



A STUDY OF RAINFALL CHARACTERISTICS OF CHANDRAGIRI MANDAL IN CHITTOOR DISTRICT, ANDHRA PRADESH, INDIA

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Abstract: *The basic characteristic of drought is absence or severe deficiency of rainfall over a fairly long period. This creates an imbalance between the soil moisture and evapotranspiration needs of an area and causes damage to standing crops and reduction in crop yields. Although several factors are responsible for causing drought situation, the key role is played by rainfall, its distribution and its variation over an area. It is therefore, very necessary to analyse these characteristics of rainfall in order to appreciate the various causes responsible for drought situations as it is one of the drought stricken mandals in the district / state. Hence a study on rainfall pattern over the Chittoor District / Chandragiri Mandal has been made in great detail and discussed in the following paragraphs.*

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INTRODUCTION

Rainfall is the major parameter influencing the agricultural activities of man. In India, agricultural economy is entirely depends the amount of rainfall receiving during monsoon season. The study of only average rainfall cannot provide an idea regarding systematic planning and judgement of crop management. Therefore modest attempt has been made to compute annual and decadal rainfall by using markov chain model and seasonal and yearly probability of assured rainfall by using Gama index and finally to delineated rainfall area on the basis of assured rainfall probability level. Such study would help in the selection of crops and in short range weather forecasting. In order to obtain optimum yield from agriculture and awareness of tourism in the heavy rain, it requires a proper knowledge about agro-climatic situation that helps for better planning of cropping pattern and tourism management. For this study, data of nine rainguage stations in and around have been used. Study area the Chandragiri mandal is situated in north eastern part of CHITTOOR District in Andhra Pradesh state. There are 23 revenue villages in the mandal. It is located $13^{\circ}20'$ to $13^{\circ}50'$ N and $79^{\circ}5'$ to $79^{\circ}30'$ E.

