Observed Rainfall Variability and Changes over Jharkhand State

Pulak Guhathakurta, Lalit Bile, Shirish Khedikar, Preetha Menon, Ashwini Kumar Prasad, Neha Sangwan and S C Advani
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### Abstract
India is in the tropical monsoon zone and receives plenty of rainfall as most of the annual rainfall during the monsoon season every year. However, the rainfall is having high temporal and spatial variability and due to the impact of climate changes there are significant changes in the mean rainfall pattern and their variability as well as in the intensity and frequencies of extreme rainfall events. The report brings the result of the analysis based on the recent 30 years of data (1989-2018) on the mean spatial rainfall pattern as well as mean spatial pattern of different rainfall events, trends and variability as well as extreme rainfall events during the monsoon months and annual for the state.
1. Introduction

The state of Jharkhand came into existence on 15th November 2000 after being carved out of southern part of the state of Bihar and became the 28th state of Republic of India. Its name originates from the “Jhar” which means bushes. Earlier, majority of the area was called Chota Nagpur which takes its origin from the land of Nagwanshis. The Jharkhand state is located in the eastern part of India. The total area of Jharkhand is 79.714 square kilometers, bounded by 21º59’N to 25º18’N latitude and 82º52’E to 87º54’E longitude. The state shares its boundary with Bihar, Uttar Pradesh and Chhattisgarh to the west, Orissa to the south and West Bengal to the east. It is a land locked state with shoreline around 100 km away. The tropic of cancer passes through Kanke, few kilometers away from Ranchi which is the capital of Jharkhand.

Due to varied topography, Jharkhand state is blessed with hills and rivers. Many parts of the Jharkhand state lie on the Chota Nagpur plateau. The Chota Nagpur plateau includes a series of hills ranges and flat topped plateau with dissecting river valleys. The Koel, Damodar, Brahmani, Kharkai and Subarnarekha rivers whose upper watersheds lies within Jharkhand.

There are many studies are available on the observed trends and variability of rainfall and extreme rainfall events, but all the studies are based on past 100 years or more data and also the recent years are not included (Chandniha et al, 2016; Guhathakurta et al, 2015; Guhathakurta et al, 2011; Guhathakurta & Rajeevan, 2008 etc). Also there are limited studies available for Jharkhand state. In the present report all the analysis of observed rainfall patterns, trends and variability have been done based on recent past 30 years (1989-2018) that will help to have idea of the recent changes for climate change adaptation and management by the state authorities.

2. Data and Methodology

Daily Rainfall data from 1989 to 2018 is considered for analysis of trend variability and mean rainfall patterns. From the daily rainfall data monthly rainfall series of each stations are computed and then monthly district rainfall series has been constructed by considering arithmetic average of all the station rainfall values within the district. The monthly rainfall series of the state has been computed by using area weighted rainfall values of all the districts within the state. The objective of the analysis is to:

1. Identify the spatial pattern of the mean rainfall

2. Understand district wise observed rainfall trend and variability in annual and SW monsoon season (June, July, August and September).
Daily station rainfall data is utilized for identification of the mean spatial patterns and rainfall intensity trends. From mean and standard deviation (SD), the coefficient of variation (CV) is calculated as follows:

\[
\text{Coefficient of variation (CV)} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100
\]

The analysis has been done in two parts. For identification of the spatial pattern mean rainfall and variability and also observed trends we have used district rainfall series and results have been brought out for four southwest monsoon months viz. June, July, August, September, for the southwest monsoon season and also for annual. Fig. 1 gives the location of the districts of the state. For identification of mean pattern and also trends of intensities of various rainfall events we used the station daily rainfall data.

Fig. 1 Location of the districts of Jharkhand

3. State rainfall mean and variability and trend

Table 1 shows the mean rainfall (mm) and coefficient of variation of the state for the monsoon months, southwest monsoon season and annual during the period 1989-2018. It can be seen that the state gets highest rainfall (31%) of south west monsoon rainfall in July month while the August month get 28% of the south west monsoon rainfall. June and September receive 19% and 22% of south west monsoon
rainfall. Also more than 84% of annual rainfall receives during the southwest monsoon season only. The variability of monsoon or annual rainfall is also very less.

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Table 1 Mean rainfall (mm) and coefficient of variation of the state for the monsoon months, southwest monsoon season and annual.

