Observed Rainfall Variability and Changes over Kerala State

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<td>Director General of Meteorology, India Meteorological Department, New Delhi</td>
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<td>16</td>
<td>Abstract</td>
<td>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.</td>
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<td>17</td>
<td>Key Words</td>
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1. Introduction

The State ‘Kerala’ lies in the extreme southwest of the Indian sub-continent, bordered by Karnataka State in the north, Tamil Nadu in the east and by the Arabian Sea in the west. It occupies the portion the sub-continent bounded by latitudes 8° and 13° north and longitudes 75° and 77° east. Based on physical features, the State divides itself into three natural sub-divisions, namely, the low-land consisting of the sea-board, the mid-land consisting of the undulating country east of the low-land and the forest clad high land on the extreme east. The hilly of the eastern portion is formed by a southern section of the Western Ghats nearly 560 km long and is broken by long spurs, extensive ravines, dense forests and tangled jungles full of flora and fauna, rising terrace after terrace, to an elevation of more than 275 m above sea-level. It stretches westward in gentler slopes and gradually widening valleys but broken here and there by isolated low hills. The plains succeed the forest clad up-land. Intersected by numerous rivers and streams, dotted elsewhere with homesteads or farms, the plains stretch in a succession of gentle undulations towards a line of back waters on the coast. Between the back waters and the sea is a narrow and long stretch of sand. It is low and generally swampy and is in several parts liable to be flooded during monsoon inundations. This area receives the drainage of the numerous streams descending from the Ghats.

The Wayanad district is an elevated and exceedingly picturesque mountainous plateau. The average height of the plateau above sea-level is 900 m and it is generally rugged and has some of the largest mountain peaks in the district. The regions bordering north Wayanad which forms the southeastern portion of the Kannur district and is a continuation of Mysore plateau run into a chain of low hills of easy slopes covered with bamboo forests. The Nilgiri-Kunda range juts into the sky on the eastern side of the South Wayanad Taluka. Idukki district is noteworthy for its mountains which with their great height and varied configuration present a grand and imposing spectacle. The mountains rise to an elevation of more than 2,560 m, with high plateau in between. The Western Ghats in this district present their highest elevation in Anamudi (2,697 m) which is the highest peak in Kerala and the highest in India, next to those of Himalayas.

A unique feature of high land of Palakkad (Palghat) district is the great Palghat Gap. The gap is a complete opening having a width of 32.2 km. During pre-monsoon hot land wind rushes from the east into the district through this gap.

Many studies are available on the observed trends and variability of rainfall and also extreme rainfall events, but all the studies are based on past 100 years or more data and also the recent years are not included (Guhathakurta et al, 2015; Nair et al, 2014; Guhathakurta et al, 2011; Guhathakurta & Rajeevan, 2008 etc). 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).
3. To identify the spatial pattern of intensities of various rainfall events and dry days and also trends if any in the intensity of various rainfall events and also number of dry days.

The analysis has been done in two parts. For identification of the spatial pattern, mean rainfall and variability and 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 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. From the mean and standard deviation, coefficient of variation (CV) is calculated as follows:

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

Fig. 1 Location of the districts of Kerala
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 in July (32.9% of south west monsoon rainfall) while the June month get 32.6% of the south west monsoon rainfall. August and September receive 21% and 13% of the south west monsoon rainfall, respectively. It is observed that more than 68.5% of annual rainfall receives during the southwest monsoon season only. The variability of southwest monsoon and annual rainfall is 19% and 14%, respectively.

