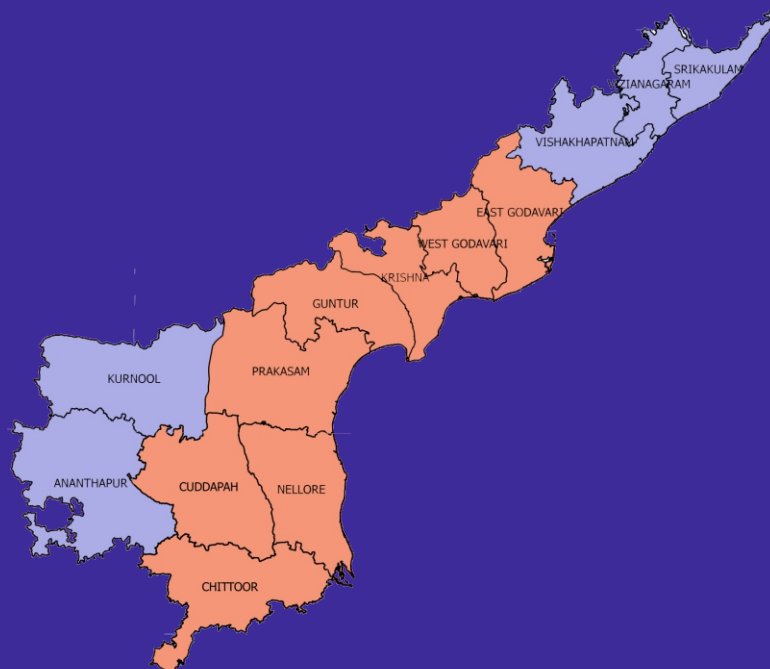




**CLIMATE RESEARCH AND SERVICES  
INDIA METEOROLOGICAL DEPARTMENT  
MINISTRY OF EARTH SCIENCES  
PUNE**

# **Observed Rainfall Variability and Changes over Andhra Pradesh State**



**Met Monograph No. ESSO/IMD/HS/Rainfall Variability/01(2020)/25**

**Pulak Guhathakurta, Sakharam Sanap, Preetha Menon,  
Ashwini Kumar Prasad, Neha Sangwan and S C Advani**



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16	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.
17	Key Words	Rainfall trend, variability, extreme events, dry days

## 1. Introduction

Andhra Pradesh state is located between 12°41' and 19.07°N latitudes and 77° and 84°40'E longitudes in the southern part of India. After Telangana State was formed on 2 June 2014, Andhra Pradesh's erstwhile capital Hyderabad remained in Telangana. Now the capital of Andhra Pradesh is Amaravati. Andhra Pradesh covers an area of 1,62,968 sq km which is 4.96% of the geographical area of the country. Physio-graphically, the state can be divided into coastal and the comparatively drier Rayalaseema region. The state is bordered by Telangana, Chhattisgarh, and Odisha in the north, the Bay of Bengal in the East, Tamil Nadu to the south and Karnataka to the west. Andhra Pradesh has got a coastline of around 974 km, which gives it the 2nd longest coastline in the nation after Gujarat. Two major rivers, the Godavari and the Krishna runs across the state. A small enclave 30 km<sup>2</sup>, the Yanam district of Puducherry, lies in the Godavari Delta in the north east of the state.

The climate of Andhra Pradesh state is generally hot and humid. The summer season in this state generally extends from March to June. During these months the moisture level is quite high. The coastal areas have higher temperatures than the other parts of the state. The summer is followed by the monsoon season, which starts during June and continues till September. This is the season for heavy tropical rains in Andhra Pradesh. The major role in determining the climate of the state is played by South-West (SW) Monsoons. About one third of the total rainfall in Andhra Pradesh is brought by the North-East Monsoons around the month of October in the state. The winters in Andhra Pradesh are pleasant. This is the time when the state attracts most of its tourists. October to February are the winter months in Andhra Pradesh. Since the state has quite a long coastline, the winters are comparatively mild. Fig.1 depicts the district map of the Andhra Pradesh state, indicating the location of the districts.

There are many studies available on the observed trends and variability of rainfall and also extreme rainfall events over India, but all the studies are based on past 100 years or more data and also the recent years are not included (Waghayee et al, 2018; Guhathakurta et al, 2015; Guhathakurta et al, 2011; Guhathakurta & Rajeevan, 2008 etc). Also, there are limited studies on district rainfall trends and variability. 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.

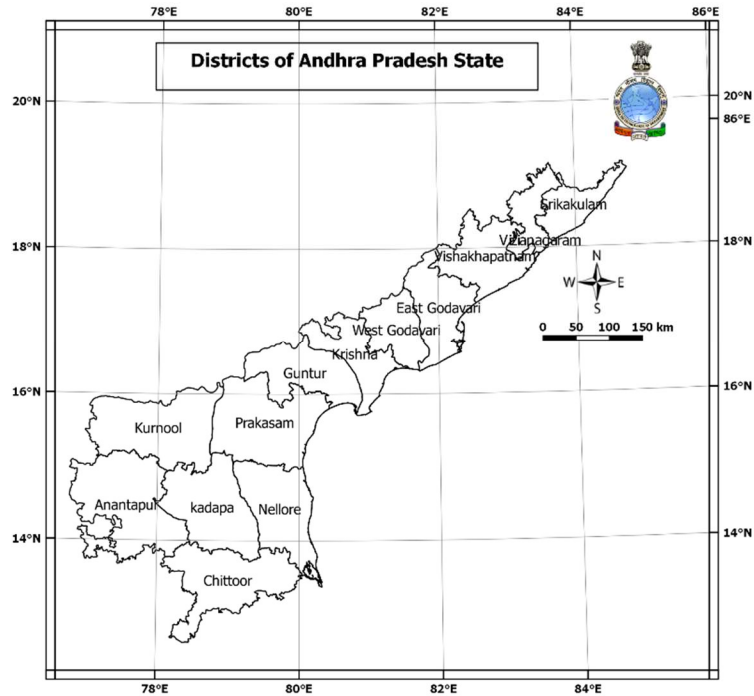


Figure 1. District wise Map of the Andhra Pradesh state.

## 2. Data and Methodology

Daily Rainfall data from 1989 to 2018 is considered for the analysis of trend variability and mean rainfall patterns. From the daily rainfall data monthly rainfall series of each stations are computed. 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:

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

### 3. State rainfall mean and variability and trend

Month wise, SW monsoon season and annual mean rainfall (mm) and CV for the Andhra Pradesh state for the period 1989-2018 is shown in Table 1. It is seen from the analysis that September month contributes (28.5%) maximum to SW monsoon rainfall than other monsoon months, followed by August (27.8 %), July (24.9 %) and June (18.80 %). Contribution of the SW monsoon to annual rainfall is about 57 %. The variability of monsoon and annual rainfall is 21.2% and 18.0 % respectively.

	June	July	August	September	JJAS	Annual
Mean	96.3	127.5	142.5	146.3	512.6	903.6
CV	55.4	37.7	31.1	32.7	21.2	18.0

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

Fig. 2 and 3 show the time series of rainfall (mm) for the months of June, July, August, September, southwest monsoon season and annual respectively. The trend lines are also displayed for each of the series. Analysis indicate that neither monthly rainfall nor seasonal or annual rainfall show any significant increasing/decreasing trend. Monthly rainfall for the month of August show the upward trend while June, July and September show decreasing trend, however they are statistically insignificant.

Southwest monsoon rainfall shows slight increasing (statistically insignificant) while annual rainfall shows slight decreasing trend. During the last 30 years highest rainfall of June received (242.3 mm) in the year 2007, for the month of July it was in the year 1989 (284.5 mm) while highest rainfall received for the month August was in the year 2000 (280.8 mm) and 255.7 mm rainfall received in September of the year 1997. Highest annual rainfall of 1306.5 mm received in the year 2010 and highest southwest monsoon rainfall of 722.8 mm received in the year 2007. Lowest annual rainfall of 636.2 mm and southwest monsoon rainfall of 312.5 mm received in the year 2002.

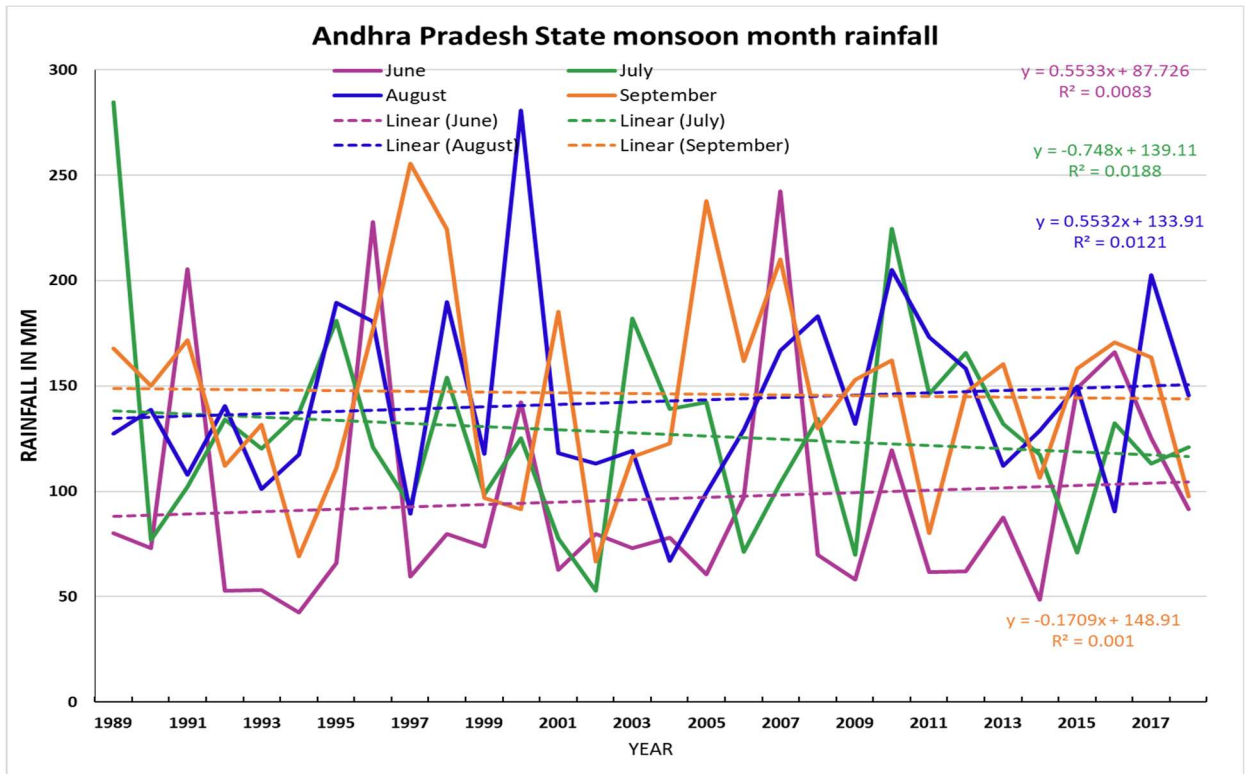


Fig. 2 Time series of rainfall (mm) for the months of June, July, August, September and trends.