Fig. 2 and 3 show the time series of rainfall in mm for the months of June, July, August, September and southwest monsoon season, annual respectively. The trend lines are also displayed for each of the series. Neither monthly rainfall nor seasonal rainfall shows any significant increasing/decreasing trend while annual rainfall shows significant decreasing trend. In the monthly rainfall June, July, August, September and seasonal rainfall shows decreasing trend. During the last 30 years highest rainfall of 390.3 mm received in June in the year 1994, 492.1 mm received in June in the year 2017, 431.5 mm received in August in the year 1997, while highest rainfall of 395.2 in September received in the year 1995. Highest annual rainfall of 1587.9 mm received in the year 1999 and highest southwest monsoon rainfall of 1364.6 mm received in the year 1994.

Fig. 2 Time series of rainfall in mm for the months of June, July, August, September and trends
4. District rainfall mean, variability and trend

4.1 Mean and coefficient of variation

Table 2 gives the rainfall statistics for the districts of Jharkhand for the four monsoon months, southwest monsoon season and annual while Fig. 4-5 show the spatial pattern of these statistics. It can be seen that districts viz. Sahebganj, Simdega and East Singhbhum receive highest rainfall during June, district Simdega receive highest rainfall during July, districts viz. Khunti, Simdega and East Singhbhum receive highest rainfall during August, districts viz. Sahebganj, Pakur and Dumka receive highest rainfall during September, districts viz. Sahebganj, Pakur and Simeda receive highest rainfall during SW monsoon while districts viz. Sahebganj, Pakur receive highest annual rainfall. Rainfall receives over these districts are around 200-250 mm in June, 400 mm in July, 300-350 mm in August, 300-350 mm in September and during the SW monsoon 1200-1300 mm and annual 1450-1600mm. Lowest rainfall during the SW monsoon season receives over Palamau district (840.5 mm) and Palamau district receives lowest annual rainfall (925.4).
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Table 1. Rainfall statistics for the districts of Jharkhand for the four monsoon months, southwest monsoon season and annual
Fig. 4 Mean rainfall pattern over districts of Jharkhand for (a) June, (b) July, (c) August, (d) September, (e) southwest monsoon season and (f) Annual
Fig. 5 Coefficient of Variation (%) over districts of Jharkhand for (a) June, (b) July, (c) August, (d) September, (e) southwest monsoon season and (f) Annual
4.2 Trend in district rainfall

Fig. 6 shows the trends in district rainfall for (a) June, (b) July, (c) August, (d) September, (e) JJAS, and (f) annual. It can be seen that June rainfall has shown significant decreasing trend in the districts Garhwa, Chatra, and Koderma while no district has shown any significant increasing trend. For the September month rainfall has shown significant decreasing trend in the districts Chatra, Koderma, Godda, Sahebganj, and Dhanbad. During the whole southwest monsoon season district viz. Garhwa, Chatra, Koderma, Godda, Sahebganj, Dhanbad, Bokaro and Simdega has shown significant decreasing trend. For the annual rainfall districts viz. Garhwa, Chatra, Koderma, Godda, Sahebganj, Dhanbad, Bokaro, Ramgarh and Simdega shows significant decreasing trend.
5. Analysis of Average frequencies for rainfall events of different intensities

5.1 Average frequency of Rainy days

The average frequency of rainy days is calculated for Maharashtra for June, July, August, September, June to September and Annual (Figure 7-12). In the month of June the maximum number of rainy days lies in the range of 9 to 11 days especially in some parts of Sahebganj, Pakur, Dumka, Jamtara, Deoghar, Dhanbad, Ranchi, Khunti and East Singhbhum districts. While minimum number of rainy days lies in the range of 6 to 7 days especially in some parts of Garhwa, Palamu and Chatra districts. Whereas in remaining districts, the number of rainy days lies in the range of 7 to 9 days.

In the month of July the maximum number of rainy days lies in the range of 15 to 17 days especially in some parts of Gumla, Simdega, Khunti, Jamtara and Dhanbad districts. While minimum number of rainy days lies in the range of 12 to 13 days especially in some parts of Garhwa, Palamu, Chatra and Giridih districts. Whereas in remaining districts, the number of rainy days lies in the range of 13 to 15 days.