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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 or annual rainfall show any significant increasing/decreasing trend. In the monthly rainfall, June and July rainfall show decreasing trend while August and September rainfall show increasing trend, and both seasonal and annual rainfall show insignificant decreasing trend. But these trends are not significant. During the last 30 years, highest rainfall of June (1063.6 mm), July (963.6 mm), August (822.4 mm) and September (522.5 mm) are received in 1991, 1997, 2018 and 2007 respectively. Highest southwest monsoon rainfall of 2654.8 mm received in 2007 and the highest annual rainfall of 3518.9 mm received in the year 2018. Similarly, the lowest rainfall of June (430.3 mm), July (318.5 mm), August (231 mm) and September (50 mm) are received in 2012, 2002, 2016 and 1991, respectively. The lowest southwest monsoon rainfall (1352.3 mm) and annual rainfall (1870.9 mm) are received in 2016.
Fig. 2 Time series of rainfall in mm for the months of June, July, August, September and trends

Fig. 3 Time series of rainfall in mm for the southwest monsoon season and annual 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 Kerala 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 the three northern districts namely Kozhikode, Kannur and Kasargod received highest amount of rainfall in June in the range of 850–995 mm, in the month of July Kozhikode, Kannur, Idukki and Kasargod received highest amount of rainfall in the range of 790-950 mm. In August, Kannur, Kasargod and Idukki received highest amount of rainfall in the range of 520-620 mm and in September, Idukki received highest amount of rainfall in the range of 330-370 mm. Kozhikode, Kannur, Kasargod and Idukki received highest amount of rainfall in the southwest monsoon season in the range of 2400-2800 mm and in Annual, Idukki and Kasargod received highest amount of rainfall in the range of 3300-3700 mm. Highest amount of rainfall in June, July and August received in Kasargod (994 mm in June, 941.8 mm in July and 618.2 mm in August) and the highest amount of rainfall in September received in Idukki district (368.9 mm). Kasargod received the highest amount of rainfall in the southwest monsoon season (2795.9 mm) and Idukki received the highest amount of rainfall in Annual scale (3671.5 mm). Thiruvananthapuram district received the lowest amount of rainfall in all the southwest monsoon months (310.1 mm in June, 204.3 mm in July, 147.7 mm in August, and 179.7 mm in September), southwest monsoon season (841.7 mm) and in the Annual scale(1828.2 mm).

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<th>JULY MEAN</th>
<th>JULY CV</th>
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Table 2. Rainfall statistics for the districts of Kerala for the four monsoon months, southwest monsoon season and annual
From Figure 5, it is evident that the variability for the southwest monsoon months is maximum for Thiruvananthapuram (47%-53% in June, 59%-66% in August and 69%-74% in September respectively) and Wayanad (44%-48% in July). The variability is minimum for Kannur, Kozhikode and Palakkad districts (24%-30%) in June, Ernakulam, Kottayam and Alapuzha (28%-32%) in July, Kasargod, Kannur and Ernakulam (30%-37%) in August and Alappuzha and Kollam (48%-53%) in September. In the southwest monsoon season, the variability is maximum for Kasargod, Idukki and Pathanamthitta (37%-41%) and minimum for Kannur, Palakkad, Ernakulam, Kottayam, Alappuzha and Kollam (19%-23%). In Annual scale, the variability is maximum for Kasargod, Wayanad, Idukki and Pathanamthitta (39%-45%) and minimum for Kannur, Palakkad, Ernakulam, Kottayam, Kollam, Thiruvananthapuram (14%-20%).
Fig. 4 Mean rainfall pattern over districts of Kerala for (a) June, (b) July, (c) August, (d) September, (e) southwest monsoon season and (f) Annual
Fig. 5 Coefficient of Variation (%) over districts of Kerala 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) southwest monsoon season and (f) annual. June, August and September rainfall has shown no significant trend either increasing or decreasing. July rainfall has shown a significant decreasing trend in Kasargod, Thrissur and Thiruvananthapuram districts.