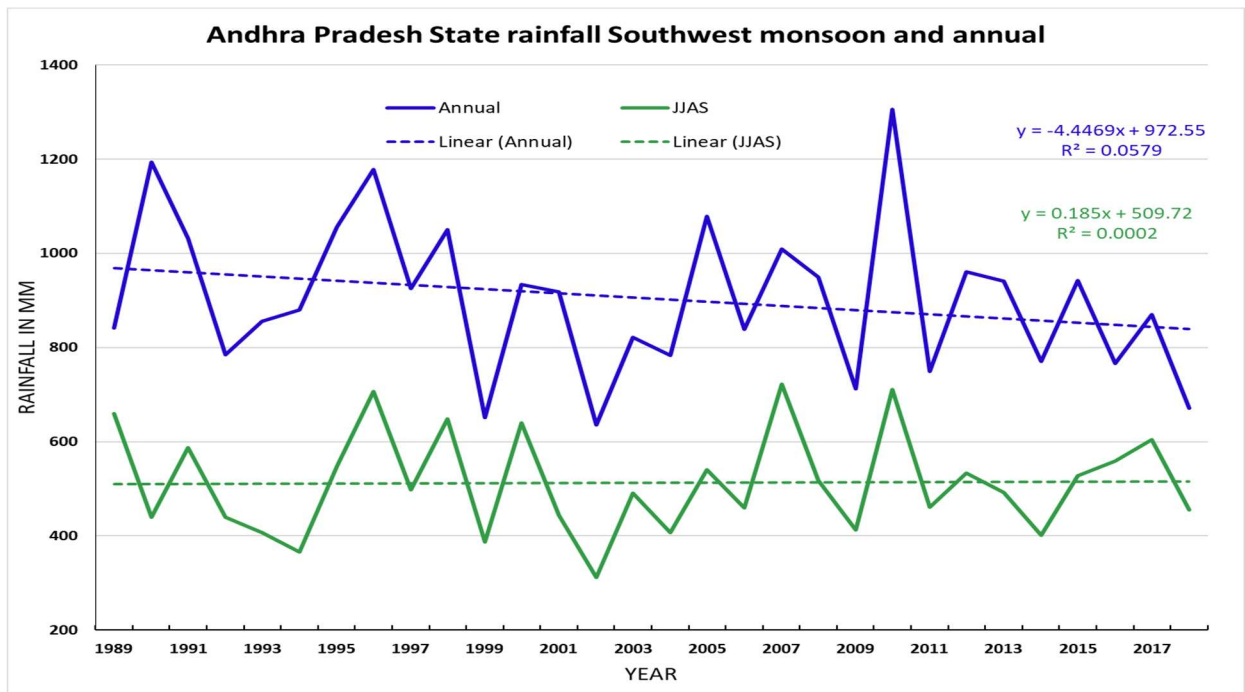


Fig. 3 Time series of rainfall (mm) for the southwest monsoon season and annual trends.

#### 4. District rainfall mean, variability and trend

##### 4.1 Mean and coefficient of variation

Table 2 demonstrates the rainfall statistics for the districts of Andhra Pradesh for the four monsoon months, southwest monsoon season and annual, while Fig.4-5 show the spatial pattern of these statistics. It is observed that highest mean SW monsoon rainfall is seen in northern coastal districts of the state, viz. West Godavari, Srikakulam, East Godavari, Vishakhapatnam, Vizianagaram, Krishna. Mean rainfall receive over these districts are around 125-150 mm in June, 170-230 mm in July, 190-235 mm in August and 160-205 mm in September. The SW monsoon mean rainfall values for these districts ranging from 69.5 mm to 141.2 mm. However, for annual it ranges from 1045 mm to 1170 mm. Districts of southern region of the Andhra Pradesh state receives less rains during SW monsoon. However, annual mean rainfall map of the state shows that coastal district of the southern part of the state receives good amount of rainfall (560-1150 mm). North East monsoon rainfall contributes significantly in mean annual rainfall of southern coastal district of the state. Being an inland region (south western region), Anantapur district receives lowest mean rainfall of 314.7 mm during SW monsoon while 558.5 mm annually. In case of monthly rainfall( Fig.5), during SW monsoon Northern coastal districts shows lesser variability in rainfall amount than southern district. While SW monsoon, season as whole district Cuddappah and Nellore shows greater variability(72-81%) over rest of districts of state. In case of annual rainfall districts Cuddappah, Anantapur and Vizianagaram shows greater variability(66-76%) than rest of districts of state.

DISTRICT	JUNE		JULY		AUGUST		SEPTEMBER		MONSOON		ANNUAL	
	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV
ANANTAPUR	62.4	60	55.3	66	81.3	55	115.7	55	314.7	32	558.5	76
CHITTOR	80.3	66	99.2	55	114.8	48	133.6	37	427.9	27	946.0	24
CUDDAPAH	70.8	289	88.6	64	109.4	52	116.5	49	385.3	72	714.7	66
EAST GODAVARI	141.2	56	205.5	39	197.2	40	188.9	52	732.7	26	1151.1	53
GUNTUR	104.2	201	146.3	48	166.1	42	157.0	49	573.6	55	884.4	59
KRISHNA	128.5	57	196.6	42	207.7	39	166.2	48	699.0	26	1048.6	55
KURNOOL	89.5	86	103.6	50	128.3	45	135.6	47	456.9	31	674.2	51
NELLORE	58.7	345	81.0	57	93.8	55	93.4	44	327.0	81	1060.6	55
PRAKASAM	65.5	86	87.4	53	107.9	60	127.3	47	388.1	32	815.9	62
SRIKAKULAM	146.1	52	192.8	32	207.5	37	196.2	37	742.6	18	1154.6	40
VISAKHAPATNAM	151.0	56	182.4	36	187.7	32	202.2	37	723.4	19	1170.1	53
VIZIANAGARAM	143.7	154	171.7	30	196.6	36	196.2	38	708.2	47	1094.2	69
WEST GODAVARI	132.5	59	227.0	37	233.5	43	180.8	47	773.9	27	1125.3	54

Table 2: Rainfall statistics for the districts of Andhra Pradesh for the four monsoon months, southwest monsoon season and annual



