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Characteristics of annual and seasonal rainfall for different districts of Chhattisgarh plains zone-I

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Abstract
In the present study entitled "Characteristics of annual and seasonal rainfall for different districts of Chhattisgarh plains zone - I" was carried out based on 30 years (1993-2022) daily weather data of eight districts i.e. Raipur, Mahasamund, Dhamtari, Durg, Rajnandgaon, Kanker, Baloda Bazar and Gariyaband. Result revealed highest annual rainfall 1403 mm, Southwest monsoon rainfall 1185 mm, Northeast monsoon rainfall 95 mm and rainfall during the summer 100 mm were noticed in Kanker district. While, Raipur district recorded highest winter rainfall 30 mm, lowest annual and summer rainfall (1190 mm, 38 mm), were recorded in Rajnandgaon district and lowest southwest monsoon and northeast monsoon were rainfall noticed in Baloda Bazar district. However Annual rainfall showed highly significant increasing trend in Raipur and Kanker districts and significant trend was found in Mahasamund, Dhamtari, Durg and Gariyaband districts.

Keywords: Rainfall variability, trend analysis, Chhattisgarh plains zone-I, characteristics annual and seasonal

1. Introduction
Climate change has raised serious concerns due to its significant impact on various weather parameters. The spatio-temporal variability of precipitation has altered the frequency and intensity of extreme events such as floods and droughts (Seenu and Jayakumar, 2021) [5]. Extreme weather events and climate anomalies significantly impact agriculture in a predominantly agricultural country like India. The economy and growth are heavily influenced by these weather fluctuations. Extreme weather events such as heavy rains, cyclones, hailstorms, dry spells, droughts, heat waves, cold waves, and frost cause significant crop production losses every year. It causes crop failures, food insecurity, famine, loss of property and lives, mass migration, and adverse effects on national economic growth. The impacts of these extreme events can be both direct and indirect. Direct impacts occur from the physical contact of these events with people, their animals and property. Indirect impacts are those induced by the events, often occurring away from the scene or after the event. These include the evacuation of people during a cyclone, disruption of household and leisure activities, stress-induced sickness, and anxiety about future events like floods or bushfires. Efficient use of available climatic, soil, and water resources can minimize the adverse effects of extreme weather and maximize the benefits of favourable weather conditions. (Chattopadhyay, 2013) [1].
Chhattisgarh is centrally located in India, spanning between latitudes 17° 46'N - 24° 5' N and longitudes 80°15' E - 84°20'E. Its proximity to the Tropic of Cancer significantly influences its climate. The state is surrounded by Maharashtra and Madhya Pradesh to the West, Uttar Pradesh to the North, Jharkhand to the North East, Odisha to the East, and Andhra Pradesh to the South, covering an area of 135,194 sq. km. Chhattisgarh experiences a dry sub-humid climate type, receiving an average annual rainfall of about 1200 mm, with nearly 80% occurring during June-September due to the southwest monsoon. This concentrated rainfall pattern often leads to water scarcity during non-monsoon periods. The entire state falls within the rice agro-climatic zone, with approximately 89% of cultivated land relying on rainfed farming.

2. Materials and Methods

2.1 Description of study area

The spatial and temporal variation of present study to Characteristics of rainfall for Chhattisgarh plain zone - I. In this study Chhattisgarh plain zone was divided in two parts I, II and both the part covers 8 - 8 districts equally. So, eight districts *i.e.* Raipur, Mahasamund, Dhamtari, Durg, Rajnandgaon, Kanker, Baloda Bazar, Gariyaband of Chhattisgarh plain zone - I were selected for the study.

2.2 Data base

2.2.1 Rainfall data base

30 years 1993-2022 daily rainfall data were collected from NASA power (Prediction of Worldwide Energy Resources) for different district of Chhattisgarh plains zone - I.

2.3 Statistical methods

2.3.1 Mean

The amount of rainfall collected by a rain gauge in 24 hrs is known as daily rainfall (mm) and the amount collected in one year is known as annual rainfall. The mean of the annual rainfall over 30 years is known as normal annual rainfall of particular place or region.

$$\text{Mean annual Rainfall} = \frac{\text{Total rainfall}}{\text{Number of Years}}$$

2.3.2 Standard deviation (SD)

It is defined as the square root of the mean of the square of deviation of the rainfall value from the arithmetic mean of all such rainfall. It is a measure of variability or the scatter or the dispersion about the mean value.

$$\text{Standard deviation} = \frac{\sqrt{\sum(\bar{x}-x)}}{n}$$

Where,
x = Rainfall Freq.
$\bar{x}$ = mean rainfall
n = number of years

2.3.3 Coefficient of Variation (CV)

Assessment of rainfall variability through coefficient of variation (CV%) appears to be simple. The cv can be obtained by dividing standard deviation by mean rainfall as indicated below

$$\text{Coefficient of Variation (\%)} = \frac{\text{standard deviation}}{\text{Mean}} \times 100$$

