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*Research Article*

# Weekly rainfall analysis using the Markov chain model in the Dharmapuri region of Tamil Nadu

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**Abstract**
During a rainy season, dry and wet spells tend to persist and can be represented using a Markov process. Knowing the succession of dry and wet periods is necessary to plant crops and carry out agricultural operations. This study aimed to analyze the probability of dry/wet spell rainfall using the Markov chain model in the Dharmapuri district of Tamil Nadu, India. In estimating the chance of dry and wet spells, the model used rainfall of below 20 mm in a week as a dry calendar week and rainfall of 20 mm or more as a wet calendar week from the years 1980 to 2019. From the 1$^{st}$ through the 32$^{nd}$ Standard Meteorological Week (SMW), a continuous dry week probability was 75-100%. The likelihood of a dry week trailed by another dry week was more up to the 32$^{nd}$ standard week, while the chance of a dry week followed by a wet week was more up to the 31$^{st}$ standard week, ranging from 75 to 100%. During the 37$^{th}$ to 45$^{th}$ weeks, the conditional likelihood of a rainy week followed by another rainy week ranged from 43.8 to 68%. According to a review of consecutive dry and wet spells, two consecutive dry weeks had a 55 to 97.5% chance of occurring within the first 32 weeks of the year. In the first 32$^{nd}$ week of the year, the chance of three successive dry weeks ranged from 32.6 to 92.6%. Consecutive dry weeks suggest the need for additional irrigation and proper moisture management practices. In contrast, consecutive wet calendar weeks indicate an abundance of extra water available for rainwater collection and the necessity for proper soil erosion control measures.

**Keywords:** Conditional probability, Dry spell, Forwards accumulation, Markov chain model, Wet spell

## INTRODUCTION

Dharmapuri District was created in 1965 when the former Salem District was divided into Salem and Dharmapuri ( District statistical office, 2016). The district is located between 11” 47' and 12” 33' north latitude and 77” 45' and 76” 45' east longitude. The average annual rainfall is 850 mm, with temperatures ranging from 17$^0$C to 37$^0$C. The main crops grown in this region are paddy, ragi, legumes, groundnut, sugarcane, cotton, coconut, and sammai. There are a variety of soil types in the district, including red loamy soil, lateritic coastal alluvium soil, black soil, red and sandy soils. Soil is generally deficient in nitrogen and phosphate, which has a negative impact on crop output. Monsoon rainfall and distribution are critical to Indian agriculture. This region is known for its unpredictable weather patterns and unequal rainfall distribution. Extremes of temperature, resulting in land degradation, exacerbate the issue. Crop yield, particularly in rainfed areas, is influenced by rainfall patterns. Researchers investigated the expected behaviour of rainfall. The characterisation of command area crops, cropping system planning, and conservation structure design will benefit from studying wet and dry spells. The idea of probability is commonly utilised in agricultural planning to examine dry and wet spells (Dhawan, 2017).
The stochastic models used to study dry spells can be subdivided into two different categories: driven data models (e.g., the non-homogeneous Poisson model), which reproduce the primary characteristics of the available data series, and physically based models

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(e.g., the Markov chain model), which schematize the generating mechanisms of atmospheric precipitation (Adane *et al*., 2020). Probability distribution analysis offers a better scope for predicting the minimum assured rainfall to help the crop planning (Singh *et al*., 2019). The Markov chain probability method is generally applied to study spell distributions of rainfall (Manikandan *et al*., 2017). The model believes that the chance of rain on any given day is determined by whether the preceding day was wet or dry. It could calculate the initial probabilities of obtaining wet spells or dry spells in an SMW. Calculating conditional probabilities offers information on whether a dry spell will be followed by a rainy spell or vice versa (Mangaraj *et al*., 2013).

Prior understanding of the probability or possibilities of dry and rainy spells occurring at specific times is becoming increasingly essential, especially considering the worldwide influence of climate change. For example, knowing how to utilise rainfall probability analysis to modify agricultural sowing dates such that crucial stages of crop production coincide with periods of greater rainfall probability might be beneficial (Mimikdu, 1983; Sharma, 1996; Tyubee and Iwan, 2019; Adane *et al*., 2020). It may be harmful if a dry period occurs during crucial moisture-required phases of crop production, such as gap-filling, but it may be advantageous during the ripening stage. However, if a rainy period occurs at the crucial moisture-requirement stages of crop production, it will be extremely helpful to crop yield (Reddy *et al.,* 2013).