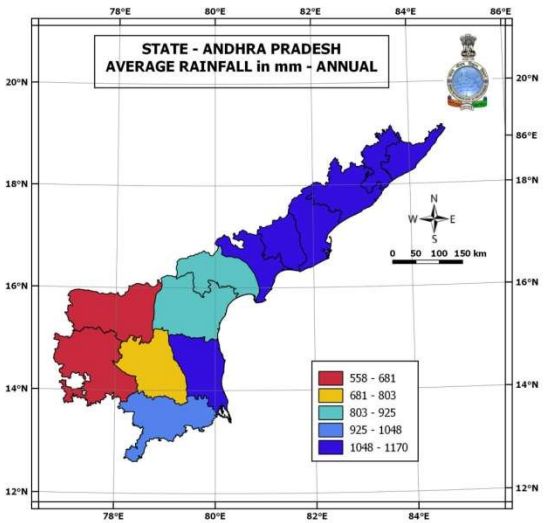
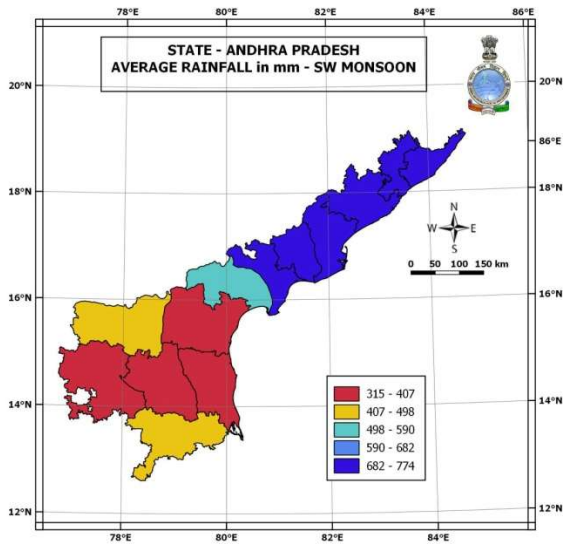
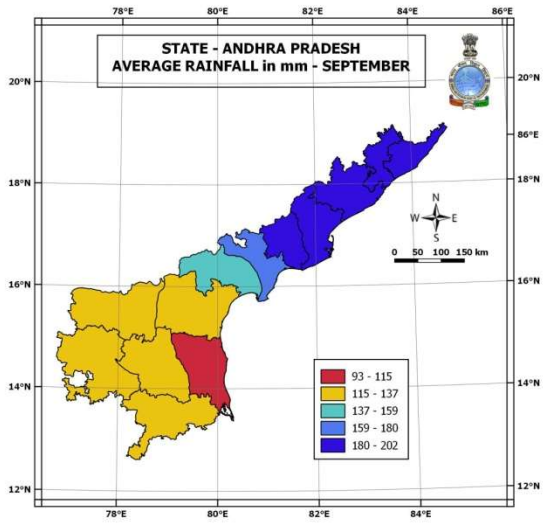
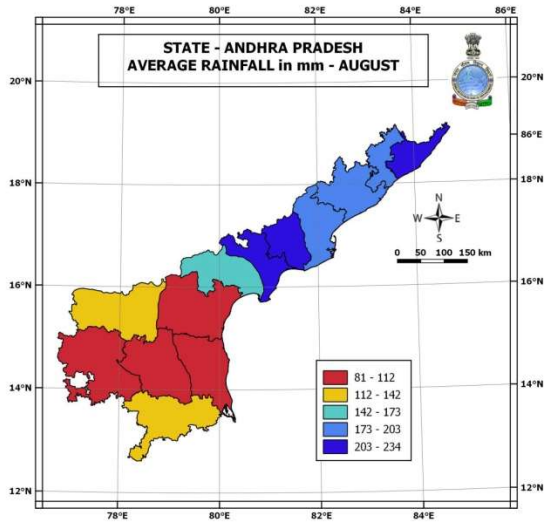
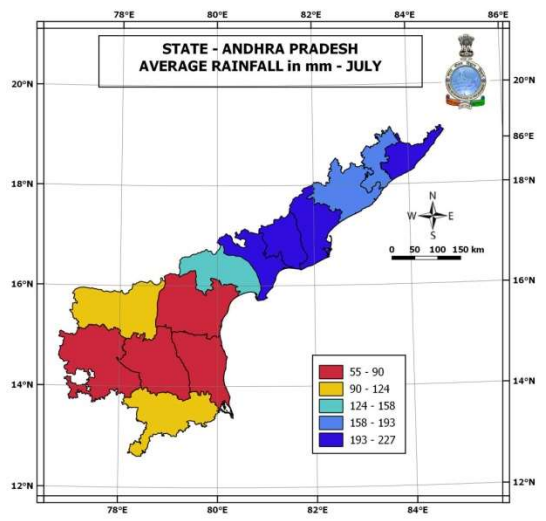
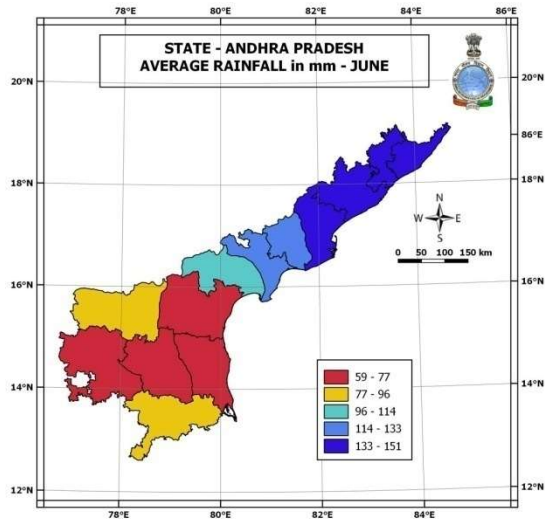


Fig.4 Mean rainfall pattern over districts of Andhra Pradesh

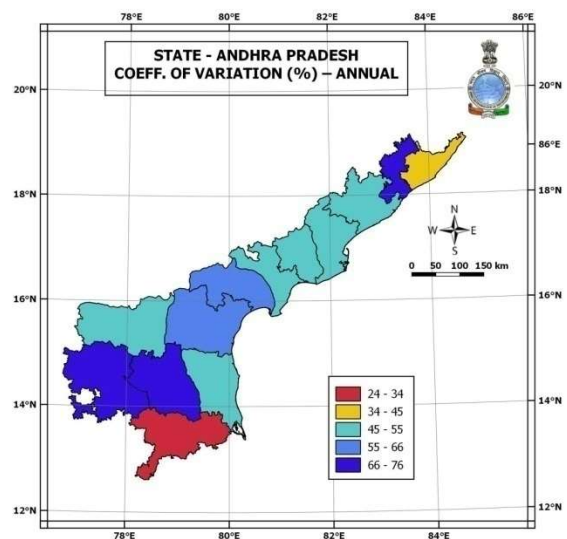
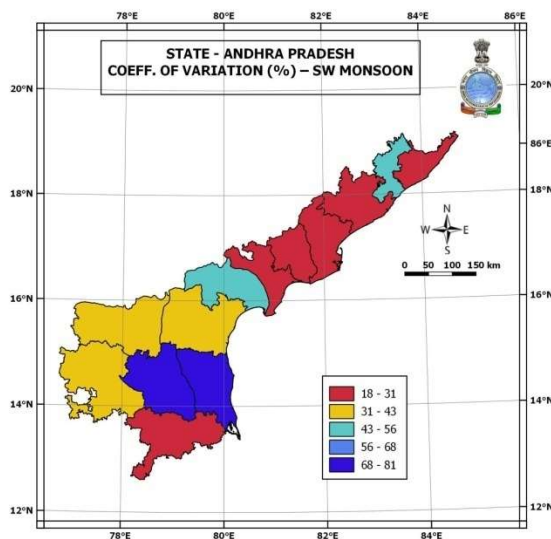
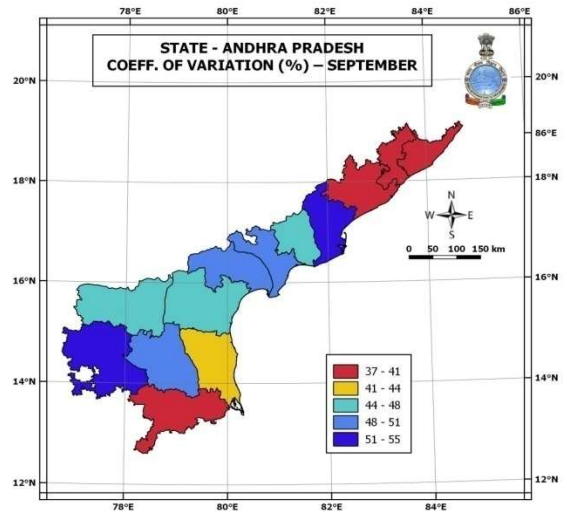
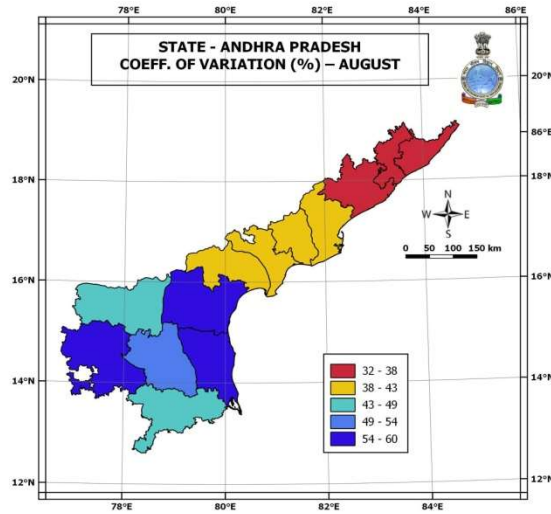
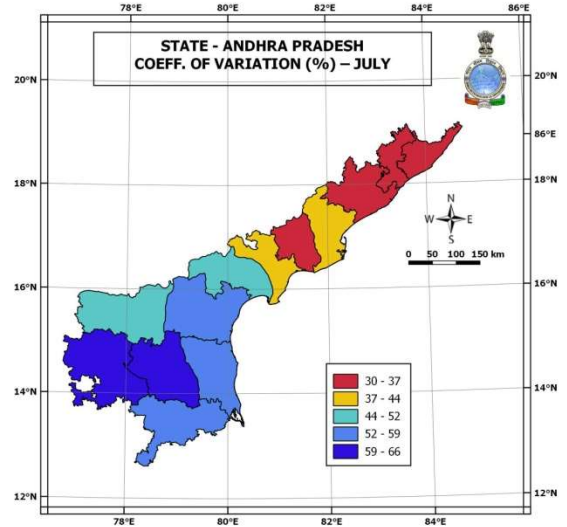
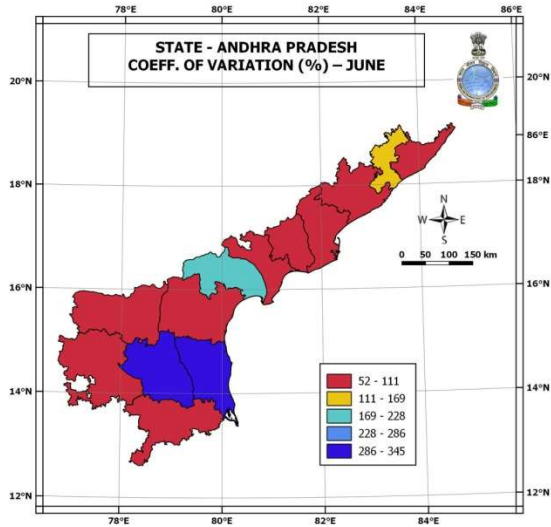
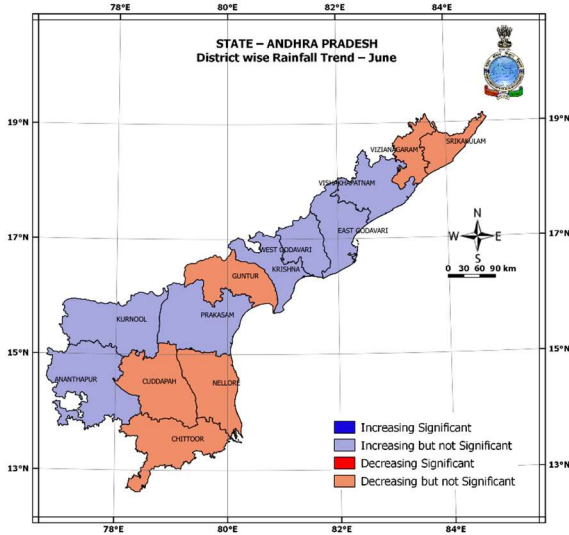


