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Rainfall analysis for crop planning and water management strategies in Gariyaband District of Chhattisgarh plain

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Abstract
The success of agricultural production depends on the volume and distribution of rainfall. For arranging agricultural operations, weekly, monthly, and seasonal rainfall data are particularly helpful. In light of this, an effort has been made to assess rainfall distribution patterns, including weekly, seasonal, and annual rainfall, using data from Gariyaband, Chhattisgarh, during a ten-year period (2011-2020). The analysis revealed that the 29th week of the monsoon season had the greatest rainfall total, which was 313.8 mm. Although the most average rainfall of 104.6 mm was observed in 29th week had. The monthly rainfall study revealed that the maximum value of average monthly rainfall (300 mm) and the minimum value (0 mm) were recorded in August and November, respectively. The highest rainfall, 1437 mm, was recorded during the crop (Kharif) seasons, accounting for 81.31 percent of the annual average rainfall. The monsoon season in the region had the most average rainfall, 969.28 mm, while the winter season had the lowest average rainfall, 15.36 mm. It typically loses a significant portion through runoff, which can be kept in in-situ or ex-situ water harvesting facilities and used for growing crops in the Kharif, Rabi, and summer seasons. It can also be used as lifesaving irrigation, particularly during the dry period of one or two weeks during the rainy season, which also has a negative impact on standing Kharif crops. The annual rainfall variance ranged from (-) 25.4% to (+) 24.64% as a percentage of the mean. As a result, the useful data collected from the analysis of rainfall in the current study can be applied to crop planning and the creation of soil and water conservation structures in the Gariyaband region.

Keywords: India's agriculture, environmental quality, water management, Rainfall, Gariyaband region

Introduction

India's agriculture, which is primarily rain-fed by nature, is still the country's economic backbone. The planning for agricultural development in rainfed agro-ecosystems is frequently made more difficult by the region's restricted access to irrigation and its highly variable agro-climatic conditions. The ecological equilibrium is under danger as a result of the ongoing increase in demand placing extreme stress on the scarce natural resources. This anticipates appropriate study of rainfall for resource management. The sectors of agriculture and water in India are perhaps the ones most vulnerable to the effects of climate change. Many hydrological issues, including floods and droughts, are caused by this volatility. One of the top priorities for ensuring sustainable food security is rainfall analysis. This is done through boosting land productivity, halting land degradation, and improving biodiversity and environmental quality.

India's Chhattisgarh state spans the latitudes of 17°46′ to 24°5′ North and the longitudes of 80°15′ to 84°24′ East. 13.51 million hectares are included in its overall area. The subtropical climate of Chhattisgarh is categorized as such. The south-west monsoon contributes 85% of the rainfall from June to September, and the remaining 15% comes from the north-east summer and winter seasons, giving rise to an average annual rainfall of 1200-1400 mm and 65 wet days (Bhuarya, 2015) [4]. In the state, rice has traditionally been grown as a source of food for the native inhabitants. Despite abundant rainfall, seasonal droughts are a common issue in rainfed farming throughout the state, especially in September and October, when crops are at their most critical growth stages (Pali AK *et al.*, 2012) [7]. Unpredictable rainfall patterns that result in unstable agricultural yields are also what cause droughts.

Depending on circumstances at present, several analyses of the rainfall data are required. Analysis of consecutive days of rainfall is more pertinent for drainage design of agricultural lands, although magnitude of rainfall values is of great importance for hydrological design of various soil and water conservation structures, like contour trenches, contour bunds, spillways of different water harvesting structures, and check dams, etc.

Veeraputhiran *et al.* (2003) [14] and Manorama K *et al.* (2007) [6] concluded that the result obtained from past rainfall data analysis helps in improve agricultural production. Vaidya *et al.* (2008) [13], Pali AK *et al.* (2012) [7], Bhuarya (2015) [4], Sinha BL *et al.* (2019) [15] and Sinha BL (2020) [16] suggested that the study of weekly rainfall data is more helpful for planning cropping patterns and water management strategies.