In practice, many decisions must be made during a crop growing season depending on the chance of receiving confident amounts of rainfall during a week [P (w)], also known as "initial probability, and then the likelihood of rain succeeding week if we had rain this week [P(w/w)], also known as conditional probability (Birhan *et al*., 2014). If a week 'i' is wet, initial chances estimate the odds of $(i+k)^{th}$ days being wet, wet/wet, or dry/dry (Fischer *et al*., 2013). The Markov chain method is used to analyse rainfall using starting and conditional probability (Dabral *et al*., 2014). Manikandan *et al.* (2017) used a Markov chain probability analysis to predict wet and dry spells for agricultural crop planning in Bhavanisagar over a 47-year period (1969–2015). They calculated the area's weekly spell probability based on a 20 mm rainfall threshold. Other research has looked examined the likelihood of dry and rainy spells. Vanitha and Ravikumar (2017) also computed the likelihood of dry and wet spells of varying lengths (equal to or greater than a specific time), observing that the distribution of spells by length was regular. The temporal analysis of dry/wet spells indicates a potential water-scarce period, which might result in severe drought or flooding due to flash rains. In view of this, an attempt was made to analyse the initial and conditional chance of wet and dry weeks and the likelihood of two and three successive wet and dry spell weeks for Dharmapuri District, Tamil Nadu State, using the Markov chain model.

## MATERIALS AND METHODS

The Regional Meteorological Centre in Chennai, Tamil Nadu, provided daily rainfall data of the past 40 years (1980–2019). Weekly rainfall based on the Markov chain model was used in the dry and wet period research, with less than 20 mm rainfall considered a dry week and more than 20 mm rainfall considered a wet week (Ray *et al*., 2018). During the rainy season, dry periods are common owing to insufficient rainfall. The atmosphere is evaporative demand shifts from '40 mm' $week^{-1}$ at the start of the spell to '30 mm' $week^{-1}$ as the rainy period progresses. 0.5 to 0.75 times the evaporation requirement may be met in a week with approximately 20 mm of rain. As a result, a dry week was defined as one with less than 20 mm of rainfall. In a dry week, crops may be able to meet their water requirements by drawing on soil moisture. If rainfall is less than 20 mm $week^{-1}$ for more than two weeks, crops are expected to undergo soil moisture stress due to a lack of stored soil moisture.

The following are the different symbolizations used in Markov chain analysis:

**Initial probability:**

$Pd = Fd/n$ ……Eq.1

$Pw = Fw/n$ ……Eq.2

**Conditional probability:**

$Pdd = Fdd/Fd$ ……Eq.3

$Pww = Fww/Fw$ ……Eq.4

$Pwd = 1-Pdd$ ……Eq.5

$Pdw = 1-Pww$ ……Eq.6

**Consecutive dry and wet week probability**

$P2d = Pd_1 \times Pdd_2$ ……Eq.7

$P2w = Pw_1 \times Pww_2$ ……Eq.8

$P3d = Pd_1 \times Pdd_2 \times Pdd_3$ ……Eq.9

$P3w = Pw_1 \times Pww_2 \times Pww_3$ ……Eq.10

where 'Pd' stands for the probability of a dry period and 'Pw' stands for the likelihood of a wet period. 'Fd' is the number of dry weeks detected, 'Fw' denotes the number of wet weeks detected, 'n' denotes the number of years of information used, and 'Pdd' denotes the likelihood of a dry week being followed by another dry week (conditional). 'Pwd' is the probability of a wet week preceding another wet week, Pdw is the probability of a dry week preceding another dry week, 'P2d' is the probability of two repeated dry weeks, 'P3d' is the chance of three successive dry weeks, 'P2w' is the chance of two consecutive wet weeks, and 'P3w' is the probability of three wet weeks. '$Pd_1$' is the chance of the first week being dry, '$Pdd_2$' is the probability of the second consecutive dry week provided that the previous week was dry, and '$Pdd_3$' is the chance of the third following dry week given that the previous week was dry. '$Pww_1$' is the likelihood of the first week of the period being wet, '$Pww_2$' is the chance of the subsequent successive wet week provided that the previous week was wet, and '$Pww_3$' is the probability of the third repeated wet week given that the previous week was wet (Vanitha and Ravikumar, 2017).

To compute backwards and forwards accumulation, weekly rainfalls are placed in columns, and the year is organised in rows. The 38$^{th}$ week was utilised as the starting period for forwards accumulation estimates due to the advent of monsoon rain. The rainfall accumulates week by week from the 38$^{th}$ week onwards to establish the matching week number in which the cumulative rainfall surpasses 75 mm and 200 mm. Similarly, rainfall totals are calculated by adding week-by-week rainfall backwards from the 52$^{nd}$ week (52$^{nd}$ week + 51$^{st}$ week +......) to arrive at totals of 100 mm, 300 mm, and 500 mm, with the relevant week numbers specified. The years are then given a rank number, which ranges from 1 to 40 for 1980 to 2019. The likelihood of each rank is predicted by using a basic statistical procedure.

f(P)= Rn/Yn+1 (Manikandan *et al*., 2017).