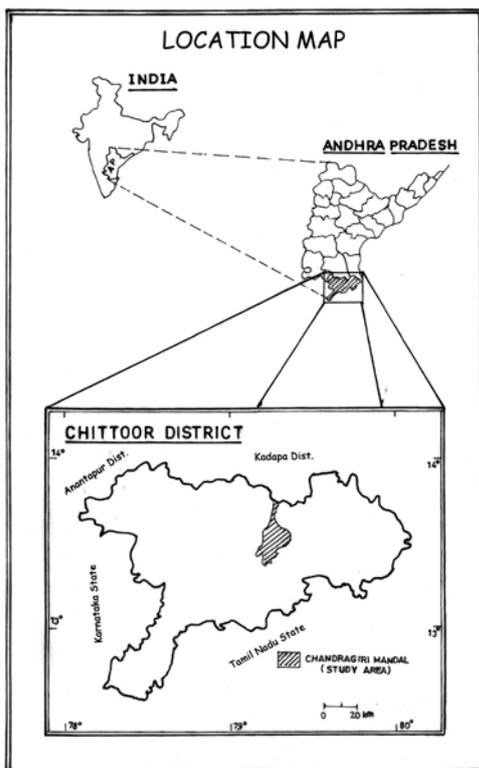


Fig. 1

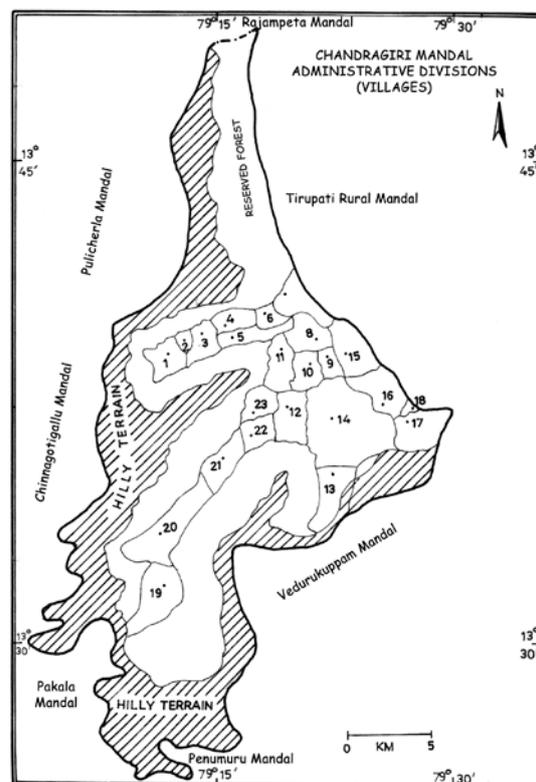


Fig. 2



It is bordered by Rajampeta mandal of Kadapa district in the north and Penumuru mandal of Chittoor district in the south and Tirupati rural and Vedurukuppam mandals of Chittoor district in the East and Pulicherla and Chinnagottigallu mandals of Chittoor district in the west. It is situated in the northeastern part of the Chittoor district with a distance of 54 Km. from Chittoor town and 10 km. from Tirupati town. It is one of the smallest mandals of the district covering an area of 1184.52 Sq.km. or 1,12,572 Hectares and a population of 53,051 (2011 provisional figures). It is included in the Survey of India Topographical sheets of $57\frac{0}{2}$ and $57\frac{0}{6}$ on a scale of 1:50,000.

OBJECTIVES

The present paper has attempted to make an assessment of rainfall characteristics of Chandragiri mandal in Chittoor district of Andhra Pradesh. This study has been undertaken with, an average rainfall, analyzing trends of rainfall and probability of rainfall to bring out the relationship between the available water resources and agriculture of the area.

The objectives of the present study are:

1. To study the Rainfall pattern in the study area
2. To identify the seasonal pattern of Rainfall in the study area
3. To identify the variability of Rainfall in study area and
4. To identify the Rainfall zones.

METHODOLOGY

The present study is based on the rainfall data collected from chief planning officer, Chittoor and Assistant statistical officer, Chandragiri mandal for 25 years. The data has been grouped in monthly and seasonally from 1985 to 2009. The monthly rainfall data over a period of 25 years was collected from 12 stations in and around Chandragiri Mandal. The data was used to analyse monthly, seasonal and annual rainfall variation and frequency of occurrence of rainfall. Based on mean annual rainfall and geographical area of Chandragiri Mandal the surface water resources potential was evaluated. The trend of rainfall is calculated and represent by markov chain model and Probability levels has identified by applying Gamma distribution method. The assured rainfall have identified at 700 m.m. to 800 m.m. from this analysis, it is possible to workout the percentage probability of occurrence of rainfall at 75 per cent of annual rainfall or more for identification of drought proneness of the study area.



GENERAL DESCRIPTION OF RAINFALL IN THE STUDY AREA

The basic characteristic of drought is absence or severe deficiency of rainfall over a fairly long period. This creates an imbalance between the soil moisture and evapotranspiration needs of an area and causes damage to standing crops and reduction in crop yields. Although several factors are responsible for causing drought situation, the key role is played by rainfall, its distribution and its variation over an area. It is therefore, very necessary to analyse these characteristics of rainfall in order to appreciate the various causes responsible for drought situations as it is one of the drought stricken mandals in the district / state. Hence a study on rainfall pattern over the Chittoor District / Chandragiri Mandal has been made in great detail and discussed in the following paragraphs.

The geographical features of India play a crucial role in influencing the climate, because they determine the direction of monsoon winds and their intensity. Rainfall in India is mainly dependent, in different degrees, on the southwest and northeast monsoons. Chittoor District and the study area i.e., Chandragiri Mandal gets benefit to some extent both from southwest and northeast monsoons. A brief description of the onset of southwest and northeast monsoons and their influence over the study area is given below.

GENERAL DESCRIPTION OF SOUTHWEST MONSOON

Due to the rapid rise of temperature in May over the Asian mainland there is a corresponding drop in air pressure over the ocean area. By the end of May the Asian high pressure region is replaced by a deep low pressure area which extends from the Sudan in Africa through West Rajasthan to West Bengal. The air circulation in the Indian Ocean and in the neighbouring areas become more and more vigorous and the southeast trade winds from the south of the equator extend northwest into the Bay of Bengal and the Arabian Sea. They are then caught up in air circulation over India and deflected inland as the southwest monsoon. Usually when the monsoon winds strike the Malabar Coast in the 1st week of June, the southwest monsoon stabilizes itself over many parts of the country by the end of June.

The study area comes under the influence of southwest monsoon and this season lasts over the mandal from June till the end of September.