2.3.4 Trend analysis

Simple Linear Regression measures the relationship between two variables: x and y where x is the independent variable and y is the dependent variable. The linear regression line is derived using the following equation,

$$Y = a + bx$$

Where,
Y = Dependent variable
x = Independent variable
a = Intercept
b = Slope

3. Results and Discussion

3.1 Characteristics of annual and seasonal rainfall for different districts of Chhattisgarh plains zone - I

Table 1 represents the district wise Mean, SD, CV values of annual and seasonal rainfall of different districts of Chhattisgarh plains zone - I. Result revealed in the highest mean annual rainfall 1403 mm was observed in Kanker district followed by Dhamtari 1367 mm and Gariyaband 1338 mm district respectively. While, lowest mean annual rainfall 1190 mm was recorded in Rajnandgaon district. However, highest SD 250 mm was found in Durg district and lowest 214 mm was noticed in Kanker and Baloda Bazar district. Whereas, highest variation in annual rainfall was observed in Rajnandgaon district 20% followed by 19% in Raipur, Mahasamund, Durg districts, respectively. But, lowest 15% variation was observed in Kanker district.

In south west monsoon season (June-Sep), highest rainfall 1185 mm was observed in Kanker district followed by 1182 mm in Dhamtari district. While, lowest mean south west monsoon rainfall 1058 mm was noticed in Baloda Bazar district. However, highest SD value 225 mm was noticed in Mahasamund and Durg district. But, lowest SD value of 182 mm was recorded in Baloda Bazar district. Highest variation 20% in rainfall was observed in Mahasamund and Durg district. But lowest variation 17% was observed in Kanker and Baloda Bazar districts, respectively.

Highest rainfall 95 mm during North East Monsoon (NEM) season (Oct - Dec) was recorded in Kanker district followed by 83 mm in Dhamtari and Gariyaband district, respectively. While, lowest rainfall 61 mm during North East Monsoon (NEM) season was observed in Baloda Bazar district. However, highest SD value 61 mm was found in Kanker district and lowest SD value 46 mm was noticed in the Rajnandgaon and Baloda Bazar district, respectively. Highest variation 75% in NEM rainfall was observed in Baloda Bazar district followed by 70% in Rajnandgaon district.

In summer season (March - May), highest rainfall 100 mm in the summer season was recorded in Kanker district followed by 76 mm was observed in Gariyaband district. Whereas, lowest summer rainfall 38 mm mean was observed in Rajnandgaon district. However, highest SD value 48 mm was found in Dhamtari district and lowest SD value 32 mm was noticed in the Baloda Bazar district. Highest variation 93% was observed in Rajnandgaon district during summer season followed by 68% in Raipur district. Whereas, lowest variation 39% in summer season was recorded in Kanker district.

Highest 30 mm mean rainfall during winter season (Jan - Feb.) was observed in Raipur district followed by 27 mm in Mahasamund, Dhamtari and Durg districts. While, lowest mean winter rainfall 23 mm was noticed in Rajnandgaon, Kanker and Baloda Bazar districts. However, highest SD 26 mm was recorded in Raipur and Rajnandgaon district. But, lowest SD value 20 mm was noticed in Kanker district. The highest variation in winter rainfall 113% was observed in Rajnandgaon district. While, lowest variation 86% was recorded in Raipur district.

Similar, Kurrey *et al.* (2023) [2] reported that the variability in seasonal and annual rainfall is relatively low, with coefficients of variation (CV) of 17-18% for both monsoon and annual totals. In contrast, pre-monsoon (June) and post-monsoon (September) rainfall showed much higher variability, ranging from 30-33%. At the district level, Kanker and Raipur exhibited the lowest monsoon rainfall variability, with a CV of 14%, while Baloda Bazar showed a CV around 17%, consistent with the

observed monsoon variability range of 17-22%. Additionally, Kanker averaged 1185 mm of rainfall, whereas Durg received 835 mm, with the highest standard deviations recorded at 259 mm for Kanker and 226 mm for Raipur.

3.2 Trend of annual and seasonal rainfall in different districts of Chhattisgarh plains zone - I

Highly significant increasing trend of annual rainfall was found in Kanker district and significant increasing trend was observed in Raipur, Mahasamund, Dhamtari, Durg and Gariyaband district. Non-significant increasing trend in annual rainfall was observed in Baloda Bazar district. While, non-significant decreasing trend was found in Rajnandgaon district.