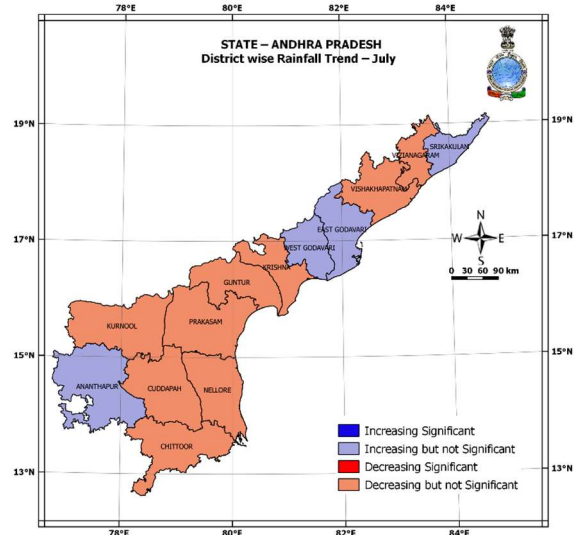
Fig.5 Coefficient of Variation (%) over districts of Andhra Pradesh

## 4.2 Trend in district rainfall

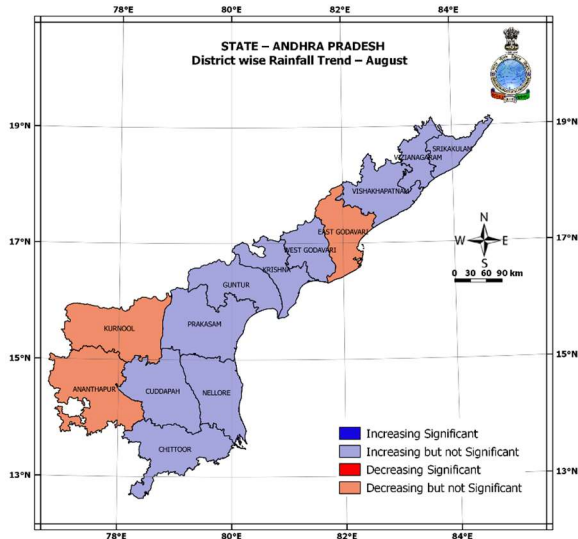
Figure 6 depicts the district rainfall trends for the month of June to September, SW monsoon season and annual. There is no significant trend during SW monsoon months as well as season as a whole. However, Guntur, Prakasam, Nellore district shows the statistically significant decreasing trend annually. There is non-significant increasing trends in rainfall over the Anantapur, Kurnool, Prakasan, Krishna, East Godavari, West Godavari, Vishakhapatnam district of the state during month of June while rest of the district show insignificant downward trends. For the month of July, most of the district indicate non-significant decreasing trends except Ananathapur, east Godavari, west Godavari and Srikakulam district. Non-significant decreasing trend is observed for the districts of Ananathapur, Kurnool and East Godavari while remaining districts of the state indicate non-significant increasing trend for the month of August. Srikakulam, Vizianagaram, Vishakhapatnam from northern parts of the state and Kurnool and Anantapur from south western part show increasing trend while remaining districts indicate the decreasing trend for the month of September. However, the trends are found to be statistically insignificant. There is upward but statistically non-significant trend in rainfall for the season( during SW monsoon) as a whole Srikakulam, Vishakhapatnam, Krishna, East Godavari, West Godavari and Anantapur while rest of the districts shows non-significant decreasing trend. Annually it is seen that Guntur, Prakasam, Nellore shows significantly decreasing trend while rest of the districts shows non-significant decreasing trend.



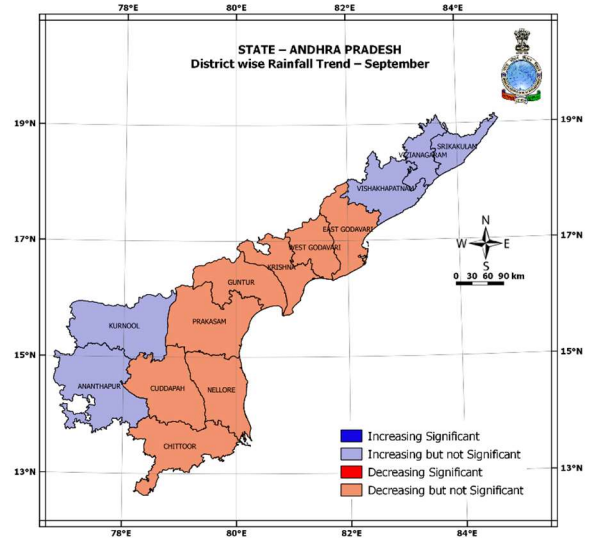
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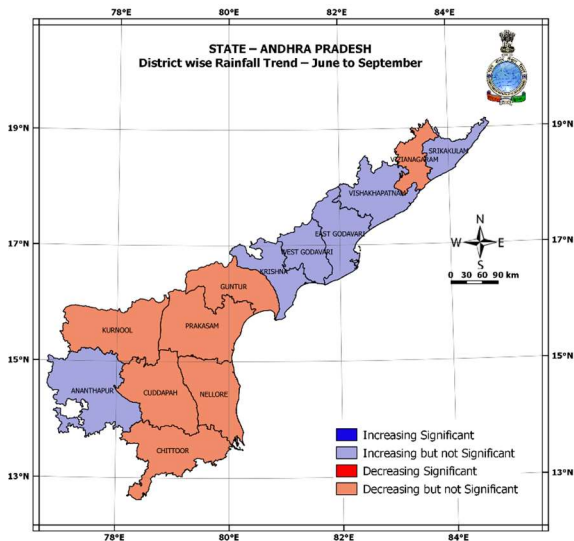
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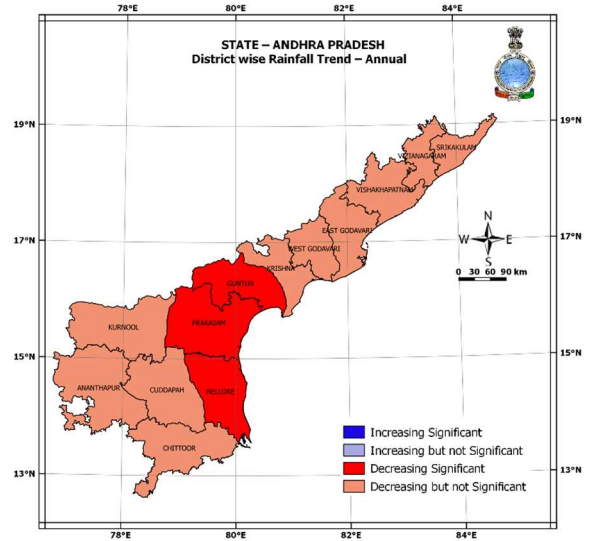
c



d



e



f

Fig.6 Trends in district rainfall for (a) June, (b) July (c) August (d) September (e) JJAS and (f) annual

## 5. Analysis of Average frequencies for rainfall events of different intensities

### 5.1 Average frequency of Rainy days

Average frequency of rainy days for the month of June (Figure 7) is high over northern districts of the state (Srikakulam, Vizianagaram, Vishakhapatnam, East Godavari, West Godavari, Krishna and Guntur). Anantapur, Kadapa, Nellore and Chittoor districts record rainy days in the range of 4-5 days

while Kurnool and Prakasam district it is in the range of 4-5.5 days. The number of rainy days for the month of July and August (Pl. see figure 8 and 9) is about 10-13 days for the northern region of the state (for the districts of Srikakulam, Vizianagaram, Vishakhapatnam, East Godavari, West Godavari, Krishna and some parts of Guntur). It is about 6-8 days for the districts of Kurnool, Prakasam, and some parts of Kadapa, Nellore and Chittoor. Lowest number of rainy days (6-7 days) is observed in the district of Anantapur and some parts of Nellore, Kadapa and Chittoor. The frequency of rainy days is remained high (low) over northern (southern) part of the state for the month of September. However, the central region of the state (Kurnool, Prakasam and Guntur) it is in the range of 5-7 days (see figure 10).

North-south Gradient in frequency of rainy days for the Andhra Pradesh state for the SW monsoon is observed. Highest rainy days (30-43) observed in northern districts, followed by central (25-30) and southern districts (21-25) of the state (Figure 11). Analysis on annual frequency of rainy days (Fig 12) indicate that northern districts and some parts of Chittoor and Nellore records 45 to 61 number of rainy days, followed by Prakasam and some parts of the Nellore, Kadapa and Kurnool districts (40-45 rainy days). Anantapur district shows lowest number of rainy days (35-40 rainy days).