Where f(P) denotes probability (percentage), Rn denotes a rank number, and Yn is the number of years observed. The rank order and probability level are placed in rising order for forwards accumulation, and the accompanying week numbers are presented in the same way. Similarly, the rank order and possible level for backwards accumulation are placed in downwards order, whereas the respective week numbers of 500 mm, 300 mm, and 100 mm are organised in rising order (Manikandan *et al*., 2017).

## RESULTS AND DISCUSSION

The average annual rainfall in Dharmapuri, Tamil Nadu, was 946.63 mm during the last 40 years (1980-2019).

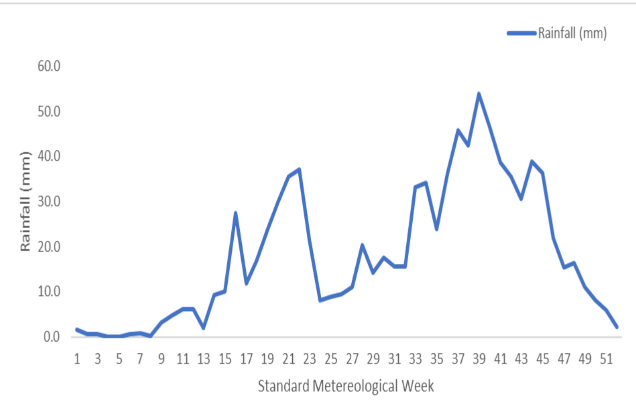


**Fig. 1.** *Weekly rainfall distribution of Dharmapuri region (1980-2019)*

The annual rainfall amount varied over the years, ranging from 474.2 mm (lowest in 2018) to 1767.3 mm (highest in 2005). Out of the 40 years studied, 14 years had annual rainfall over average or normal (946.63 mm), whereas 26 years had rainfall below average. Except for the 19$^{th}$ to 22$^{nd}$ weeks, the weekly rainfall variability indicated that the mean weekly rainfall was 20 mm through to the 33$^{rd}$ week (Fig. 1). At Dharmapuri, the mean weekly rainfall showed that the steadiest period was 33 to 46 SMW, with a total average length of the rainy period of 14 weeks. The 33 – 46$^{th}$ SMW contributes the most rainfall to the annual average rainfall.

### Initial, conditional, consecutive dry and wet probability of weekly rainfall

Table 1 shows the results for all 52 standard meteorological weeks for the initial and conditional probability of wet and dry weeks and following wet and dry weeks. A dry week was possibly 75-100 % from the first to the 32$^{nd}$ Standard Meteorological Week (SMW). Up to the 32$^{nd}$ standard week, the likelihood of a dry week followed by another dry week was high, ranging from 75 to 100%, while the chance of a dry calendar week followed by a wet calendar week was high, ranging from 75 to 100%. The conditional likelihood of a rainy week followed by another wet week ranged from 43.8 to 68 % over the 37$^{th}$ to 45$^{th}$ weeks (Fig. 2). According to an examination of successive dry and wet spells, two consecutive dry weeks have a 55 to 97.5 % chance of occurring around the first 32 weeks of the year. The chance of three repeated dry weeks ranged from 32.6 to 92.6 % in the first 32 weeks of the year. From the first to the 35th weeks, the comparable values for two and three successive wet weeks were low, ranging from 0% to 40% and 0% to 12%, respectively. The chances of having two or three repeated dry weeks were only 10% to 30% and 0-12.5 %, respectively, from the 39$^{th}$ to the 45$^{th}$ week. According to the study, the last 2-3 weeks of the year are likely to be stressful since there is a greater than 50% chance of two or three consecutive dry weeks. The identical results were observed by Manikandan *et al*. (2017) in Bhavanisagar river basin, Tamil Nadu.

### Backwards and forwards analysis of accumulated rainfall

The outcomes of backwards and forwards accumulated rainfall are given in Table 2. The forward accumulation started on week 9$^{th}$. According to the prediction, there is a 75% chance of 75 mm of cumulative rainfall in week 20. Similarly, in the 28$^{th}$ week, there was an approximately 75% chance of receiving 200 mm of cumulative rain. According to the results of backwards rainfall accumulation, there was a 97.6% possibility of receiving 100 mm and 300 mm cumulative rainfall in the