In the month of August the maximum number of rainy days lies in the range of 15 to 16 days especially in some parts of Gumla, Simdega, Khunti and Jamtara districts. While minimum number of rainy days lies in the range of 12 to 13 days especially in some parts of Garhwa, Palamu, Chatra, Koderma, Giridih, Godda and Sahebganj districts. Whereas in remaining districts, the number of rainy days lies in the range of 13 to 15 days.
In the month of September the maximum number of rainy days lies in the range of 11 to 12 days especially in some parts of Gumla, Simdega, Khunti, East Singhbhum, Dhanbad, Jamtara, Dumka and Pakur districts. While minimum number of rainy days lies in the range of 8 to 9 days especially in some parts of Garhwa, Palamu and Chatra districts. Whereas in remaining districts, the number of rainy days lies in the range of 9 to 11 days.

During the period June to September the maximum number of rainy days lies in the range of 46 to 50 days especially in some parts of Gumla, Simdega, West Singhbhum, East Singhbhum, Dhanbad, Jamtara and Pakur districts. While minimum number of rainy days lies in the range of 35 to 39 days especially in some parts of Garhwa, Palamu, Chatra, Koderma and Giridih districts. Whereas in remaining districts, the number of rainy days lies in the range of 39 to 46 days.

During the entire year the maximum number of rainy days lies in the range of 58 to 63 days especially in some parts of West Singhbhum, East Singhbhum, Dhanbad, Jamtara, Suburban, Pakur and Gumla districts. While minimum number of rainy days lies in the range of 42 to 47 days especially in some parts of Garhwa, Palamu, Chatra and Giridih districts. Whereas in remaining districts, the number of rainy days lies in the range of 47 to 58 days.

Fig. 7 Average frequency of rainy days: June

Fig. 8 Average frequency of rainy days: July
5.2 Average frequency of Heavy rainfall days

The average frequency of Heavy rainfall days is calculated for Maharashtra for June, July, August, September, June to September and Annual (Figure 13-18). In the month of June maximum number of heavy rainfall days lies in the range of 0.6 to 1 days especially in some parts of Sahebganj, Pakur, Latehar, Lohardaga, Ranchi, Simdega, West Singhbhum and East Singhbhum districts. While minimum number of Heavy rainfall days lies in the range of 0.3 to 0.4 days especially in some parts of Garhwa, Palamu, Chatra, Giridih, Deoghar, Godda, Jamtara, Dhanbad and Gumla districts. Whereas in remaining districts, the number of Heavy rainfall days lies in the range of 0.4 to 0.6 days.
July shows the maximum number of heavy rainfall days in the range of 1 to 2 days especially in some parts of Godda, Sahebganj, Pakur, Dumka and Simdega districts. While minimum number of heavy rainfall days lies in the range of 0.5 to 0.7 days especially in some parts of Garhwa, Palamu, Giridih, Dhanbad, Bokaro, Ranchi, Gumla and East Singhbhum districts. Whereas in remaining districts, the number of heavy rainfall days lies in the range of 0.7 to 1 days.

In the month of August the maximum number of heavy rainfall days lies in the range of 0.8 to 1 days especially in some parts of Garhwa, Palamu, Latehar, Simdega, Ramgarh, Dhanbad, Sahebganj, Pakur, Dumka, West Singhbhum and East Singhbhum districts. While minimum number of heavy rainfall days lies in the range of 0.4 to 0.6 days especially in some parts of Giridih, Deoghar, Dumka, Godda, Bokaro, Ranchi, Dhanbad, Gumla and Saraikela Kharsawan districts. Whereas in remaining districts, the number of heavy rainfall days lies in the range of 0.6 to 0.8 days.

In September the maximum number of heavy rainfall days lies in the range of 0.8 to 1 days especially in some parts of Sahebganj, Pakur and Dumka districts. While minimum number of heavy rainfall days lies in the range of 0.3 to 0.5 days especially in some parts of Garhwa, Palamu, Chatra, Latehar, Lohardaga, Gumla, Simdega, Khunti, West Singhbhum, Saraikela Kharsawan, Ranchi and Bokaro districts. Whereas in remaining districts, the number of heavy rainfall days lies in the range of 0.5 to 0.8 days.

During June to September the maximum number of heavy rainfall days lies in the range of 3 to 4 days especially in some parts of Sahebganj, Pakur, Dumka and Simdega districts. While minimum number of heavy rainfall days lies in the range of 1 to 2 days especially in some parts of Garhwa, Palamu, Giridih, Godda, Bokaro, Ramgarh, Ranchi and Gumla districts. Whereas in remaining districts, the number of heavy rainfall days lies in the range of 2 to 3 days.