Kanker district showed highly significant increasing trend for south west monsoonal rainfall. While, 3 districts i.e. Mahasamund, Dhamtari and Gariyaband district showed significantly increasing trend and rest of other districts i.e. Raipur, Durg and Baloda Bazar reported the nonsignificant increasing trend except Rajnandgaon district. It showed the nonsignificant decreasing trend in south west monsoon season.

Six districts *i.e.* Raipur, Mahasamund, Dhamtari, Durg, Baloda Bazar, Gariyaband showed the non-significant trend of rainfall during north east monsoon, But Rajnandgaon and Kanker districts reported non-significant decreasing trend. Similarly, non-significant increasing trend of rainfall was noticed *i.e.* Raipur, Mahasamund, Dhamtari, Durg, Rajnandgaon, Kanker, Baloda Bazar district of Chhattisgarh plain zone - I. Whereas, Kanker and Gariyaband showed non- significant decreasing trend of rainfall in winter season. In summer season, all eight districts showed non - significant increasing trend of rainfall.

Similarly, Patra *et al.* (2012) [3] found an insignificant declining trend in annual and monsoon rainfall, while post-monsoon rainfall showed an increasing trend in the state of Orissa. Rainfall during the winter and summer seasons also exhibited an upward trend. Statistically, monsoon rainfall was found to be highly consistent, with a coefficient of variation of 14%. However, monthly rainfall trends showed decreases in June, July, and September, while August recorded an increasing trend.

Table 1: Characteristics of annual and seasonal rainfall in different districts of Chhattisgarh plains zone - I based on data set of 1993-2022

District	Annual			South West Monsoon			North East Monsoon			Summer			Winter		
	Mean (mm)	SD (mm)	CV (%)	Mean (mm)	SD (mm)	CV (%)	Mean (mm)	SD (mm)	CV (%)	Mean (mm)	SD (mm)	CV (%)	Mean (mm)	SD (mm)	CV (%)
Raipur	1262	241	19	1096	214	19	72	49	67	63	43	68	30	26	86
Mahasamund	1297	246	19	1132	225	20	74	48	65	64	39	62	27	24	90
Dhamtari	1367	227	17	1182	209	18	83	54	65	74	48	65	27	24	88
Durg	1314	250	19	1148	225	20	75	50	67	64	42	66	27	24	88
Rajnandgaon	1190	233	20	1064	205	19	65	46	70	38	36	93	23	26	113
Kanker	1403	214	15	1185	198	17	95	61	64	100	39	39	23	20	87
Baloda Bazar	1198	214	18	1058	182	17	61	46	75	53	32	61	23	22	92
Gariyaband	1338	220	16	1153	205	18	83	52	63	76	36	47	25	22	90

Table 2: Trend analysis of annual and seasonal rainfall for different distrit of Chhattisgarh pains zone - I

District	Annual		South West Monsoon		North East Monsoon		Summer		Winter	
	Trend (mm/year)	R^2	Trend (mm/year)	R^2	Trend (mm/year)	R^2	Trend (mm/year)	R^2	Trend (mm/year)	R^2
Raipur	+ (10.95)	0.154*	+ (8.62)	0.122	+ (0.92)	0.027	+ (1.14)	0.052	+ (0.25)	0.007
Mahasamund	+ (11.17)	0.154*	+ (9.40)	0.131*	+ (0.83)	0.022	+ (0.82)	0.033	+ (0.10)	0.001
Dhamtari	+ (10.90)	0.173*	+ (4.12)	0.159*	+ (2.04)	0.078	+ (0.40)	0.003	+ (0.04)	0.008
Durg	+ (10.16)	0.123*	+ (8.40)	0.104	+ (0.77)	0.017	+ (0.86)	0.032	+ (0.10)	0.001
Rajnandgaon	- (6.22)	0.053	- (6.30)	0.071	- (1.09)	0.042	+ (0.93)	0.051	+ (0.25)	0.007
Kanker	+ (12.58)	0.260**	+ (12.33)	0.029**	- (0.42)	0.003	+ (0.79)	0.031	- (0.12)	0.002
Baloda Bazar	+ (6.08)	0.060	+ (4.45)	0.044	+ (0.56)	0.011	+ (0.33)	0.008	+ (0.25)	0.010
Gariyaband	+ (9.61)	0.143*	+ (8.71)	0.134*	+ (0.36)	0.003	+ (0.56)	0.018	- (0.01)	0.005

(**1%, *5% level of significant)

Conclusion

Kanker received highest rainfall in all this season except winter season. Although low variability. Whereas, Baloda Bazar district received low rainfall as compared to other districts of Chhattisgarh plain zone in all the season. Highest variation in rainfall during annual, Northeast monsoon (NEM), Summer and Winter season was found in Rajnandgaon districts. But, Mahasamund and Durg district showed highly variation in Southwest monsoon season (SWM).

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