The rainfall is discontinuous and is characterized by alternations of moderate to high rain with intervening dry spells. It is this variation of the monsoon which is of great agricultural



significance for Kharif crops in the mandal. The mean maximum rainfall in this season (calculated from the collected data) is 423.13 mm at Pakala and the minimum is 203.05 mm at Koduru towards the surrounding areas, the total normal seasonal rainfall of 318.2 mm, in the mandal is received during the southwest monsoon season. This reveals that the rainfall in the southwest monsoon is comparatively low and periodically the mandal suffers from lack of rain. This is because the southwest monsoon works its way inland from the Bay of Bengal Coast. As this mandal is away from the sea coast and situated adjacent to Tamil Nadu more over the intensity of rainfall gets considerably reduced from east to west. The lee effect of Western Ghats also felt clearly.

GENERAL DESCRIPTION OF NORTHEAST MONSOON

The Southwest monsoon period is the principal rainy season in many parts of India. But over South Coastal Andhra Pradesh and Tamilnadu, the principal rainy season is from October to December. This is known as the Northeast monsoon period during this monsoon period the circulation of winds over peninsular India, at low levels is round an anticyclone centered at about 25°N. Under its influence the retreating southwest monsoon current curves found as it is deflected towards the peninsula from the northeast.

The retreating monsoon winds cause occasional showers. However, during October to December cyclonic storms form in the Bay of Bengal and when they strike the Coromandel coast they bring heavy rains. In this season the Chandragiri mandal receives the highest rainfall in the month of October under the influence of northeast monsoon high rainfall occurs along the eastern part in the mandal mainly based on the northeast monsoon. The total mean rainfall of the mandal in this season is 231.9 mm.

DESCRIPTION OF WINTER RAINFALL

From the analysis of mean seasonal rainfall in the study area in winter it is evident that it varies from a minimum of 1.67mm in Koduru in the northern part of the study area to a maximum of 33.89 mm in Pakala in the southwestern part of the study area, the normal rainfall being 18.8 mm (Table 1). The spatial distribution of rainfall in the study area depicts that it is reducing from southwest to northwest.

The average number of rainy days ranges from a minimum of 0.20 in Koduru to a maximum of 2.00 in Vedurukuppam, the normal is 1.2. The intensity of rainfall in the study area reveals that it varies from a minimum of 8.35 mm per a rainyday in koduru to a maximum of



19.42 mm per a rainy day in Tirupati, the normal intensity of the study area is 14.16 mm per a rainy day. The spatial pattern of intensity in the study area shows that it is more in the southeastern parts of the study area, than in the western part.

From the study and analysis of co-efficient of variability in the mandal, it is discernible that it ranges from a minimum of 153.60 per cent in Panapakam to a maximum of 250.2 per cent in Bhakarapeta, the normal variability of the study area is 115.9 per cent, which shows the erratic nature of rainfall. The spatial distribution of variability in the study area shows that in the southeastern part it is less variable than in the remaining part of the study area.

The rainfall ratio or the abnormalities in the occurrence of rainfall in the study area is ranging from a minimum of 202.0 per cent in Chinnagottigallu to a maximum of 997.0 per cent in Vedurukuppam, the normal ratio in winter is 524.2 per cent. The spatial pattern of rainfall ratio in the study area shows that the southern part shows more abnormality than the northern part.

Table No. 1

Particulars of Rainfall in Winter Season

S. No.	Name of the Rain gauge Station	Mean Seasonal Rainfall (mm)	Average No. of Rainy days	Rainfall Intensity (mm)	Rainfall variability (%)	Rainfall Ratio (%)
1.	Bhakarapeta	8.66	1.32	10.3	250.2	250
2.	Chandragiri	26.02	1.51	17.23	185.90	329.4
3.	Chinnagottigallu	7.78	0.70	11.11	216.20	202.0
4.	Koduru	1.67	0.20	8.35	230.70	230.4
5.	Pakala	33.89	1.82	18.60	160.30	824.7
6.	Panapakam	15.52	1.23	18.61	153.60	678.8
7.	Penumuru	20.06	1.4	18.72	192.42	390.10
8.	Tirupati	28.16	1.45	19.42	154.10	816.6
9.	Vedurukuppam	28.04	2.0	18.21	245.30	997.0
	Chandragiri mandal	18.8	1.2	14.6	115.9	524.2