During the entire year the maximum number of heavy rainfall days lies in the range of 3.4 to 4 days especially in some parts of Sahebganj, Pakur, Dumka and Simdega districts. While minimum number of heavy rainfall days lies in the range of 1 to 2.3 days especially in some parts of Garhwa, Palamu, Chatra, Giridih, Dhanbad, Ranchi and Gumla districts. Whereas in remaining districts, the number of heavy rainfall days lies in the range of 2.3 to 3.4 days.
Fig. 13 Average frequency of heavy rainfall days: June

Fig. 14 Average frequency of rainy days: July

Fig. 15 Average frequency of rainy days: August

Fig. 16 Average frequency of rainy days: September

Fig. 17 Average frequency of rainy days: JJAS

Fig. 18 Average frequency of rainy days: Annual
5.3 Average frequency of Dry days

The average frequency of dry days is calculated for Maharashtra for June, July, August, September, June to September and Annual (Figure 19-24). In the month of June the maximum number of dry days lies in the range of 21 to 23 days especially in some parts of Garhwa, Palamu, Chatra, Hazaribagh, Koderma and Giridih districts. While minimum number of dry days lies in the range of 16 to 18 days especially in some parts of Pakur, Dumka, Jamtara, Dhanbad, Ranchi, Khunti, Gumla, Simdega, Saraikela, Kharsawan, West Singhbhum and East Singhbhum districts. Whereas in remaining districts, the number of dry days lies in the range of 18 to 21 days.

In the month of July the maximum number of dry days lies in the range of 16 to 17 days especially in some parts of Garhwa, Palamu, Chatra, Hazaribagh, Koderma and Giridih districts. While minimum number of dry days lies in the range of 12 to 13 days especially in some parts of Gumla, Simdega, Ranchi, Khunti, Saraikela Kharsawan, East Singhbhum and Pakur districts. Whereas in remaining districts, the number of dry days lies in the range of 13 to 16 days.

During August the maximum number of dry days lies in the range of 16 to 17 days especially in some parts of Garhwa, Palamu, Chatra, Hazaribagh, Koderma, Giridih, Deoghar, Dumka, Godda and Sahebganj districts. While minimum number of dry days lies in the range of 12 to 13 days especially in some parts of Lohardaga, Gumla, Simdega, Ranchi, Khunti, Saraikela Kharsawan, East Singhbhum and West Singhbhum districts. Whereas in remaining districts, the number of dry days lies in the range of 13 to 16 days.

In the month of September the maximum number of dry days lies in the range of 19 to 20 days especially in some parts of Garhwa, Palamu, Chatra, Hazaribagh, Koderma and Giridih districts. While minimum number of dry days lies in the range of 15 to 17 days especially in some parts of Gumla, Simdega, Ranchi, Khunti, Saraikela Kharsawan, East Singhbhum and West Singhbhum districts. Whereas in remaining districts, the number of dry days lies in the range of 17 to 19 days.

Figure 23 shows that during June to September the maximum number of dry days lies in the range of 66 to 71 days especially in some parts of Garhwa, Palamu, Chatra, Hazaribagh, Koderma and Giridih districts. While minimum number of dry days lies in the range of 51 to 56 days especially in some parts of Lohardaga, Gumla, Simdega, Ranchi, Khunti, Saraikela Kharsawan and East Singhbhum districts. Whereas in remaining districts, the number of dry days lies in the range of 56 to 66 days.
Figure 24 shows that in the month of during the entire year the maximum number of dry days lies in the range of 274 to 286 days especially in some parts of Garhwa, Palamu, Chatra, Hazaribagh, Koderma and Jamtara districts. While minimum number of dry days lies in the range of 226 to 238 days especially in some parts of Lohardaga, Gumla, Simdega, Ranchi, Khunti, Pakur, Jamtara and East Singhbhum districts. Whereas in remaining districts, the number of dry days lies in the range of 238 to 274 days.