There is no significant trend observed in the southwest monsoon season rainfall. In the Annual scale, Kasargod and Kollam districts show a significant decreasing trend in rainfall.
Fig. 6 Trends in district rainfall for (a) June, (b) July (c) August (d) September (e) southwest monsoon season and (f) Annual
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 Kerala for June, July, August, September, southwest monsoon and Annual and depicted in Figure 7. It shows that during June the maximum number of rainy days lies in the range of 18-21 days in north and central Kerala, i.e. in some parts of Idukki, Ernakulam, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanad, Kannur and Kasargod. While, the minimum number of rainy days lies in the range of 6-10 days in south Kerala, i.e. in Thiruvananthapuram, Kollam, Pathanamthitta, and most parts of Idukki, Kottayam and Alappuzha districts. In July, the maximum number of rainy days lies in the range of 20-24 days and the minimum number of rainy days lies in the range of 8-11 days. The spatial distribution of the average frequency of rainy days is the similar to that of June with a slight decrease in the spatial distribution of the maximum range over central Kerala and a slight increase of the same in north Kerala, especially in Kasargod and Kannur. In the month of August, the maximum number of rainy days lies in the range of 18-21 days in Kasargod, Kannur and isolated parts in the other districts of north Kerala and central Kerala, i.e. Kozhikode, Wayanad, Malappuram, Palakkad, Thrissur, Idukki and Ernakulam. While, minimum number of rainy days is in the range of 7-10 days, and the spatial distribution is the same as that of June and July. It is observed that there is a markable decrease in the spatial distribution of maximum number of rainy days in central Kerala in August, compared to that of June and July. In September, the maximum number of rainy days lies in the range of 11-13 days and the minimum number of rainy days lies in the range of 6-8 days. The spatial distribution of rainy days in September is similar to that of June and July with a slight decrease in the distribution of maximum range of rainy days mainly in the central Kerala.

In southwest monsoon season, maximum number of rainy days lies in the range of 64-74 days in north and central Kerala, and minimum number of rainy days lies in the range of 28-37 days in south Kerala, and the spatial distribution is similar to that of the monthly pattern of June and July, i.e. the maximum number of rainy days is distributed from Kasargod in the north to Idukki in the central Kerala, and minimum number of rainy days is distributed in the southern districts namely Thiruvananthapuram, Kollam, Pathanamthitta, and most parts of Idukki, Kottayam and Alappuzha districts. The maximum number of rainy days is observed in most parts of Kasargod, while it is distributed only in some parts of the other districts.
In Annual scale, maximum number of rainy days lies in the range of 93-104 days and minimum number of rainy days lies in the range of 53-63 days. The spatial distribution is similar to that of southwest monsoon, but the maximum number of rainy days in Kasargod is distributed to some parts only.
5.2 Average frequency of Heavy rainfall days

The average frequency of Heavy rainfall days in Kerala is calculated for June, July, August, September, southwest monsoon season and Annual and given in Figure 8. It shows that the maximum number of heavy rainfall days lies in the range of 3-4 days in most parts of Kasargod and in some parts of Kannur, Kozhikode, Thrissur, Ernakulam and Idukki districts, and minimum number of heavy rainfall days lies in the range of 0-1 days in the eastern parts of Wayanad, Malappuram, Palakkad and most parts of south Kerala, i.e. Idukki, Kottayam, Alappuzha, Pathanamthitta, Kollam and Thiruvananthapuram in June. In July, the maximum number of heavy rainfall days is in the range of 3-5 days in most parts of Kasargod and in some parts of Kannur, Kozhikode and Idukki districts. While, minimum number of heavy rainfall days lies in the range of 0-1 days in the eastern parts of Wayanad, Malappuram, Palakkad and most parts of Idukki, Kottayam, Alappuzha, Pathanamthitta, Kollam and Thiruvananthapuram. In August, the maximum number of heavy rainfall days lies in the range of 2-3 days in Kasargod, Kannur and Idukki and minimum number of heavy rainfall days lies in the range of 0-1 days in southern districts i.e. Idukki, Kottayam, Alappuzha, Pathanamthitta, Kollam and Thiruvananthapuram and in some parts of Malappuram, Palakkad, Wayanad, Thrissur and Ernakulam. In September, the maximum number of heavy rainfall days lies in the range of 2-3 days, minimum number of heavy rainfall days lies in the range of 0-1 days, and the spatial distribution is similar to that of August.
In the southwest monsoon season, the maximum number of heavy rainfall days lies in the range of 9-11 days in Kasargod, Kannur, Kozhikode and Idukki districts and minimum number of heavy rainfall days lies in the range of 1-3 days in eastern parts of Wayanad, Malappuram, Palakkad and most parts of south Kerala, i.e. Idukki, Kottayam, Alappuzha, Pathanamthitta, Kollam and Thiruvananthapuram districts. While considering the Annual scale, the maximum number of heavy rainfall days lies in the range of 10-12 days in Kasargod, Kannur, Kozhikode, Thrissur, Ernakulam and Idukki districts and the minimum number of heavy rainfall days lies in the range of 2-4 days. The spatial distribution of minimum number of heavy rainfall days in Annual is similar to that of southwest monsoon season.
5.3 Average frequency of Dry days