Source: Computed from the data collected

DESCRIPTION OF SUMMER RAINFALL

From the study of mean seasonal rainfall in summer it is found that the rainfall ranges from a minimum of 54.6 mm. in Koduru to a maximum of 132.8 mm in Tirupati, the normal being 98.9 mm (Table 2). The spatial distribution shows that the rainfall is more in the southeastern part than in the northwestern part. The average number of rainy days in the



study area ranges from a minimum of 3.08 in Bhakarapeta to a maximum of 6.5 in Vedurukuppam, the normal being 4.87. The rainfall intensity shows that it ranges from a minimum of 12.02 mm per a rainy day in Chinnagottigallu to a maximum of 30.64mm. per a rainyday in Tirupati. The normal is 20.5 mm per a rainy day. The rainfall variability shows that it varies from a minimum of 30.1 per cent in Panapakam to a maximum of 55.6 per cent in Bhakarapeta, the mandal average is 42.1 per cent, which shows the erratic nature of rainfall. The spatial distribution shows that in the northern part it is more variable than in the southern part.

The rainfall ratio in the study area ranges from a minimum of 138.4 per cent in Chinnagottigallu to a maximum of 404.0 per cent in Tirupati, the normal being 210.4 per cent. The spatial pattern shows that the abnormality in the occurrence of rainfall is increasing from southeast to northwest.

Table No. 2

Particulars Rainfall in Summer Season

S. No.	Name of the Rain gauge Station	Mean Seasonal Rainfall (mm)	Average No. of Rainy days	Rainfall Intensity (mm)	Rainfall variability (%)	Rainfall Ratio (%)
1.	Bhakarapeta	95.0	3.08	15.7	55.6	145.4
2.	Chandragiri	105.2	5.78	20.5	40.2	210.5
3.	Chinnagottigallu	74.0	4.2	12.02	45.6	138.3
4.	Koduru	54.6	4.5	15.02	55.1	151.6
5.	Pakala	111.8	5.0	22.23	36.0	180.0
6.	Panapakam	100.5	4.3	20.2	30.1	165.3
7.	Penumuru	105	6.1	24.7	35.6	264.0
8.	Tirupati	132.8	4.37	30.64	50.9	404
9.	Vedurukuppam	112.0	6.5	23.2	30.1	235.4
	Chandragiri mandal	98.9	4.87	20.5	42.1	210.4

Source: Computed from the data collected.

DESCRIPTION OF RAINFALL IN SOUTHWEST MONSOON SEASON

The southwest monsoon and northeast monsoon seasons are the principal rainy seasons of the study area. As the study area lies hardly 150 km. from the Bay of Bengal coast, the normal rainfall in this area is more consistent, more increasing and less variable. From the study and analysis of rainfall in this season, it is observed that the normal rainfall ranges from a minimum of 203.05 mm in Koduru to a maximum of 423.13 mm in Pakala, the



normal being 318.2mm. The spatial rainfall shows that it is decreasing from southeast to northwest.

The average number of rainydays in the study area ranges from a minimum of 16.20 in koduru to a maximum of 24.60 in Chandragiri, the normal being 21.48 (Table 3). The rainfall intensity shows that it ranges from a minimum of 14.9 mm per a rainyday in Bhakarapeta to a maximum of 20.46 mm per a rainyday in Penumuru, the normal is 17.60 mm per a rainyday. The rainfall variability shows that it varies from a minimum of 33.5 per cent in Vedurukuppam to a maximum of 51.90 per cent, in Koduru, the normal being 39.4 per cent. The spatial distribution shows that it is decreasing from north to southeast.

The rainfall ratio in the study area ranges from a minimum of 90 per cent in Panapakam to a maximum of 257.5 per cent in Koduru, the normal being 180.78 per cent. The spatial pattern shows that the abnormality in the occurrence of rainfall is increasing from northwest to southern part of the study area.