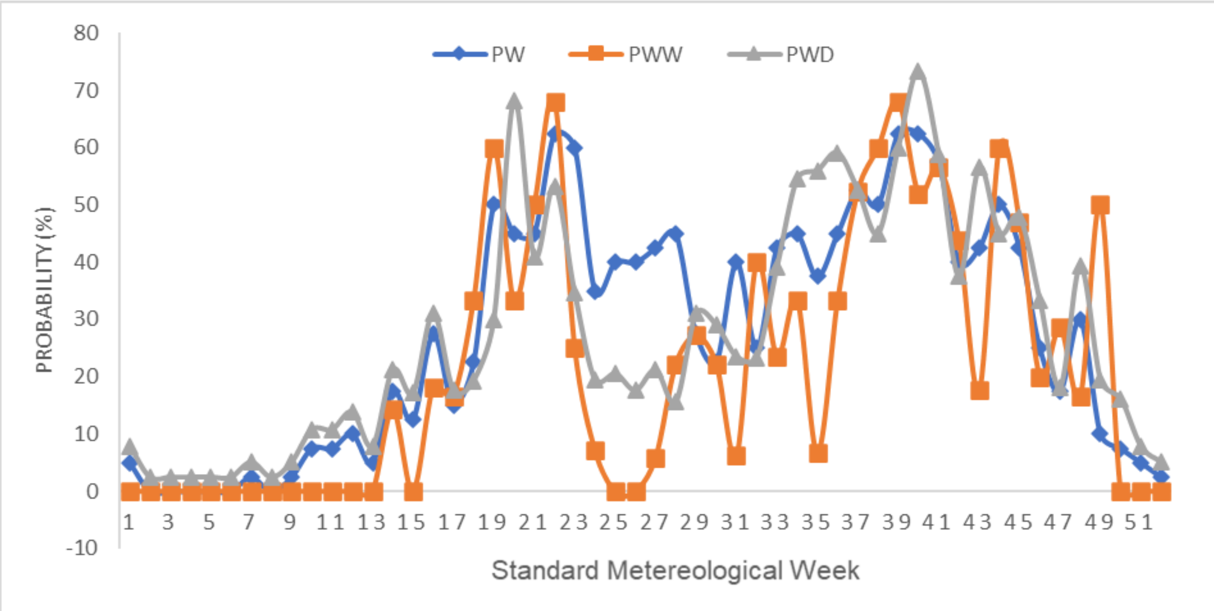


**Fig. 2.** *Initial and conditional probability of rainfall in Dharmapuri by Markov chain mode*

36th and 20th weeks, respectively. In the 10th week, there was a 95.1 % chance of receiving 500 mm of total rainfall. As a result, crop sowing could begin in the 27th week, and the average span of the rainy period was found to be 14 weeks.

**Crop planning strategies**

The main causes of low crop productivity in the Dharmapuri region of Tamil Nadu include erratic rainfall distribution and the frequent occurrence of early, intermittent, and late season prolonged dry spells (District statistical office, 2016). The findings of the foregoing analysis can be put to good use in agricultural planning. During the 16th to 18th weeks, the probability of a wet week is approximately 22%, with an average weekly rainfall of 10 mm. Summer plowing and seedbed preparations can be performed with this premonsoon rain. The similar suggestion for the agricultural operation was observed by Vanitha and Ravikumar, (2017) for the Trichy District, Tamil Nadu State. The rainy season lasted an average of 14 weeks. Farmers can make good use of the rain during the three-crop season. Agricultural operations such as weeding, hoeing, etc. can be carried out successfully.

Adane *et al*. (2020) also insisted the above suggestions during the rainy season for making the best utilization of rain. Short-term crops such as groundnut, pigeon pea, pearl millet, maize, sorghum, green gramme, soybean, sunflower, field bean, cowpea, and other less water-dependent crops with high return values can be planted during *Kharif* (the 23rd to 32nd standard week) since dry circumstances are more likely. Minimum duration crops such as cereals, pulses, and oilseeds are planted in the June first two weeks to have an additional benefit, and they can also be harvested by the end of September. Consecutive dry weeks in the middle of the rainfall weeks necessitate supplemental irrigation and appropriate soil moisture maintenance practices; however, consecutive wet weeks indicate an abundance of runoff water available for rainwater management and the implementation of appropriate soil erosion control measures. For rabi crops, high rainfall and more rainy weeks with a high probability from the 37th to 44th week could be used. Because the northeast monsoon is more predictable than the southwest monsoon, producing high-value rabi crops such as cotton, rice, and vegetables during the 36th to 44th weeks would be highly profitable.