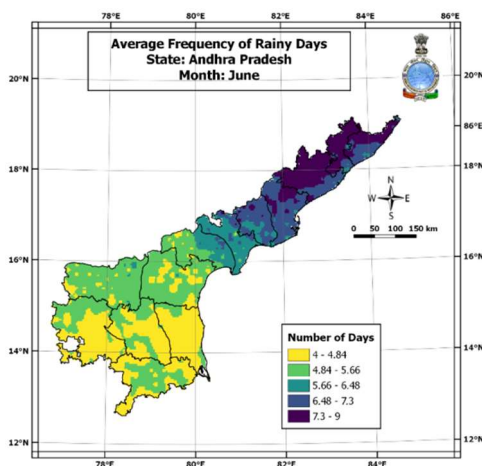


Fig. 7 Average frequency of rainy days: June

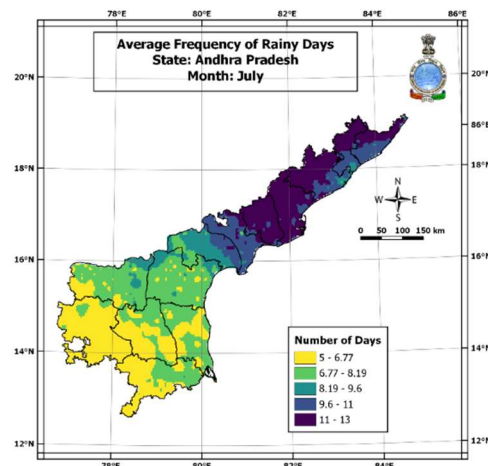


Fig. 8 Average frequency of rainy days: July

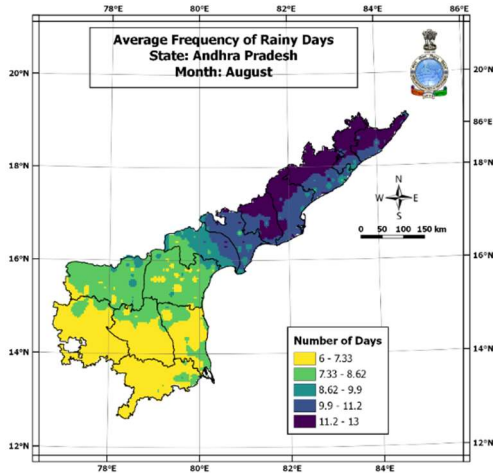


Fig. 9 Average frequency of rainy days: August

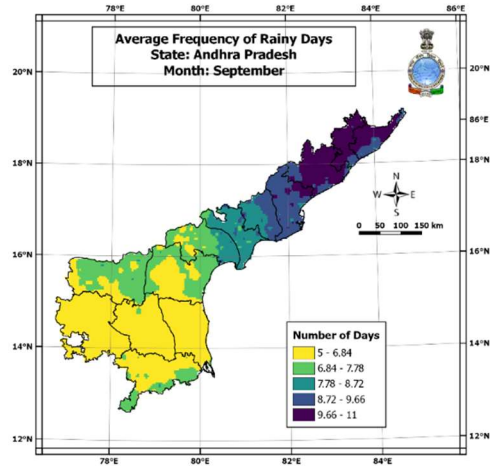


Fig10 Average frequency of rainy days: September

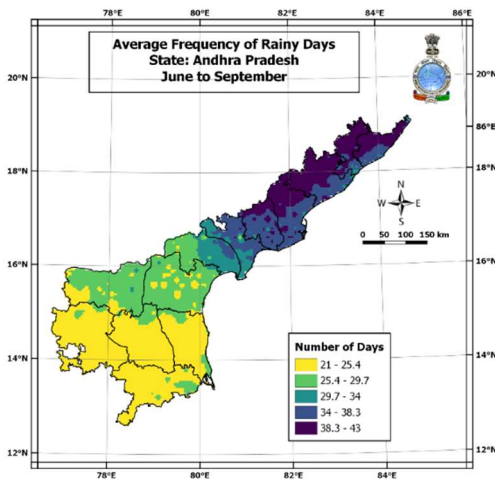


Fig. 11 Average frequency of rainy days: JJAS

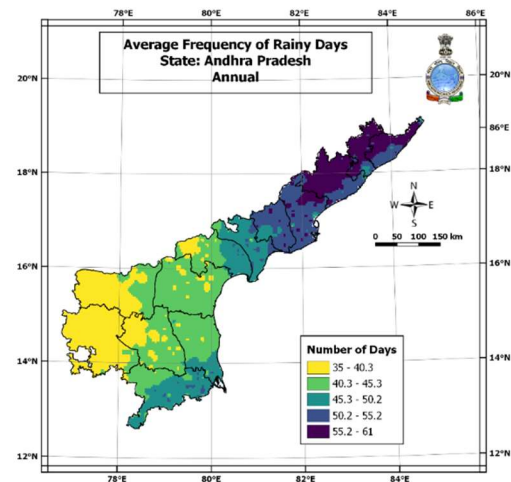


Fig. 12 Average frequency of rainy days: Annual

## 5.2 Average frequency of Heavy rainfall days

Average frequency of heavy rainfall days for the months of June and July (Figure 13 and 14) indicate that northern districts of the state records more number of average heavy rainfall days (0.2-0.3 days) as compare to central and southern region. Central and southern region of the state show average frequency of heavy rainfall days ranging from 0.1 to 0.3 days. Like June and July, north-south gradient in average frequency of number of heavy rainfall days is also seen for the months of August and September (see Fig 15 and 16). However, region with a greater number of heavy rainfall days have shifted slightly southwards. Also, highest average numbers of heavy rainfall days (0.4-0.5 days) are recorded in the districts of Vishakhapatnam, East and West Godavari. Average frequency of heavy rainfall days for SW monsoon season (Figure 17) also show the similar pattern seen in June to

September. Annual pattern in average frequency of heavy rainfall days depicts different picture than observed for SW monsoon season (Figure 18). High average frequency of occurrence of the heavy rainfall days (ranging from 2 to 3 days) for annual are seen in all the coastal districts. However, it is found to be low for inland districts (1-2 days). Genesis of synoptic systems (low pressure systems, cyclones etc) over Bay of Bengal and its movement over coastal region of the Andhra Pradesh during pre-monsoon (March, April and May) and post-monsoon (October, November and December) season contribute significantly to annual average frequency of heavy rainfall days.