Table No. 3

Particulars of Rainfall in Southwest Monsoon Season

S. No.	Name of the Rain gauge Station	Mean Seasonal Rainfall (mm)	Average No. of Rainy days	Rainfall Intensity (mm)	Rainfall variability (%)	Rainfall Ratio (%)
1.	Bhakarapeta	215.9	20	14.9	43.6	188
2.	Chandragiri	384.62	24.60	18.03	39.13	185.0
3.	Chinnagottigallu	347.57	23.72	14.63	43.05	212.5
4.	Koduru	203.05	16.20	14.92	51.90	257.5
5.	Pakala	423.13	23.59	19.73	35.00	194.9
6.	Panapakam	300.6	19.5	19.0	39.7	90
7.	Penumuru	313.9	19	20.46	34.31	146.9
8.	Tirupati	338.29	24.19	18.98	35.53	164.9
9.	Vedurukuppam	334.7	22.6	19.0	33.5	184.4
	Chandragiri mandal	318.2	21.48	17.60	39.4	180.78

Source: Computed from the data collected.

DESCRIPTION OF RAINFALL IN NORTHEAST MONSOON SEASON

From the study and analysis of mean seasonal rainfall in the northeast monsoon in the mandal it is observed that it ranges from a minimum of 180.05 mm. in Koduru to a maximum of 298.2 mm in Panapakam, the average being 231.9 mm. The spatial pattern shows that it is more in southern part than in the northern part of the study area. The



average number of rainy days ranges from a minimum of 12.1 Tirupati to a maximum of 18.7 in Chandragiri, the average is 21.48 (Table No. 4).

Table No.4

Particulars of Rainfall in Northeast Monsoon Season

S. No.	Name of the Rain gauge Station	Mean Seasonal Rainfall (mm)	Average No. of Rainy days	Rainfall Intensity (mm)	Rainfall variability (%)	Rainfall Ratio (%)
1.	Bhakarapeta	190.6	14.7	12.0	41.8	169.6
2.	Chandragiri	267.7	18.72	21.53	40.31	281.46
3.	Chinnagottigallu	192.13	11.9	14.8	41.48	167.58
4.	Koduru	180.05	12.2	14.6	41.6	158.3
5.	Pakala	250.1	16.1	20.0	28.9	201.1
6.	Panapakam	298.2	17.9	21.5	26.7	103.1
7.	Penumuru	264.6	14.1	22.0	30.6	289.5
8.	Tirupati	222.9	12.1	16.8	39.1	213.75
9.	Vedurukuppam	220.5	14.7	22.0	27.8	159.1
	Chandragiri mandal	231.9	21.48	18.3	35.2	193.7

Source: Computed from the data collected.

The rainfall intensity of the mandal ranges from a minimum of 14.6 mm per a rainy day in Koduru (outside the boundary) to a maximum of 22.0 mm per a rainy day in Penumuru, the average being 18.3 mm per a rainy day. The spatial pattern shows that the intensity has been decreasing towards northwest.

The rainfall variability of the study area ranges from a minimum of 26.7 per cent in Panapakam to a maximum of 41.48 per cent in Chinnagottigallu, the average being 35.2 per cent. The spatial pattern shows that it is more in the northern part than in the southern part of the study area. The rainfall ratio ranges from a minimum of 103.1 per cent in Panapakam to a maximum of 289.6 per cent in Penumuru, the average being 193.7 per cent, the spatial pattern shows that the abnormality in the distribution of rainfall is more in the southeastern part than in the north part of the study area.

YEARLY RAINFALL PARTICULARS

From the study and analysis of mean annual rainfall in the study area it is discernible that it ranges from a minimum of 450.5 mm in Bhakarapeta to a maximum of 736.5 mm in Tirupati,



the average is 646.1 mm. The spatial distribution of rainfall shows that it is decreasing from southeastern part to north. The average number of rainy days in Bhakarapeta ranges from a minimum of 23.9 to a maximum of 46.12 in Tirupati, the normal being 39.7 (Table No.5).

Table No. 5

Particulars of Annual Rainfall

S. No.	Name of the Rain gauge Station	Mean Annual Rainfall (mm)	Average No. of Rainy days	Rainfall Intensity (mm)	Rainfall variability (%)	Rainfall Ratio (%)
1.	Bhakarapeta	450.5	23.9	12.9	44.35	180.14
2.	Chandragiri	860.1	44.8	17.61	26.13	190.8
3.	Chinnagottigallu	574.5	34.6	14.3	23.2	181.65
4.	Koduru	564.1	40.2	12.71	24.2	189.5
5.	Pakala	698.0	42.5	15.9	34.5	201.5
6.	Panapakam	633.5	42.5	14.59	25.51	205.4
7.	Penumuru	600.4	36.5	14.36	24.3	183.75
8.	Tirupati	736.0	46.12	16.4	28.47	207.37
9.	Vedurukuppam	698.1	42.68	15.89	33.1	205.0
	Chandragiri mandal	646.1	39.7	14.96	29.32	193.9

Source: Computed from the data collected.