Based on Tyubee and Iwan (2019) suggestions on moisture techniques and results of the moisture conservation in the middle belt region of Nigeria, the current study area was also directed to practice identical moisture conservation techniques such as mulching, use of anti-transparent, effective weed control, adequate plant stands per square metre, etc., can help in better crop production under moisture stress or dry spell periods, and mitigate the effect of drought during active periods, because dry probabilities are high throughout the year. Land levelling and grading would aid in the distribution of irrigation in the region, making it easier and more evenly distributed. It is indeed possible to attain a higher water application efficiency by using micro-irrigation. Contour farming, conservation tillage, trenching, mixed and intercropping and agro forestry techniques and the addition of organic matter through residue management or green manures are used to conserve moisture, minimise evaporation losses and increase the water-holding capacity of soil and fulfil the food, fuel, fodder and fibre needs of the local people to check migration during drought periods.

**Table 1.** Initial, conditional and consecutive dry and wet week probabilities of rainfall in Dharmapuri region (1980-2019)

| **Initial Probability %** | | | **Conditional Probability %** | | | | **Consecutive Probability %** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Week** | **PD** | **PW** | **PDD** | **PWD** | **PWW** | **PDW** | **P2D** | **P3D** | **P2W** | **P3W** |
| W1 | 95.0 | 5.0 | 92.1 | 7.9 | 0.0 | 100.0 | 87.5 | 73.7 | 0.0 | 0.0 |
| W2 | 100.0 | 0.0 | 97.5 | 2.5 | 0.0 | 100.0 | 97.5 | 92.6 | 0.0 | 0.0 |
| W3 | 100.0 | 0.0 | 97.5 | 2.5 | 0.0 | 100.0 | 97.5 | 92.6 | 0.0 | 0.0 |
| W4 | 100.0 | 0.0 | 97.5 | 2.5 | 0.0 | 100.0 | 97.5 | 92.6 | 0.0 | 0.0 |
| W5 | 100.0 | 0.0 | 97.5 | 2.5 | 0.0 | 100.0 | 97.5 | 92.6 | 0.0 | 0.0 |
| W6 | 100.0 | 0.0 | 97.5 | 2.5 | 0.0 | 100.0 | 97.5 | 92.6 | 0.0 | 0.0 |
| W7 | 97.5 | 2.5 | 94.9 | 5.1 | 0.0 | 100.0 | 92.5 | 83.0 | 0.0 | 0.0 |
| W8 | 100.0 | 0.0 | 97.5 | 2.5 | 0.0 | 100.0 | 97.5 | 92.6 | 0.0 | 0.0 |
| W9 | 97.5 | 2.5 | 94.9 | 5.1 | 0.0 | 100.0 | 92.5 | 83.0 | 0.0 | 0.0 |
| W10 | 92.5 | 7.5 | 89.2 | 10.8 | 0.0 | 100.0 | 82.5 | 62.4 | 0.0 | 0.0 |
| W11 | 92.5 | 7.5 | 89.2 | 10.8 | 0.0 | 100.0 | 82.5 | 64.7 | 0.0 | 0.0 |
| W12 | 90.0 | 10.0 | 86.1 | 13.9 | 0.0 | 100.0 | 77.5 | 58.1 | 0.0 | 0.0 |
| W13 | 95.0 | 5.0 | 92.1 | 7.9 | 0.0 | 100.0 | 87.5 | 73.7 | 0.0 | 0.0 |
| W14 | 82.5 | 17.5 | 78.8 | 21.2 | 14.3 | 85.7 | 65.0 | 39.4 | 2.5 | 0.0 |
| W15 | 87.5 | 12.5 | 82.9 | 17.1 | 0.0 | 100.0 | 72.5 | 51.8 | 0.0 | 0.0 |
| W16 | 72.5 | 27.5 | 69.0 | 31.0 | 18.2 | 81.8 | 50.0 | 25.9 | 5.0 | 0.0 |