Fig. 19 Average frequency of dry days: June
Fig. 20 Average frequency of dry days: July
Fig. 21 Average frequency of dry days: August
Fig. 22 Average frequency of dry days: September
6 Trends in the frequencies of different rainfall events

6.1 Trend in frequency of Rainy days

The Trend in frequency of rainy days is calculated for the raingauge stations of Jharkhand for June, July, August, September, June to September and Annual (Figure 25-30). In the month of June there is a significant increase in Rainy days in Giridih district. Whereas there is a significant decrease in Rainy days in stations in Palamu, Koderma, Sahebganj, Godda, Dumka, Deoghar, Giridih, Dhanbad, Bokaro, Ramgarh, Ranchi, Lohardaga, Gumla, Khunti, Simdega and West Singhbhum districts. While remaining districts did not show any significant change.

During July there is a significant increase in Rainy days in stations in Deoghar, Jamtara, Bokaro, Ramgarh, Ranchi and Gumla districts. Whereas there is a significant decrease in Rainy days in stations in Chatra, Hazaribagh, Dhanbad, Bokaro, Ranchi and Gumla districts. While remaining districts did not show any significant change.

In the month of August there is a significant increase in Rainy days in stations in Hazaribagh, Pakur and Gumla districts. Whereas there is a significant decrease in Rainy days in stations in Palamu, Chatra, Hazaribagh Giridih, Deoghar, Sahebganj, Godda, Pakur, Dumka, Jamtara, Dhanbad, Bokaro, Ramgarh, Ranchi, Lohardaga, Gumla, Khunti, Saraikela Kharsawan, East Singhbhum and West Singhbhum districts. While remaining districts did not show any significant change.

In the month of September there is a significant increase in Rainy days in stations in West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in Rainy days in
stations in Garhwa, Palamu, Chatra, Hazaribagh Giridih, Sahebganj, Godda, Dumka, Jamtara, Dhanbad, Bokaro, Ramgarh, Ranchi, Khunti, Gumla, Simdega and East Singhbhum districts. While remaining districts did not show any significant change.

During the entire period of June to September there is a significant increase in Rainy days in stations in Hazaribagh, Giridih, Pakur, Dhanbad, Bokaro, Ramgarh, Ranchi and Gumla districts. Whereas there is a significant decrease in Rainy days in stations Garhwa, Palamu, Chatra, Hazaribagh Giridih, Deoghar, Godda, Dumka, Jamtara, Dhanbad, Ramgarh, Latehar, Lohardaga, Saraikela Kharsawan and West Singhbhum districts. While remaining districts did not show any significant change.

During the entire year there is a significant increase in Rainy days in Hazaribagh, Giridih, Deoghar, Pakur, Dhanbad, Ramgarh, Ranchi, Gumla, Simdega Saraikela Kharsawan and West Singhbhum districts. Whereas there is a significant decrease in Rainy days in Garhwa, Palamu, Chatra, Hazaribagh Giridih, Deoghar, Godda, Dumka, Dhanbad, Ramgarh, Latehar, Lohardaga and West Singhbhum districts. While remaining districts did not show any significant change.

![Trend in frequency of rainy days: June](image1)

![Trend in frequency of rainy days: July](image2)
6.2 Trend in frequency of Heavy rainfall days

The Trend in frequency of Heavy rainfall days is calculated for Jharkhand for June, July, August, September, June to September and Annual (Figure 31-36). During the month of June there is a significant increase in Heavy rainfall days in Giridih and East Singhbhum districts. Whereas there is a significant decrease in Heavy days in Palamu, Dumka, Dhanbad, Ranchi, Gumla, Simdega and West Singhbhum districts. While remaining districts did not show any significant change.

In the month of July there is a significant increase in Heavy rainfall days in Sahebganj, Godda, Dhanbad, Gumla, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in Heavy rainfall days in Sahebganj, Godda, Dumka, Dhanbad, Ranchi, Gumla and Simdega
In August there is a significant increase in Heavy rainfall days in Koderma, Hazaribagh, Latehar, Lohardaga, Gumla and East Singhbhum districts. Whereas there is a significant decrease in Heavy rainfall days in Garhwa, Latehar, Bokaro, Gumla and West Singhbhum districts. While remaining districts did not show any significant change.

During the month of September there is a significant increase in Heavy rainfall days in Simdega and East Singhbhum districts. Whereas there is a significant decrease in Heavy rainfall days in Sahebganj, Godda, Dumka, Giridih, Dhanbad, Bokaro, Ramgarh, Chatra, Lohardaga, Gumla, Simdega and Saraikela Kharsawan districts. While remaining districts did not show any significant change.