The rainfall intensity ranges from a minimum of 12.71 mm per a rainy day in Koduru to a maximum of 17.61 mm per a rainy day in Chandragiri. The normal intensity of the mandal is 14.96 mm per a rainy day. The spatial pattern shows that the intensity has been decreasing from northern part to southern part of the study area. The rainfall variability in the study area ranges from a minimum 23.2 per cent in Chinnagottigallu to a maximum of 44.35 per cent in Bhakarapeta, the normal variability is 29.32 per cent. The spatial distribution of rainfall variability shows that it is more in the northern part than in the southern part.

The rainfall ratio or the abnormality in the occurrence of rainfall ranges from a minimum of 180.14 per cent in Bhakarapeta to a maximum of 207.37 per cent in Tirupati, the average being 193.9 per cent.

PROBABILITY DISTRIBUTION OF ANNUAL RAINFALL

Probability is a constant characterizing a given set of objects or incidents in a particular period. Thus it is clearly a mathematical abstraction. The theory of probability is useful to predict with reasonable accuracy the relative frequency of occurrence in different group



ranges of the Rainfall. From this analysis, it is possible to work out the percentage probability of occurrence of rainfall at 75 per cent of Annual Rainfall or more for identification of drought proneness of the study area.

Histogram showing the probability distribution analysis of rainfall of the study area is given above. It transpires from the above figure that Chandragiri Mandal has 75 per cent or more probability of getting Rainfall in the range of 700 mm to 800 mm or more.

RAINFALL TRENDS

It is observed from the preceding pages that Chandragiri Mandal is a droughtprone area due to its peculiar geographical location in the leeward side of the Western Ghats. So it cannot derive the full benefit of southwest monsoon or the northeast monsoon. Hence it is identified as a droughtprone mandal by the Irrigation Commission of 1972.

Rainfall data of 25 years from 1985 to 2009 has plotted on a graph paper to know the Rainfall trends. On the X – axis the number of years are taken and on the Y – axis Rainfall in millimeters has been plotted and it is observed from the graph that out of 25 years, the Rainfall is below the normal (i.e., 850. 65mm) for six years (i.e, 1989, 1992, 1999, 2001, 2002 and 2009). It is just normal in five years (i.e., 1987, 1994, 2000, 2004 and 2006), and above normal in 14 years.

So altogether in 50 per cent of years of Rainfall is not sufficient for the growth of the crops and also in groundwater point of view. It is only in 14 years Rainfall is sufficient in the mandal for betterment of agriculture and water resources.

CONCLUSION

This paper is an attempt to study typical rainfall characteristics as well as probability levels in the study area. According to the concept of water resources when the water supply due to rainfall exceeds the water need, there is surplus of water part of which goes into the soil and the rest joins the streams and rivers by way of surface and sub-surface runoff. Under favourable conditions the excess water reaches even the deeper parts of the earth's crusts and rises the groundwater table. Thus, the groundwater potential of any region is dependent upon its accumulated water surplus.

Climate is not so favourable for the development of land, water and agricultural resources. The mandal falls under the Semi-arid zone of south India due to its typically geographically location and diversified physical conditions. Temperature is as high as 34.8°C and the normal



annual rainfall is 850.65 mm. The mandal receives rainfall from winter (21.8 mm), summer (98.3) southwest monsoon (318.2 mm) and the northeast monsoon (231.9 mm). From the analysis of seasonal rainfall it is found that the mandal receives high rainfall in both southwest and northeast monsoon periods. In the eastern plains of the mandal the rainfall recorded is high in northeast monsoon period. It is presumed that owing to the formation of low pressure in Bay of Bengal during this monsoon, the rainfall received is high in this part of the mandal.

From the analysis of the probability distribution of rainfall in the study area Chandragiri mandal has 75 per cent or more probability of getting rainfall in the range of 700mm to 800mm or more.

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