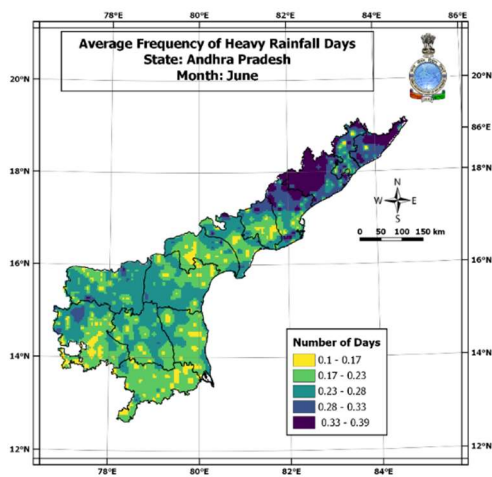


Fig. 13 Average frequency of heavy rainfall days: June

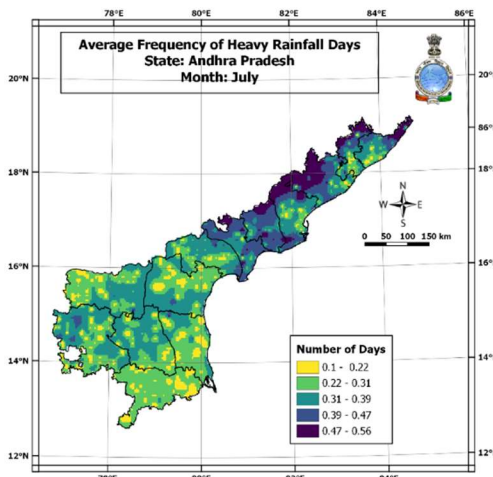


Fig. 14 Average frequency of heavy rainfall days: July

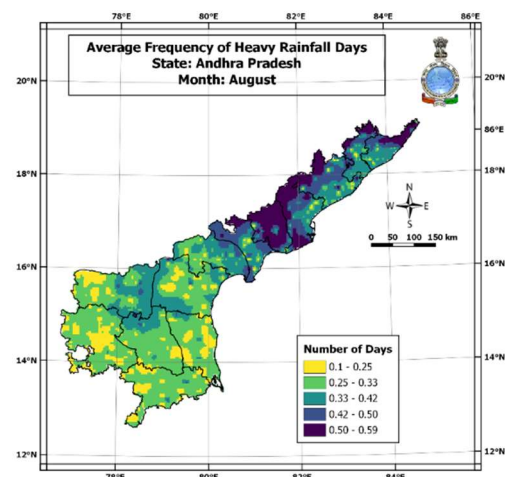


Fig. 15 Average frequency of heavy rainfall days: August

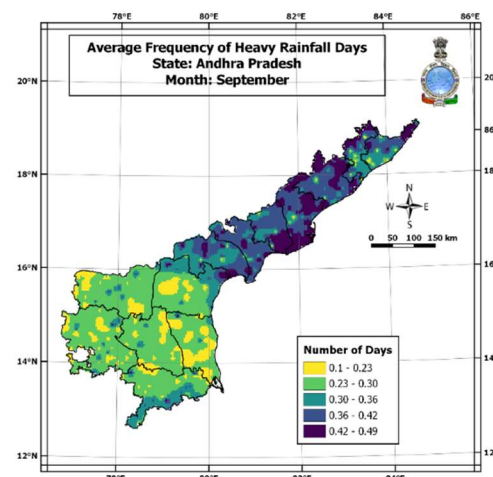


Fig. 16 Average frequency of heavy rainfall days: September

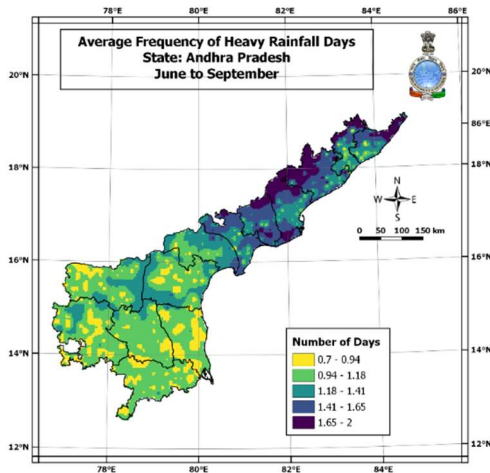


Fig. 17 Average frequency of rainy days: JJAS

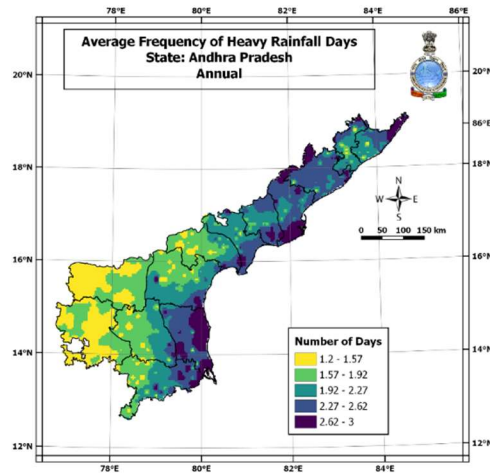


Fig. 18 Average frequency of rainy days: Annual

### 5.3 Average frequency of Dry days

Average frequency of dry days for the SW monsoon months, season as a whole and annual (Fig. 19-24) show north-south gradient (more dry days in southern part and less dry days in northern part of the state). Anantapur, Kadapa, Nellore and Chittoor districts consistently indicate more average number of dry days (ranging from 19-23 days for months, 77-93 days for season and 245-279 for annual) for all time scales. Districts from northern region of the state (Srikakulam, Vizianagaram, Vishakhapatnam, East and West Godavari, Krishna Guntur) show lesser number of dry days. It is in the range of 19-21 days for south west monsoon months, 66 to 77 days for season as a whole and 225-260 days for annual.

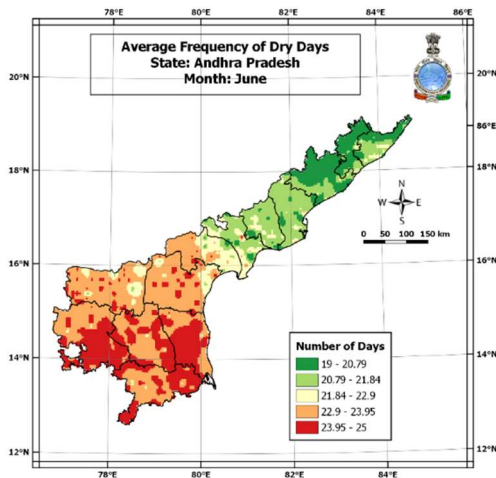


Fig. 19 Average frequency of dry days: June

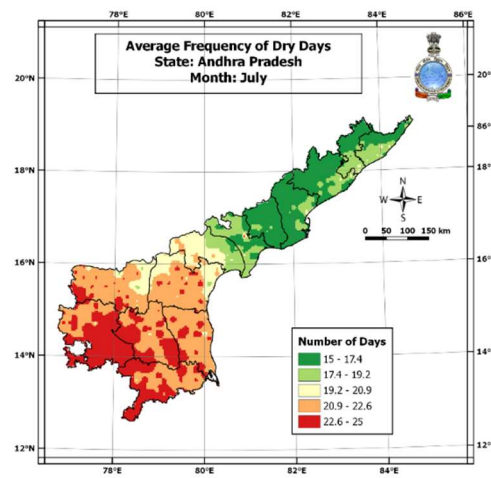


Fig. 20 Average frequency of dry days: July



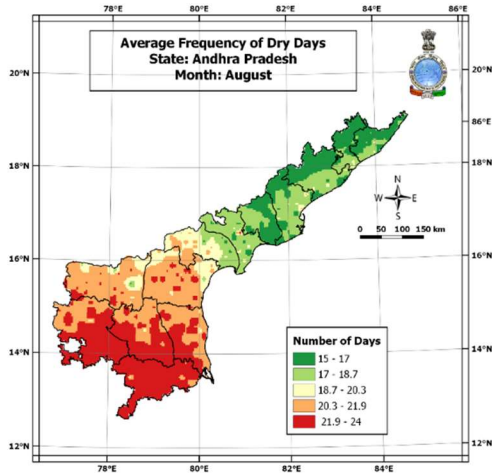


Fig. 21 Average frequency of dry days: August

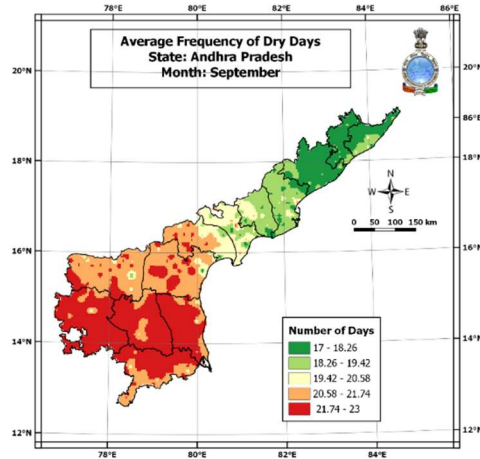


Fig. 22 Average frequency of dry days: September

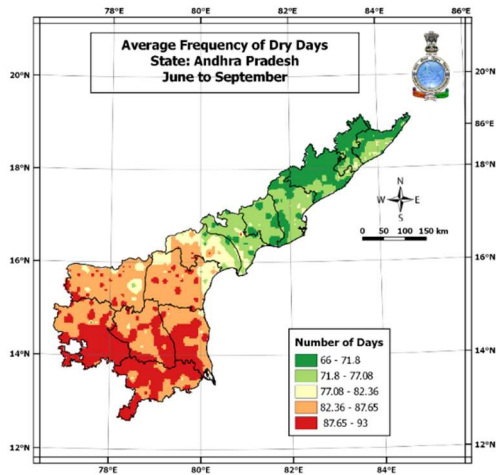


Fig. 23 Average frequency of dry days: JJAS

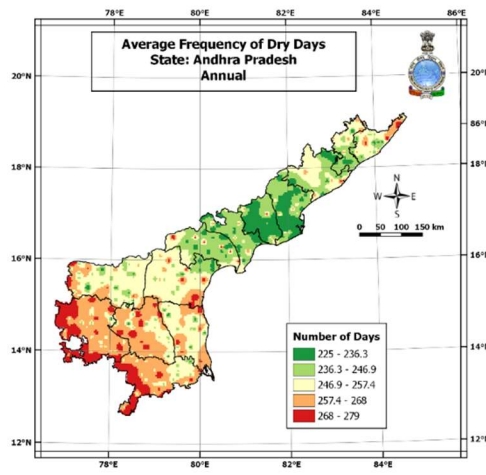


Fig. 24 Average frequency of dry days: Annual

## 6. Trends in the frequencies of different rainfall events

### 6.1 Trend in frequency of Rainy days

The statistically significant trends in frequency of rainy days at 95% of significant level is computed for the rain gauge stations of Andhra Pradesh for June, July, August, September, SW monsoon season and annual (Figure 25-30). There is decreasing trend in one each station of the Chittoor, Anantapur and West Godavari district of the state for the month of June (Figure 25). Rest of the stations show statistically significant upward trend in frequency of rainy days. Anantapur, Kurnool, East Godavari and Krishna district shows statistically significant upward trend for the month of July (Figure 26), while remaining district of the state confirms the decreasing trend in number of rainy days. For the month of August, majority of the districts demonstrate upward trend in number of rainy days except two stations from west Godavari and one station from Srikakulam district (Figure 27). One station each

from Chittoor and Nellore show downward trend in frequency of rainy days for the month of September (Figure 28). Trend in frequency of rainy days are found to be insignificant for the districts of Guntur, Krishna and West Godavari. Remaining districts of the state illustrate upward trend in frequency of rainy days for the month of September. For SW monsoon season majority of the stations indicate upward trend in frequency of the rainy days. Annual trend in frequency of rainy days illustrates that majority of the stations in southern region of the state show upward trend, however a few stations of the central and northern region of the state indicate downward trend (Prakasam, Krishna, West and East Godavari and Vizianagaram).