Materials and Methods

Gariyaband is located amid Chhattisgarh plains region. This district is located between latitudes N 20˚57'46" and 20˚17'36" and longitudes E 82˚53'05" and 81˚53'05" at an elevation of 340 m above MSL. It was formed on January 1, 2012, from the Raipur district, and its headquarters are 90 kilometers south of Raipur. This district is delimited to the north by Raipur, to the west by Dhamtari, and to the east by Orissa State (Anonymous 2019) [2]. The overall gross cropped area in the Gariyaband district (in the year 2020-21) was anticipated to be 157872 ha, while the net cropped area in the district is roughly 136110 ha. The district has a total geographical area of 582286 ha. The district's Kharif area was 136103 hectares. (Anonymous 2021) [3].

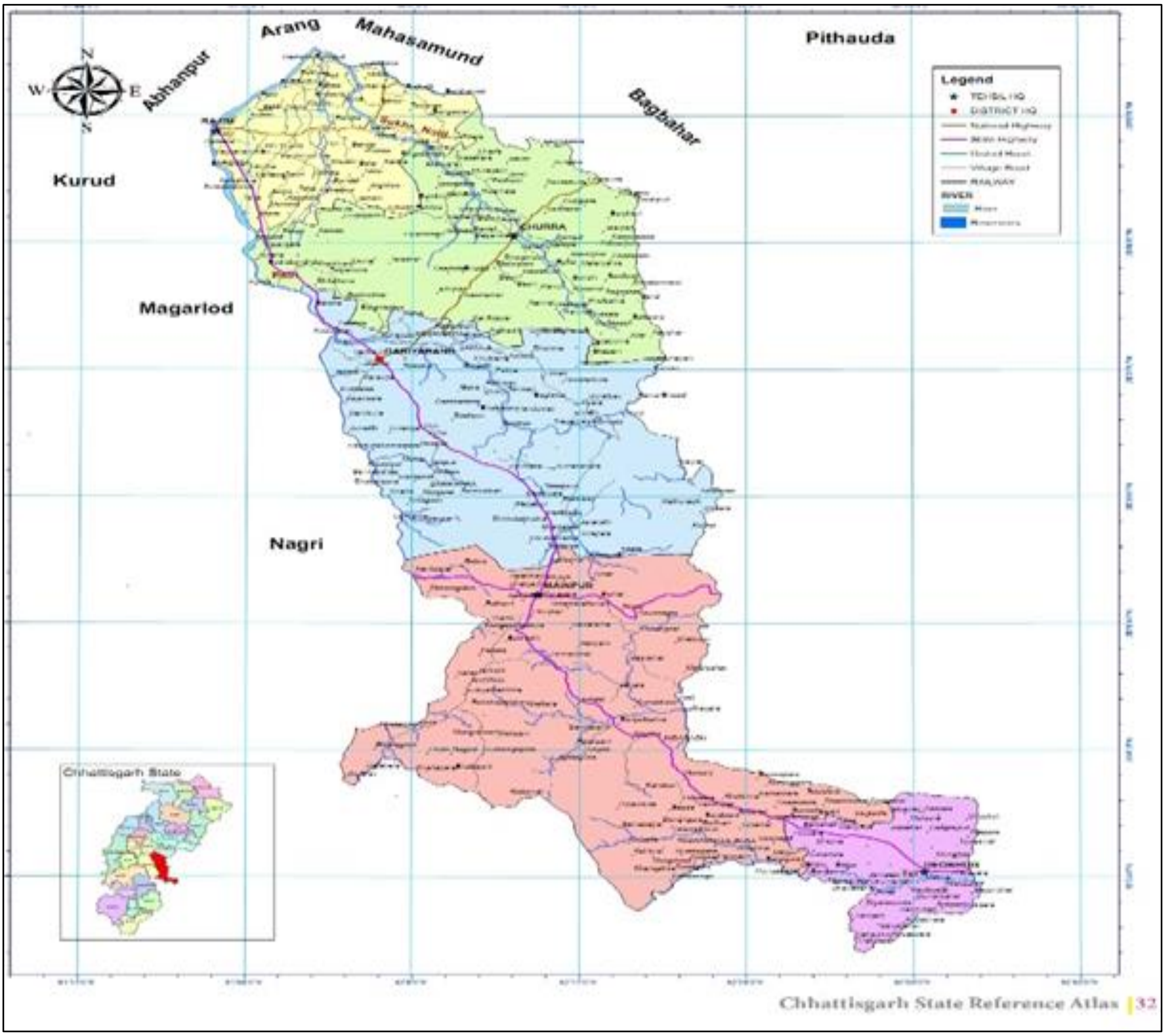

Fig1: Map of Gariyaband district

The Gariyaband District Collect orate was the source of the majority of the data for the Gariyaband district. Daily rainfall statistics were provided for the ten-year period by the Department of Land Records Gariyaband District (2011-2020).

