
| 33 | 12 | 46.2 | 14 | 53.8 | 6 | 50.0 | 6 | 50.0 | 9 | 64.3 | 5 | 35.7 |
| 34 | 16 | 61.5 | 10 | 38.5 | 10 | 62.5 | 6 | 37.5 | 5 | 50.0 | 5 | 50.0 |
| 35 | 15 | 57.7 | 11 | 42.3 | 9 | 60.0 | 6 | 40.0 | 6 | 54.5 | 5 | 45.5 |
| 36 | 15 | 57.7 | 11 | 42.3 | 14 | 93.3 | 1 | 6.7 | 9 | 81.8 | 2 | 18.2 |
| 37 | 23 | 88.5 | 3 | 11.5 | 18 | 78.3 | 5 | 21.7 | 2 | 66.7 | 1 | 33.3 |
| 38 | 20 | 76.9 | 6 | 23.1 | 20 | 100.0 | 0 | 0.0 | 5 | 83.3 | 1 | 16.7 |
| 39 | 25 | 96.2 | 1 | 3.8 | 25 | 100.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 |
| 40 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 41 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 42 | 24 | 92.3 | 2 | 7.7 | 24 | 100.0 | 0 | 0.0 | 2 | 100.0 | 0 | 0.0 |
| 43 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 44 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 45 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 46 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 47 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 48 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 49 | 26 | 100.0 | 0 | 0.0 | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 50 | 26 | 100.0 | 0 | 0.0 | 25 | 96.2 | 1 | 3.8 | 0 | 0.0 | 0 | 0.0 |
| 51 | 25 | 96.2 | 1 | 3.8 | 23 | 92.0 | 2 | 8.0 | 1 | 100.0 | 0 | 0.0 |
| 52 | 24 | 92.3 | 2 | 7.7 | 23 | 95.8 | 1 | 4.2 | 2 | 100.0 | 0 | 0.0 |

Markov chain model for the analysis of south-west monsoon rainfall of arid zone of Haryana. Knowledge of dry and wet spell occurrence could be very useful in managing the critical water requirement period of the crop. As from knowledge of rainfall probability analysis, crop sowing dates can be adjusted in such a way that critical stages of the crop coincide with the period of higher rainfall probability. Apart from saving crops from water deficit, insect-pest and disease occurrence can also be predicted based on these sequences of dry and wet spell.

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Received: 9 January 2013; Accepted: 20 November 2013