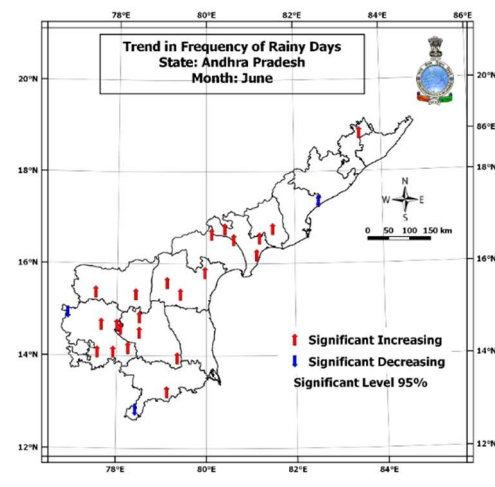


Fig. 25 Trend in frequency of rainy days: June

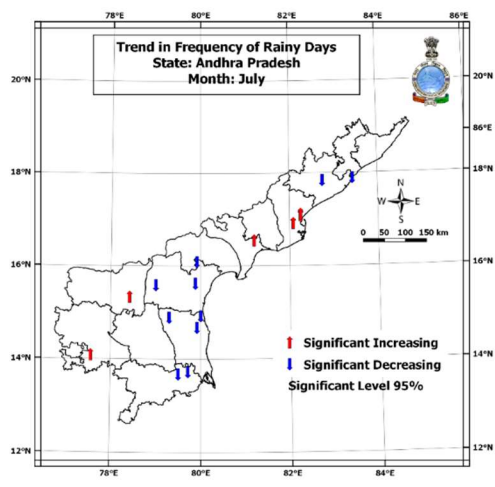


Fig. 26 Trend in frequency of rainy days: July

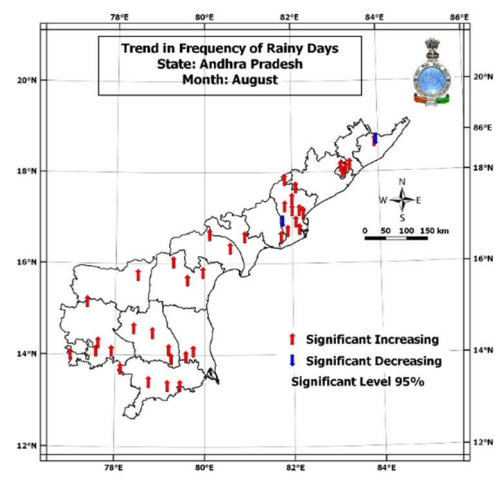


Fig. 27 Trend in frequency of rainy days: August

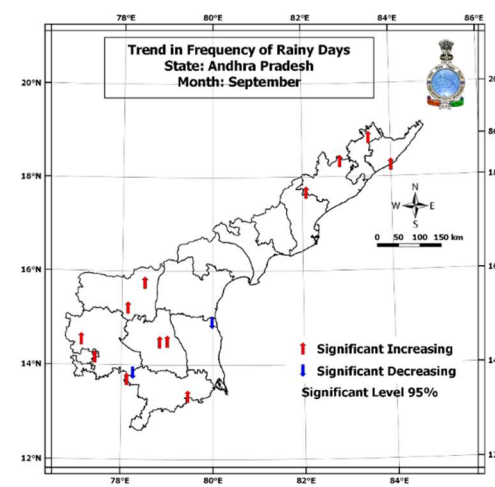


Fig. 28 Trend in frequency of rainy days: September

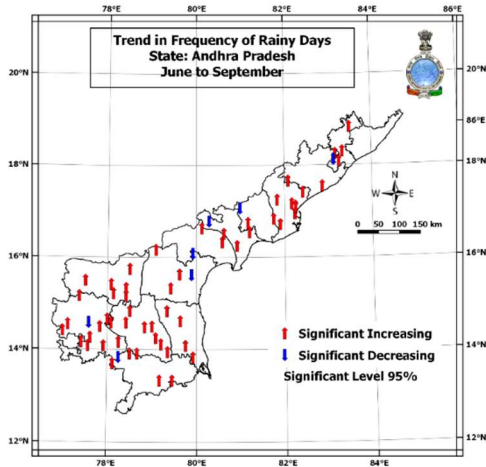


Fig. 29 Trend in frequency of rainy days: JJAS

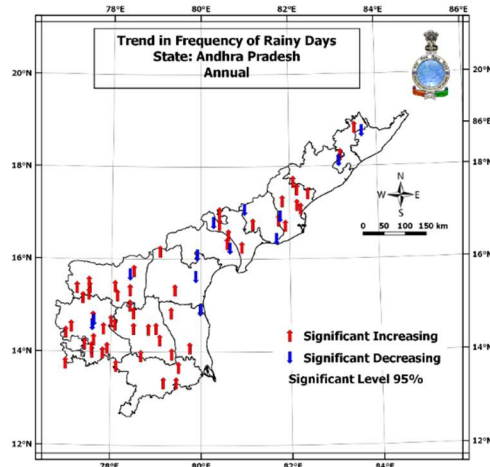


Fig. 30 Trend in frequency of rainy days: Annual

## 6.2 Trend in frequency of Heavy rainfall days

The statistically significant trends in frequency of heavy rainfall days at 95% of significant level has been found for the rain gauge stations of Andhra Pradesh for June, July, August, September, SW monsoon and annual (Figure 31-36). The trend in frequency of the heavy rainfall days for the month of June (Figure 31) demonstrates that Chittoor, Kadapa and Krishna districts show decreasing trend, Srikakulam, East Godavari indicate statistically insignificant trend while rest of the district show upward trend. A few stations of Chittoor and Srikakulam district, one station each of Nellore, Kurnool, Guntur and Vizianagaram district confirms upward trend and remaining districts of the state demonstrate downward trend in frequency of heavy rainfall days for the month of July (Figure 32). One station each from Kurnool, East Godavari and Nellore districts and two stations from Chittoor district of the state show downward trend in frequency of heavy rainfall events while Kadapa district show insignificant trend and rest of the districts show increasing trend in frequency of heavy rainfall days for the month of August (Figure 33). North south gradient of trend in frequency of heavy rainfall days is seen for the month of September (Figure 34, majority of the stations in northern districts of the state show upward trend however southern district mainly show downward trend). For SW monsoon season (Figure 35) most of the stations from Kurnool, Kadapa and Nellore district demonstrates the decreasing trend while rest of the district show upward trend. Annual trend in frequency of heavy rainfall days (Figure 36) for most of the stations in northern districts of the state indicate increasing trend and southern districts show decreasing trend respectively.

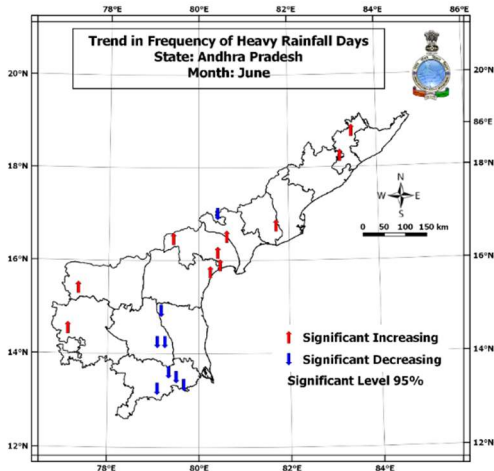


Fig.31 Trend in frequency of heavy rainfall days: June

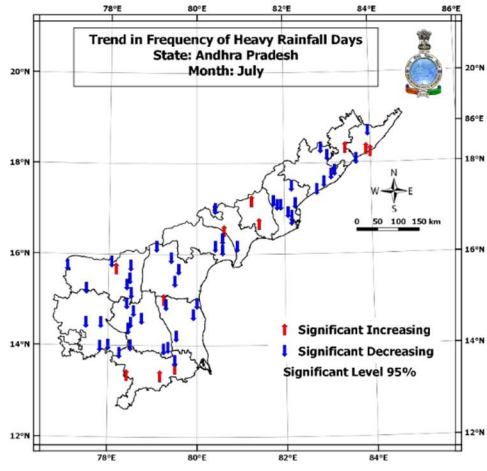


Fig. 32 Trend in frequency of heavy rainfall days: June

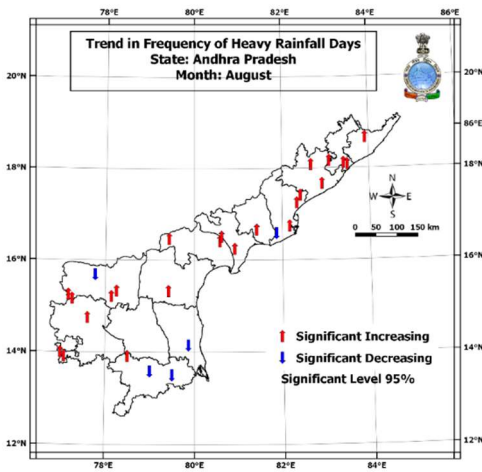


Fig. 33 Trend in frequency of heavy rainfall days: August

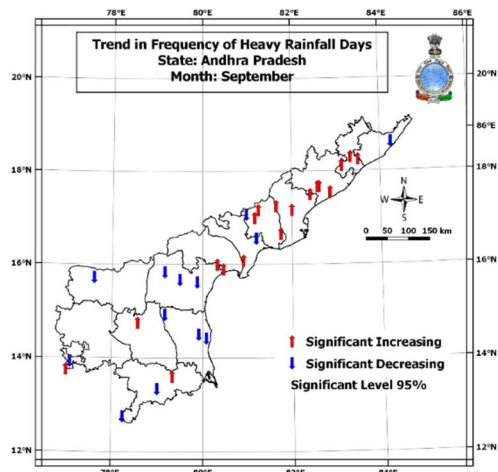


Fig. 34 Trend in frequency of heavy rainfall days: September

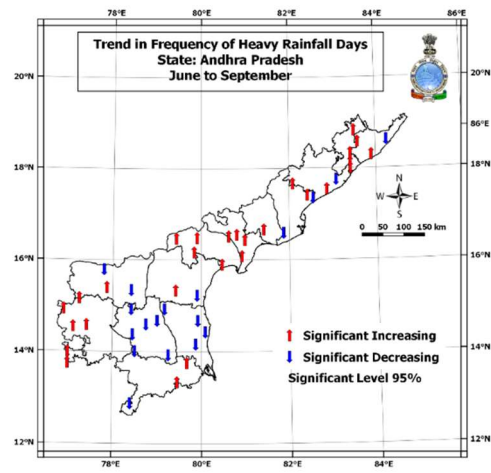


Fig. 35 Trend in frequency of heavy rainfall days: JJAS

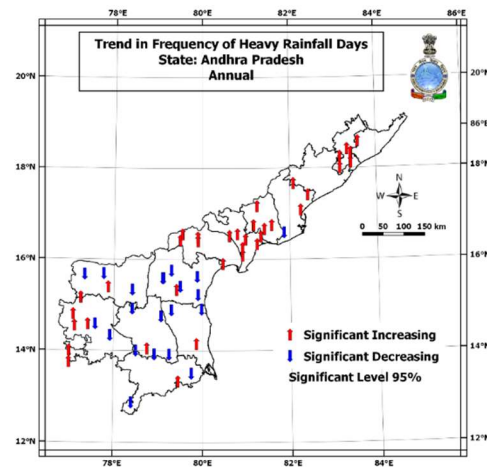


Fig. 36 Trend in frequency of heavy rainfall days: Annual

### 6.3 Trend in frequency of Dry days

The statistically significant trends in frequency of dry days at 95% of significant level is computed for the rain gauge stations of Andhra Pradesh for June, July, August, September, SW monsoon and annual (Figure 37-42). A few stations from Chittoor and Srikakulam and one station each from Vishakhapatnam and Krishna district show upward trend while rest of the stations demonstrate decreasing trend in frequency of dry days for the month of June (Figure 37). Srikakulam, Vizianagaram, Vishakhapatnam, Guntur, Prakasam, Nellore and Chittoor district show increasing trend while rest of the district show decreasing trend in frequency of the dry days for the month of July (Figure 38). Most of the stations illustrate decreasing trends in frequency of dry days for the month of August except a few stations from Srikakulam, Vishakhapatnam and West Godavari district. Most of the districts show decreasing trend in frequency of dry days for the month of September, except one each station from the Chittoor, Guntur, West Godavari and Vishakhapatnam. Nellore and Kurnool district do not show any significant trend in frequency of dry days for the month of September. Majority of the stations in West and East Godavari (Guntur and Prakasam) districts indicate downward (upward) trend in frequency of the dry days for SW monsoon season while rain gauge stations in rest of the districts demonstrate either increasing or decreasing trend. For annual, most stations in all district show upward trend in frequency of dry days.