| W17 | 85.0 | 15.0 | 82.4 | 17.6 | 16.7 | 83.3 | 70.0 | 45.3 | 2.5 | 0.0 |
| W18 | 77.5 | 22.5 | 80.6 | 19.4 | 33.3 | 66.7 | 62.5 | 38.3 | 7.5 | 0.8 |
| W19 | 50.0 | 50.0 | 70.0 | 30.0 | 60.0 | 40.0 | 35.0 | 17.5 | 30.0 | 12.0 |
| W20 | 55.0 | 45.0 | 31.8 | 68.2 | 33.3 | 66.7 | 17.5 | 0.8 | 15.0 | 1.7 |
| W21 | 55.0 | 45.0 | 59.1 | 40.9 | 50.0 | 50.0 | 32.5 | 10.3 | 22.5 | 6.3 |
| W22 | 37.5 | 62.5 | 46.7 | 53.3 | 68.0 | 32.0 | 17.5 | 2.3 | 42.5 | 18.7 |
| W23 | 65.0 | 60.0 | 65.4 | 34.6 | 25.0 | 75.0 | 42.5 | 18.0 | 15.0 | 0.6 |
| W24 | 90.0 | 35.0 | 80.6 | 19.4 | 7.1 | 92.9 | 72.5 | 50.3 | 2.5 | 0.0 |
| W25 | 85.0 | 40.0 | 79.4 | 20.6 | 0.0 | 100.0 | 67.5 | 41.7 | 0.0 | 0.0 |
| W26 | 85.0 | 40.0 | 82.4 | 17.6 | 0.0 | 100.0 | 70.0 | 41.2 | 0.0 | 0.0 |
| W27 | 82.5 | 42.5 | 78.8 | 21.2 | 5.9 | 94.1 | 65.0 | 41.4 | 2.5 | 0.0 |
| W28 | 80.0 | 45.0 | 84.4 | 15.6 | 22.2 | 77.8 | 67.5 | 46.4 | 10.0 | 1.1 |
| W29 | 72.5 | 27.5 | 69.0 | 31.0 | 27.3 | 72.7 | 50.0 | 22.4 | 7.5 | 0.0 |
| W30 | 77.5 | 22.5 | 71.0 | 29.0 | 22.2 | 77.8 | 55.0 | 30.2 | 5.0 | 0.6 |
| W31 | 85.0 | 40.0 | 76.5 | 23.5 | 6.3 | 93.8 | 65.0 | 36.3 | 2.5 | 0.0 |
| W32 | 75.0 | 25.0 | 76.7 | 23.3 | 40.0 | 60.0 | 57.5 | 32.6 | 10.0 | 2.0 |
| W33 | 57.5 | 42.5 | 60.9 | 39.1 | 23.5 | 76.5 | 35.0 | 12.2 | 10.0 | 0.6 |
| W34 | 55.0 | 45.0 | 45.5 | 54.5 | 33.3 | 66.7 | 25.0 | 5.7 | 15.0 | 1.7 |
| W35 | 62.5 | 37.5 | 44.0 | 56.0 | 6.7 | 93.3 | 27.5 | 3.3 | 2.5 | 0.0 |
| W36 | 55.0 | 45.0 | 40.9 | 59.1 | 33.3 | 66.7 | 22.5 | 4.1 | 15.0 | 0.8 |
| W37 | 47.5 | 52.5 | 47.4 | 52.6 | 52.4 | 47.6 | 22.5 | 4.7 | 27.5 | 5.2 |
| W38 | 50.0 | 50.0 | 55.0 | 45.0 | 60.0 | 40.0 | 27.5 | 8.3 | 30.0 | 10.5 |
| W39 | 37.5 | 62.5 | 40.0 | 60.0 | 68.0 | 32.0 | 15.0 | 2.0 | 42.5 | 18.7 |
| W40 | 37.5 | 62.5 | 26.7 | 73.3 | 52.0 | 48.0 | 10.0 | 0.0 | 32.5 | 7.8 |
| W41 | 42.5 | 57.5 | 41.2 | 58.8 | 56.5 | 43.5 | 17.5 | 2.1 | 32.5 | 12.7 |
| W42 | 60.0 | 40.0 | 62.5 | 37.5 | 43.8 | 56.3 | 37.5 | 12.5 | 17.5 | 3.3 |
| W43 | 57.5 | 42.5 | 43.5 | 56.5 | 17.6 | 82.4 | 25.0 | 5.4 | 7.5 | 0.0 |
| W44 | 50.0 | 50.0 | 55.0 | 45.0 | 60.0 | 40.0 | 27.5 | 9.6 | 30.0 | 10.5 |
| W45 | 57.5 | 42.5 | 52.2 | 47.8 | 47.1 | 52.9 | 30.0 | 7.8 | 20.0 | 2.4 |
| W46 | 75.0 | 25.0 | 66.7 | 33.3 | 20.0 | 80.0 | 50.0 | 28.3 | 5.0 | 0.0 |
| W47 | 82.5 | 17.5 | 81.8 | 18.2 | 28.6 | 71.4 | 67.5 | 43.0 | 5.0 | 0.0 |
| W48 | 70.0 | 30.0 | 60.7 | 39.3 | 16.7 | 83.3 | 42.5 | 15.2 | 5.0 | 0.0 |
| W49 | 90.0 | 10.0 | 80.6 | 19.4 | 50.0 | 50.0 | 72.5 | 50.3 | 5.0 | 0.0 |
| W50 | 92.5 | 7.5 | 83.8 | 16.2 | 0.0 | 100.0 | 77.5 | 56.6 | 0.0 | 0.0 |
| W51 | 95.0 | 5.0 | 92.1 | 7.9 | 0.0 | 100.0 | 87.5 | 66.8 | 0.0 | 0.0 |
| W52 | 97.5 | 2.5 | 94.9 | 5.1 | 0.0 | 100.0 | 92.5 | 83.0 | 0.0 | 0.0 |