During the period June to September there is a significant increase in Heavy rainfall days in Koderma, Dhanbad, Ranchi, Gumla, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in Heavy rainfall days in Palamu, Latehar, Hazaribagh, Bokaro, Dhanbad, Dumka, Godda, Gumla, Simdega and West Singhbhum districts. While remaining districts did not show any significant change.

In the entire year there is a significant increase in Heavy rainfall days in Hazaribagh, Koderma, Dhanbad, Bokaro, Ranchi, Lohardaga, Gumla, Simdega, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in Heavy rainfall days in Garhwa, Palamu, Latehar, Hazaribagh, Bokaro, Dumka, Godda, Gumla, Simdega and West Singhbhum districts. While remaining districts did not show any significant change.
The Trend in frequency of dry days is calculated for Jharkhand for June, July, August, September, June to September and Annual (Figure 37-42). In the month of June there is a significant increase in dry days in Palamu, Hazaribagh, Koderma, Giridih, Deoghar, Dumka, Godda, Sahebganj, Dhanbad, Ramgarh, Ranchi, Lohardaga, Gumla, Simdega, West Singhbhum and East Singhbhum districts. Whereas there is no significant decrease in dry days in any districts. While remaining districts did not show any significant change.

In the month of July there is a significant increase in dry days in Palamu, Chatra, Hazaribagh, Giridih, Godda, Sahebganj, Dhanbad, Ramgarh, Ranchi and Gumla districts. Whereas there is a
significant decrease in dry days in Jamtara, Bokaro, Gumla and Saraikela Kharsawan districts. While remaining districts did not show any significant change.

In August there is a significant increase in dry days in Palamu, Hazaribagh, Giridih, Deoghar, Godda, Sahebganj, Pakur, Dumka, Jamtara, Dhanbad, Bokaro, Ramgarh, Ranchi, Lohardaga, Gumla, Khunti, Saraikela Kharsawan, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in dry days in Giridih, Pakur, Gumla and Saraikela Kharsawan districts. While remaining districts did not show any significant change.

In the month of September there is a significant increase in dry days in Palamu, Chatra, Hazaribagh, Giridih, Deoghar, Godda, Sahebganj, Pakur, Dumka, Jamtara, Dhanbad, Bokaro, Ramgarh, Ranchi, Lohardaga, Gumla, Khunti and East Singhbhum districts. Whereas there is a significant decrease in dry days in Saraikela Kharsawan district. While remaining districts did not show any significant change.

During the period June to September there is a significant increase in dry days in Palamu, Chatra, Hazaribagh, Giridih, Deoghar, Godda, Sahebganj, Pakur, Dumka, Jamtara, Dhanbad, Bokaro, Ramgarh, Ranchi, Lohardaga, Gumla, Khunti, Saraikela Kharsawan, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in dry days in Saraikela Kharsawan district. While remaining districts did not show any significant change.

During the entire year there is a significant increase in dry days in Palamu, Giridih, Deoghar, Godda, Sahebganj, Dumka, Jamtara, Dhanbad, Ramgarh, Ranchi, Latehar, Gumla, Khunti, Saraikela Kharsawan, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in dry days in Garhwa and Hazaribagh districts. While remaining districts did not show any significant change.
Fig. 37 Trend in frequency of dry days: June

Fig. 38 Trend in frequency of dry days: July

Fig. 39 Trend in frequency of dry days: August

Fig. 40 Trend in frequency of dry days: September

Fig. 41 Trend in frequency of dry days: JJAS

Fig. 42 Trend in frequency of dry days: Annual
7. Conclusions

In the present study we have investigated the rainfall pattern and its variability and also changes based on recent 30 years data. In the analysis we have considered monsoon months, the monsoon season and annual scale. The spatial scale has been considered from state to district for study of rainfall total and stations are being considered for seeing intensities of rainfall. The analysis brought many significant features of rainfall pattern and can be used for water agricultural managements. Some of the important results can be summarized as:

- Jharkhand gets maximum rainfall in July (31% of SW monsoon rainfall) followed by August (28% of SW monsoon rainfall).
- 84% of annual rainfall receives during southwest monsoon rainfall (June –September).
- Palamau district receive 90-91% of annual rainfall in SW monsoon season while Dumka, Godda and East Singhbhum districts receive 80-81% of annual rainfall in SW monsoon season.
- No significant increasing/decreasing trends in June, July, August, September monthly rainfall.
- Maximum rainfalls receive during the SW monsoon season over Pakur district (1275.2 mm) while Palamau district receives lowest rainfall of 840.5mm.
- Maximum rainfalls receive during the year over Pakur district (1571.8mm) while Palamau receives lowest annual rainfall of 925.4mm.
- Significant decreasing trend in SW monsoon rainfall has been noticed in Garhwa, Chatra, Koderma, Godda, Sahebganj, Dhanbad, Bokaro and Simdega districts while no district show significant increasing trend.
- In annual rainfall Garhwa, Chatra, Koderma, Godda, Sahebganj, Dhanbad, Bokaro, Ramgarh and Simdega districts shows significant decreasing trend while no district show significant increasing trend.
- Western and South-eastern regions receive on an average 45-50 rainy days (daily rainfall \( \geq 2.5 \text{mm} \)) out of 122 days of SW monsoon season while North-west region gets 35-39 rainy days and central parts of Jharkhand get 41-44 rainy days.
- For heavy to extremely heavy rainfall (daily rainfall \( \geq 6.5 \text{mm} \)) North-eastern and South-west region of Jharkhand gets 3-4 days during the SW monsoon season, remaining parts of the state get around 1-3 heavy to extremely heavy rainfall days.
- Number of dry days is maximum over NW parts of the state (66-71 dry days out of 122 days) during the SW monsoon season while on an average 274-286 dry days out of 365 days have been noticed in many parts of NW districts of Jharkhand.
• During the period June to September there is a significant increase in the frequency of Rainy days in stations in Hazaribagh, Giridih, Pakur, Dhanbad, Bokaro, Ramgarh, Ranchi and Gumla districts. Whereas there is a significant decrease in Rainy days in stations Garhwa, Palamu, Chatra, Hazaribagh Giridih, Deoghar, Godda, Dumka, Jamtara, Dhanbad, Ramgarh, Latehar, Lohardaga, Saraikela Kharsawan and West Singhbhum districts.

• During the entire year there is a significant increase in Rainy days in Hazaribagh, Giridih, Deoghar, Pakur, Dhanbad, Ramgarh, Ranchi, Gumla, Simdega Saraikela Kharsawan and West Singhbhum districts. Whereas there is a significant decrease in Rainy days in Garhwa, Palamu, Chatra, Hazaribagh Giridih, Deoghar, Godda, Dumka, Dhanbad, Ramgarh, Latehar, Lohardaga and West Singhbhum districts.

• During the period June to September there is a significant increase in Heavy rainfall days in Koderma, Dhanbad, Ranchi, Gumla, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in Heavy rainfall days in Palamu, Latehar, Hazaribagh, Bokaro, Dhanbad, Dumka, Godda, Gumla, Simdega and West Singhbhum districts. While remaining districts did not show any significant change.

• During the entire year there is a significant increase in Heavy rainfall days in Hazaribagh, Koderma, Dhanbad, Bokaro, Ranchi, Lohardaga, Gumla, Simdega, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in Heavy rainfall days in Garhwa, Palamu, Latehar, Hazaribagh, Bokaro, Dumka, Godda, Gumla, Simdega and West Singhbhum districts.

• During June to September there is a significant increase in dry days in Palamu, Chatra, Hazaribagh, Giridih, Deoghar, Godda, Sahebganj, Pakur, Dumka, Jamtara, Dhanbad, Bokaro, Ramgarh, Ranchi, Lohardaga, Gumla, Khunti, Saraikela Kharsawan, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in dry days in Saraikela Kharsawan district.

• During the entire year there is a significant increase in dry days in Palamu, Giridih, Deoghar, Godda, Sahebganj, Dumka, Jamtara, Dhanbad, Ramgarh, Ranchi, Latehar, Gumla, Khunti, Saraikela Kharsawan, West Singhbhum and East Singhbhum districts. Whereas there is a significant decrease in dry days in Garhwa and Hazaribagh districts.
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References:

The report brings out observed rainfall variability and trends over the state as an impact of climate change based on recent 30 years of data (1981 - 2018).

Rainfall pattern of monsoon months, south west monsoon season and annual of the state and it’s districts as well as extreme rainfall event of different intensity of stations are analysed.