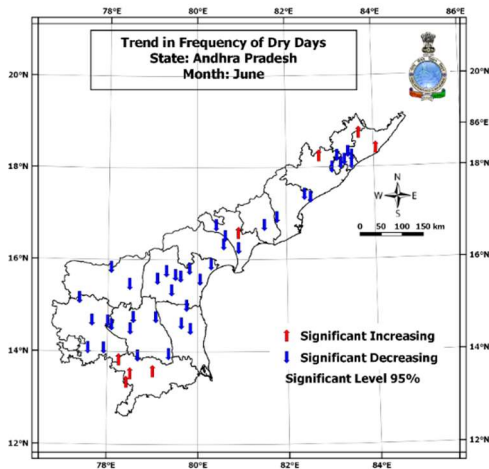


Fig. 37 Trend in frequency of dry days: June

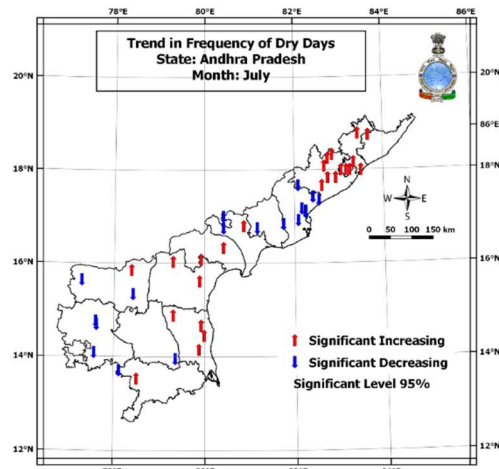


Fig. 38 Trend in frequency of dry days: July

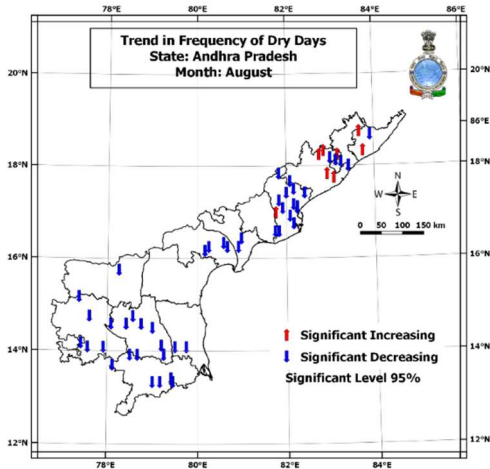


Fig. 39 Trend in frequency of dry days: August

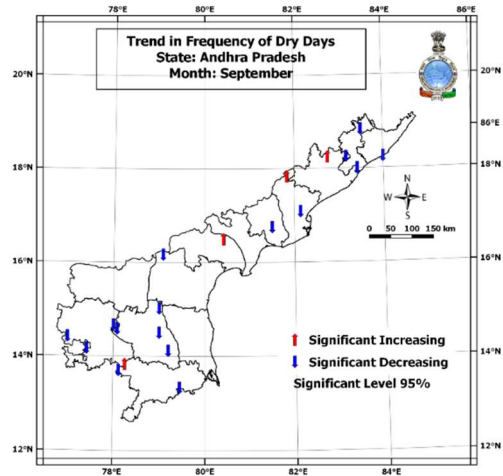


Fig. 40 Trend in frequency of dry days: September

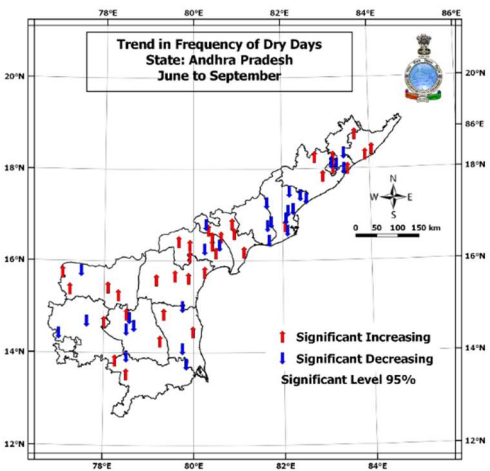


Fig. 41 Trend in frequency of dry days: JJAS

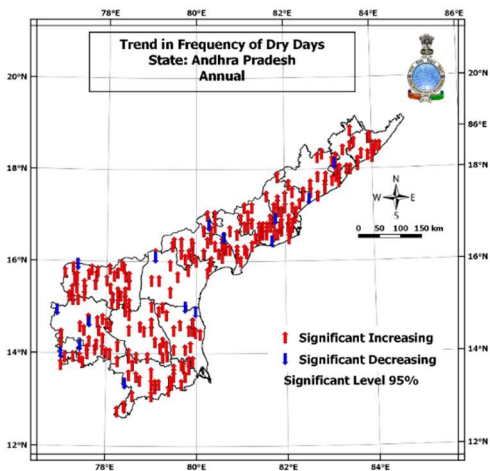


Fig. 42 Trend in frequency of dry days: Annual

## 7. Conclusions

In present report, we have investigated the rainfall pattern, variability and change based on recent 30 years (1989-2018) of data. Here we have considered, June, July, August and September, SW Monsoon season and annual time scales for the analysis. The district spatial patterns are considered to study rainfall total and stations are considered to study rainfall intensities. This study brought out many significant features of the rainfall pattern which can be utilized for the water and agricultural management. Some of the important findings are summarized below:

- Andhra Pradesh state receives maximum rainfall in the month of August (28.0 % of SW monsoon rainfall) followed by September (27.7 %), July (25.3%) and June (18.9 %). Contribution of the SW monsoon rainfall to annual total is 58.5%.

✚ Analysis indicates that neither monthly, nor seasonal and annual rainfall for the state as whole rainfall show any statistically significant increasing/decreasing trend.

✚ Maximum mean SW monsoon rainfall (690-780 mm) is received in northern coastal districts of the state, viz. Vishakhapatnam, Srikakulam, Vizianagaram, East Godavari, West Godavari, Krishna. Maximum rainfall received in a year for coastal districts of the state is ranging from 1045 to 1170 mm.

✚ Though there is no statistically significant trend in rainfall for SW monsoon months as well as season as a whole. However, Prakasam, Guntur, Nellore district shows the statistically significant decreasing trend when we consider annual rainfall data for analysis.

✚ North-south Gradient in frequency of rainy days for SW monsoon is seen for the state. Highest rainy days (30-43) observed in northern districts, followed by central (25-30) and southern districts (21-25) of the state.

✚ Analysis on annual frequency of rainy days (daily rainfall  $\geq 2.5$ mm, Fig 12) indicate that northern districts and some parts of Chittoor and Nellore records 45 to 61 number of rainy days, followed by Prakasam and some parts of the Nellore, Kadapa and Kurnool districts (40-45 rainy days). Anantapur district records lowest number of rainy days (35-40 rainy days).

✚ Average frequency of heavy rainfall (rainfall intensity  $\geq 65$ mm) days for SW monsoon illustrate the north south gradient (more heavy rainfall days in northern districts and less heavy rainfall days in southern region of the state).

✚ Srikakulam, Vizianagaram, Vishakhapatnam, East and West Godavari, Krishna and Guntur districts demonstrate lesser number of dry days. It is in the range of 19-21 days for south west monsoon months, 66 to 77 days for season as a whole and 225-260 days for a year. Anantapur, Kadapa, Nellore and Chittoor districts consistently indicate a greater number of dry days (ranging from 19-23 days for months, 77-93 days for season and 245-279 for annual) for all time scales.

✚ Majority of the stations in most of the districts indicate upward trend in frequency of the rainy days for SW monsoon. For annual, trend in frequency of rainy days illustrates that majority of the stations in southern region of the state show upward trend, however a few stations of the central and northern region of the state indicate downward trend (Prakasam, Krishna, West and East Godavari and Vizianagaram districts).

✚ Majority of the stations from Kurnool, Kadapa and Nellore district demonstrates the decreasing trend in frequency of heavy rainfall days while rest of the districts show upward trend for SW monsoon season. Annual trend in frequency of heavy rainfall days for most of the stations in northern districts of the state indicate increasing trend and southern districts show decreasing trend respectively.

✚ Majority of the stations in West and East Godavari (Guntur and Prakasam) districts indicate downward (upward) trend in frequency of the dry days for SW monsoon season while rain gauge stations in

rest of the districts demonstrate either increasing or decreasing trend. For annual, most stations in all district show upward trend in frequency of dry days.

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**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.**

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