Source: Regional Meteorological centre, Chennai; PD- probability of a dry period, PW- probability of a wet period, PDD- probability of a dry week being followed by another dry week, PWD- probability of a wet week preceding another wet week, PWW- probability of a wet week being followed by another wet week, PDW- probability of a dry week preceding another wet week, P2D- probability of two repeated dry weeks, P3D- probability of three repeated dry weeks, P2W- probability of two repeated wet weeks, P3W- probability of three repeated wet weeks

**Table 2.** Onset and end of rainy season based on forwards and backwards accumulation of rainfall

| Year | Forwards Accumulation | | Backwards Accumulation | | | Forwards Accumulation | | | | Backwards Accumulation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 75 mm | 200 mm | 500 mm | 300 mm | 100 mm | Rn | f(p) | 75 mm | 200 mm | Rn | f(p) | 500 mm | 300 mm | 100 mm |
| | Accumulated on week | | To be expected from week | | | Ranked | | | | Ranked | | | | |
| 1980 | 38 | 43 | 25 | 43 | 46 | 1 | 2.4 | 9 | 15 | 40 | 97.6 | 0 | 20 | 36 |
| 1981 | 19 | 29 | 29 | 36 | 38 | 2 | 4.9 | 10 | 16 | 39 | 95.1 | 10 | 21 | 38 |
| 1982 | 18 | 23 | 28 | 40 | 45 | 3 | 7.3 | 19 | 16 | 38 | 92.7 | 19 | 28 | 39 |
| 1983 | 20 | 21 | 36 | 37 | 51 | 4 | 9.8 | 21 | 18 | 37 | 90.2 | 21 | 29 | 40 |
| 1984 | 11 | 29 | 30 | 39 | 40 | 5 | 12.2 | 22 | 19 | 36 | 87.8 | 22 | 33 | 40 |
| 1985 | 14 | 23 | 23 | 36 | 41 | 6 | 14.6 | 23 | 20 | 35 | 85.4 | 23 | 34 | 41 |
| 1986 | 20 | 25 | 35 | 40 | 45 | 7 | 17.1 | 25 | 20 | 34 | 82.9 | 25 | 36 | 41 |
| 1987 | 12 | 26 | 37 | 39 | 41 | 8 | 19.5 | 27 | 20 | 33 | 80.5 | 27 | 36 | 41 |
| 1988 | 17 | 27 | 34 | 37 | 41 | 9 | 22.0 | 28 | 20 | 32 | 78.0 | 28 | 36 | 41 |
| 1989 | 20 | 27 | 27 | 29 | 41 | 10 | 24.4 | 29 | 21 | 31 | 75.6 | 29 | 36 | 41 |
| 1990 | 10 | 21 | 21 | 36 | 43 | 11 | 26.8 | 29 | 21 | 30 | 73.2 | 29 | 37 | 42 |
| 1991 | 19 | 23 | 41 | 44 | 46 | 12 | 29.3 | 30 | 21 | 29 | 70.7 | 30 | 37 | 42 |
| 1992 | 22 | 27 | 32 | 38 | 44 | 13 | 31.7 | 30 | 21 | 28 | 68.3 | 30 | 37 | 43 |
| 1993 | 20 | 23 | 38 | 44 | 49 | 14 | 34.1 | 31 | 21 | 27 | 65.9 | 31 | 38 | 43 |
| 1994 | 16 | 21 | 33 | 39 | 44 | 15 | 36.6 | 32 | 21 | 26 | 63.4 | 32 | 38 | 43 |
| 1995 | 19 | 21 | 38 | 42 | 44 | 16 | 39.0 | 33 | 21 | 25 | 61.0 | 33 | 38 | 44 |
| 1996 | 16 | 21 | 40 | 42 | 50 | 17 | 41.5 | 33 | 21 | 24 | 58.5 | 33 | 39 | 44 |
| 1997 | 14 | 21 | 38 | 43 | 78 | 18 | 43.9 | 33 | 22 | 23 | 56.1 | 33 | 39 | 44 |
| 1998 | 29 | 33 | 35 | 40 | 50 | 19 | 46.3 | 33 | 22 | 22 | 53.7 | 33 | 39 | 44 |
| 1999 | 15 | 20 | 39 | 43 | 47 | 20 | 48.8 | 33 | 22 | 21 | 51.2 | 33 | 39 | 44 |
| 2000 | 9 | 16 | 33 | 39 | 43 | 21 | 51.2 | 33 | 23 | 20 | 48.8 | 33 | 39 | 44 |
| 2001 | 15 | 16 | 37 | 39 | 44 | 22 | 53.7 | 34 | 23 | 19 | 46.3 | 34 | 39 | 44 |
| 2002 | 21 | 35 | 35 | 39 | 42 | 23 | 56.1 | 35 | 23 | 18 | 43.9 | 35 | 39 | 44 |
| 2003 | 11 | 20 | 31 | 39 | 40 | 24 | 58.5 | 35 | 23 | 17 | 41.5 | 35 | 39 | 44 |
| 2004 | 18 | 19 | 38 | 41 | 44 | 25 | 61.0 | 35 | 25 | 16 | 39.0 | 35 | 40 | 45 |
| 2005 | 14 | 15 | 43 | 45 | 47 | 26 | 63.4 | 36 | 26 | 15 | 36.6 | 36 | 40 | 45 |
| 2006 | 11 | 20 | 10 | 20 | 39 | 27 | 65.9 | 36 | 27 | 14 | 34.1 | 36 | 40 | 45 |
| 2007 | 22 | 30 | 29 | 34 | 44 | 28 | 68.3 | 36 | 27 | 13 | 31.7 | 36 | 40 | 45 |
| 2008 | 18 | 33 | 22 | 36 | 48 | 29 | 70.7 | 37 | 27 | 12 | 29.3 | 37 | 41 | 45 |
| 2009 | 20 | 21 | 33 | 38 | 44 | 30 | 73.2 | 37 | 27 | 11 | 26.8 | 37 | 41 | 46 |
| 2010 | 16 | 21 | 41 | 44 | 47 | 31 | 75.6 | 38 | 28 | 10 | 24.4 | 38 | 42 | 46 |
| 2011 | 17 | 18 | 30 | 33 | 45 | 32 | 78.0 | 38 | 29 | 9 | 22.0 | 38 | 42 | 47 |
| 2012 | 19 | 28 | 36 | 41 | 44 | 33 | 80.5 | 38 | 29 | 8 | 19.5 | 38 | 43 | 47 |
| 2013 | 21 | 22 | 36 | 37 | 45 | 34 | 82.9 | 38 | 30 | 7 | 17.1 | 38 | 43 | 47 |
| 2014 | 21 | 22 | 33 | 40 | 43 | 35 | 85.4 | 39 | 31 | 6 | 14.6 | 39 | 43 | 48 |
| 2015 | 18 | 20 | 39 | 45 | 45 | 36 | 87.8 | 39 | 31 | 5 | 12.2 | 39 | 44 | 49 |
| 2016 | 20 | 22 | 19 | 28 | 36 | 37 | 90.2 | 40 | 33 | 4 | 9.8 | 40 | 44 | 50 |
| 2017 | 19 | 31 | 33 | 39 | 44 | 38 | 92.7 | 41 | 33 | 3 | 7.3 | 41 | 44 | 50 |
| 2018 | 20 | 27 | 0 | 21 | 41 | 39 | 95.1 | 41 | 35 | 2 | 4.9 | 41 | 45 | 51 |
| 2019 | 21 | 31 | 33 | 38 | 42 | 40 | 97.6 | 43 | 43 | 1 | 2.4 | 43 | 45 | 78 |