The average frequency of dry days is calculated for Kerala for June, July, August, September, southwest monsoon season and Annual and depicted in Figure 9. In June, the maximum number of dry days lies in the range of 19-22 days mainly in the southern districts namely Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam and Idukki and in eastern most part of Palakkad. While, the minimum number of dry days lies in the range of 7-10 days in some parts of all other districts. In July, maximum number of dry days lies in the range of 18-21 days and minimum number of dry days lies in the range of 5-9 days. The spatial distribution of the number of dry days is similar to that of June, although the minimum number of dry days extends to more parts of Kasargod and Kannur in July. In August, the maximum number of dry days lies in the range of 18-21 days, minimum number of dry days lies in the range of 7-10 days, and in September, the maximum number of dry days lies in the range of 19-21 days and minimum number of dry days lies in the range of 14-16 days. The spatial distribution of dry days in August and September is similar to that of July, but with a markable decrease in the spatial extent of minimum number of dry days.

In the southwest monsoon, the maximum number of dry days lies in the range of 70-78 days, mainly in the southern districts namely Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam and Idukki and in eastern most part of Palakkad. While the minimum number of dry days lies in the range of 35-44 days in some parts of all other districts. While in Annual scale, the maximum number of dry days is in the range of 256-266 days and minimum number of dry days is in the range
of 220-230 days. The spatial distribution of number of dry days is similar to that of southwest monsoon with a markable decrease in the number of minimum numbers of dry days in Kasargod and Kannur.
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 in Kerala having minimum 20 years data during the 30 years period for June, July, August, September, southwest monsoon and Annual which is depicted in Figure 10. It shows that in the month of June, there is a significant increase in the number of rainy days in Wayanad and a significant decrease in the number of rainy days in Kasargod districts. While remaining districts do not have any significant trend. In July, the increasing trend is significant in Alappuzha, while decreasing trend is significant in Kasargod, Kottayam and Kollam districts. Remaining districts do not have any significant trend in the month of July. In August, a significant decreasing trend in rainy days is observed in Kasargod, Thrissur, Ernakulam, Idukki and Kottayam districts, while there is no significant trend in other districts. Interestingly, in September, all the districts except Kollam has a significant increase in the number of rainy days. Kollam has a significant decreasing trend in the number of rainy days during the month.

In the southwest monsoon season, a significant increase in the number of rainy days are observed in Alappuzha, Kottayam, Thrissur and Kozhikode districts, whereas a significant decrease is observed in Wayanad, Ernakulam and Kollam districts. Remaining districts do not have any significant trend. In Annual scale, the increasing trend is significant in Alappuzha, Kottayam, Idukki and Kozhikode while, decreasing trend is significant in Ernakulam, Idukki and Kollam districts. Remining
districts do not have any significant trend.
6.2 Trend in frequency of Heavy rainfall days

The trend in frequency of Heavy rainfall days of rain gauge stations in Kerala having minimum 20 years data during the 30 years period for June, July, August, September, southwest monsoon season and Annual is depicted in Figure 11. It shows that, in June there is a significant increase in the heavy rainfall days in Kozhikode and Kottayam districts and there is a significant decrease in the number of heavy rainfall days in Kasargod, Kottayam, Pathanamthitta and Thiruvananthapuram districts. While, remaining districts do not have any significant trend. In July, all districts except Kannur, Wayanad and Thiruvananthapuram has a significant decreasing trend. In August, Kasargod and Malappuram districts have a significant decreasing trend while Kozhikode and Palakkad have a significant increasing trend, while remaining districts do not have any significant trend. In September, Kannur, Kozhikode and Malappuram districts show a significant increasing trend, Kollam district show a significant decreasing trend, while other districts do not show any significant trend.