Source: Regional Meteorological centre, Chennai

## Conclusion

In this study, the Markov chain model was used to evaluate the probabilities of the occurrence of dry and wet spells in Dharmapuri District, Tamil Nadu State. The simplest type of persistence may be represented by a Markov process of order one, in which today's state is dependent only up to 1 day behind. Due to variable rainfall distributions and the occurrence of early, intermittent, and late-season extended dry spells. Small-duration crops such as cowpea, field bean, groundnut, pearl millet, maize, pigeon pea, sorghum, sunflower, green gramme, soybean, and other low water demanding crops with maximum economic returns can be sown on during *kharif* since supplemental irrigation is necessary. However, during the 16th and 18th weeks, the odds of a wet week were approximately 22%, with an average weekly rainfall of 10 mm. Hence, premonsoon rainfall was useful for summer plowing and initial land preparations such as sowing and nursery beds. Because the wet season lasts an average of 14 weeks, farmers may make the most of it throughout the two-crop season. The conditional likelihood of a rainy week followed by a wet week grows after the 32$^{nd}$ week. If there is enough additional irrigation, there is a potential to harvest a summer crop. The substantial contribution of weekly rainfall and the number of consecutive rainy weeks indicated that rabi crops had much promise to have sufficient moisture for crop production.

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### Conflict of interest

The authors declare that they have no conflict of interest.

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