In the southwest monsoon season, Kozhikode district show a significant increasing trend, while Kasargod, Kannur, Thrissur, Ernakulam, Idukki, Kottayam, Alappuzha and Pathanamthitta show a significant decreasing trend. Remaining districts do not show any trend. In Annual scale, Kozhikode district show a significant increasing trend while Kasargod, Kannur, Thrissur, Ernakulam, Idukki, Kottayam and Alappuzha show a significant decreasing trend. Remaining districts do not show any significant trend.
Fig. 11 Trend in frequency of heavy rainfall days for (a) June, (b) July (c) August (d) September (e) southwest monsoon season and (f) Annual.
6.3  Trend in frequency of Dry days

The trend in frequency of dry days of rain gauge stations in Kerala for June, July, August, September, southwest monsoon season and Annual is depicted in Figure 12. In the month of June, a significant increase in the number of dry days is observed in Kasargod and Kozhikode districts, while a significant decrease in the number of dry days is observed in Alappuzha and Kollam districts. Remaining districts do not show any significant trend. In July, a significant increase in Malappuram, Thrissur, Kollam and Thiruvananthapuram districts and a significant decrease in Alappuzha and Kottayam is observed. Similarly, in the month of August, a significant increase is observed in Kasargod, Kozhikode, Malappuram, Thrissur, Ernakulam, Idukki, Alappuzha and Kollam districts and a significant decrease is observed in Palakkad, Kottayam, Alappuzha and Idukki districts. While, there is no significant trend in the remaining districts. Interestingly, all the districts show a significant decreasing trend in the number of dry days in the month of September, while stations in Kollam shows a significant increasing trend in dry days as well.

Considering southwest monsoon season as a whole, a significant decrease in the number of dry days is observed in Kasargod, Kozhikode, Thrissur, Palakkad, Alappuzha, Kottayam, Idukki and Thiruvananthapuram and a significant increase in the number of dry days is observed in Thrissur district. While, remaining districts do not show any significant trend. In Annual scale, a significant decrease is observed in Kasargod, Palakkad and Kottayam and a significant increase is observed in Malappuram, Thrissur and Ernakulam districts.
Fig. 12 Trend in frequency of dry days for (a) June, (b) July (c) August (d) September (e) southwest monsoon season and (f) 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 southwest monsoon months, southwest monsoon season and annual scale. The spatial scale has been considered from state to district for study of rainfall total and stations are considered for seeing intensities of rainfall. The analysis brought many significant features of rainfall pattern and can be used for hydrology and agricultural managements. Some of the important results can be summarized as:
Kerala receives highest rainfall in July (32.9% of south west monsoon rainfall) followed by June (32.6% of the south west monsoon rainfall).

Southwest monsoon receives more than 68.5% of annual rainfall.

The mean rainfall over the state does not show any significant increasing/decreasing trend in June, August, September and monsoon season. July rainfall shows significant decreasing trend in Kasargod, Thrissur and Thiruvananthapuram districts.

Kasargod district received the highest amount of rainfall (2795.9 mm) and Thiruvananthapuram district received the lowest amount of rainfall (841.7 mm) in southwest monsoon season.

In annual scale, Idukki (3671.5 mm) and Thiruvananthapuram (1828.2 mm) received the highest and lowest amount of rainfall, respectively.

In August, all the districts show an increasing trend except Thrissur and Alapuzha.

September rainfall shows an increase in all districts except Alapuzha.

No district has shown any significant trend in southwest monsoon rainfall.

In the Annual scale, Kasargod and Kollam districts show a significant decreasing trend in rainfall.

Maximum number of rainy days (~64-74 days) observed in north and central Kerala, i.e. in Kasargod, Kannur, Wayanad, Kozhikode, Malappuram, Palakkad, Thrissur, Ernakulam and Idukki, and minimum number of rainy days (~28-37 days) observed in south Kerala, i.e. Thiruvananthapuram, Kollam, Pathanamthitta, and most parts of Idukki, Kottayam and Alappuzha districts, in southwest monsoon season.

In Annual scale, maximum number of rainy days lies in the range of 93-104 days and minimum number of rainy days lies in the range of 53-63 days. The spatial distribution is similar to that of southwest monsoon, but with a markable decrease in the spatial extent of maximum number of rainy days in Kasargod district.
The maximum number of heavy rainfall days (~9-11 days) in Kasargod, Kannur, Kozhikode and Idukki districts and minimum number of heavy rainfall days (~1-3 days) in eastern parts of Wayanad, Malappuram, Palakkad and most parts of south Kerala, i.e. Idukki, Kottayam, Alappuzha, Pathanamthitta, Kollam and Thiruvananthapuram districts are observed in the southwest monsoon season.

In Annual scale, the maximum number of heavy rainfall days (~10-12 days) in Kasargod, Kannur, Kozhikode, Thrissur, Ernakulam and Idukki districts and the minimum number of heavy rainfall days (~2-4 days) in eastern parts of Wayanad, Malappuram, Palakkad and most parts of south Kerala, i.e. Idukki, Kottayam, Alappuzha, Pathanamthitta, Kollam and Thiruvananthapuram districts are observed.

In the southwest monsoon, the maximum number of dry days (~70-78 days) is observed mainly in the southern districts namely Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam and Idukki and in eastern most part of Palakkad, While the minimum number of dry days (~35-44 days) observed in some parts of all other districts.

In Annual scale, the maximum number of dry days is in the range of 256-266 days and minimum number of dry days is in the range of 220-230 days. The spatial distribution of number of dry days is similar to that of southwest monsoon with a markable decrease in the number of minimum number of dry days in Kasargod and Kannur.

A significant decreasing trend in rainy days is observed in Kasargod, Thrissur, Ernakulam, Idukki and Kottayam districts in the month of August, while there is no significant trend in other districts.

In September, all the districts except Kollam has a significant increase in the number of rainy days.

In the southwest monsoon season, a significant increase in the number of rainy days are observed in Alappuzha, Kottayam, Thrissur and Kozhikode districts, whereas a significant decrease is observed in Wayanad, Ernakulam and Kollam districts.

In Annual scale, a significant increasing trend in the number of rainy days in Alappuzha, Kottayam, Idukki and Kozhikode while, a significant decreasing trend in Ernakulam, Idukki and Kollam districts.
Number of heavy rainfall days show a significant increase in Kozhikode district while Kasargod, Kannur, Thrissur, Ernakulam, Idukki, Kottayam, Alappuzha and Pathanamthitta show a significant decreasing trend.

In Annual scale, Kozhikode district show a significant increasing trend while Kasargod, Kannur, Thrissur, Ernakulam, Idukki, Kottayam and Alappuzha show a significant decreasing trend.

All the districts show a significant decreasing trend in the number of dry days in the month of September.

A significant decrease in the number of dry days is observed in Kasargod, Kozhikode, Thrissur, Palakkad, Alappuzha, Kottayam, Idukki and Thiruvananthapuram and a significant increase in the number of dry days is observed in Thrissur district during southwest monsoon season.

In Annual scale, a significant decrease in the number of dry days is observed in Kasargod, Palakkad and Kottayam and a significant increase is observed in Malappuram, Thrissur and Ernakulam 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 its districts as well as extreme rainfall event of different intensity of stations are analysed.