A rainfall characteristics analysis included determining statistical parameters such as maximum, minimum, mean, standard deviation and coefficient of variation, skewness, (Table 1) and percentage deviation of weekly, monthly, seasonal, and annual rainfall values using a computer programmer in MS Excel. By taking into account the largest and lowest amounts of rainfall throughout each particular week, month, season, and year, the maximum and minimum values of rainfall were calculated.

Result and Discussion

The regional rainfall's characteristics were assessed using quantitative metrics such the maximum, minimum, mean, standard deviation, coefficient of variation, skewness, and percentage deviation of the weekly, monthly, seasonal, and yearly values of rainfall. The following are the outcomes of quantitative measures.

Weekly Rainfall Distribution Pattern

The assessment of weekly rainfall data over ten years (2011-2020) demonstrates a significant fluctuation in rainfall in Standard Meteorological Weeks (SMW) throughout the years. The SMW weeks spanning 22nd to 44th were recognized as monsoon weeks,

Table 1: Weekly rainfall parameters over Gariyaband

SMW	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
22	9.3	51.3	0	16.4	176.6	1.7
23	16.0	57.5	0	19.8	123.6	1.2
24	36.5	96	0	26.0	71.3	1.0
25	69.1	184.4	4.6	56.7	82.1	0.7
26	30.8	64.8	7.1	22.5	73.3	0.9
27	37.6	86.4	4.4	28.7	76.3	0.3
28	57.6	112.8	15.2	32.0	55.5	-0.5
29	104.6	313.8	19	106.4	101.7	1.3
30	65.5	166	26	44.8	68.5	1.0
31	78.6	284.3	2.8	92.4	117.6	1.1
32	78.1	155	22.6	37.4	47.9	0.0
33	50.9	133.8	13.2	37.6	73.8	1.1
34	35.6	69	1.6	25.0	70.3	0.2
35	101.7	240.5	38	75.7	74.4	1.6
36	70.9	198	0	64.7	91.2	0.1
37	48.6	123	0	38.7	79.7	0.9
38	64.8	127.2	2.6	40.0	61.7	-0.2
39	16.4	61.2	0	22.6	137.4	1.9
40	28.2	76.8	0	30.9	109.5	0.9
41	12.1	36.2	0	14.4	118.6	1.5
42	7.0	64.2	0	20.2	289.1	1.0
43	3.3	22.6	0	7.3	223.2	1.3
44	0.0	0	0	0.0	-	-

During which time there was a higher concentration of rainfall. The weekly rainfall distribution makes it amply clear that 90% of the rainfall occurs from the 22nd to the 44th SMW. The statistics indicate that the maximum average rainfall of 104.6 mm, or 10.22 percent of the total rainfall of monsoon weeks, was recorded in the 29th SMW, while the lowest value of 0 mm was recorded in the 44th SMW, as shown in Table 1.

Maximum weekly rainfall varied between 0 mm and 313.8 mm in the 44th and 29th SMWs, respectively, while minimum rainfall varied between 0.0 mm in the 22nd - 24th, 36th, 37th, 39th - 44th SMWs, and 15.2 mm in the 28th SMW (Table 1). Standard deviation (SD) ranged from 0 to 106.4, while coefficient of variation (CV) ranged from 55.5 to 289.1 percent, respectively. Dependability is shown by a higher standard deviation and smaller coefficient of variation (Pali AK *et al.* 2012) [7]. This also demonstrates the weeks' uniform and consistent rainfall trend. This analysis reveals large changes in quantitative metrics, indicating that rainfall in the region is highly irregular.

Monthly rainfall distribution pattern

An examination of monthly rainfall (Table 2) shows unequivocally that this region receives more than 95% of its yearly rainfall from June to October. The wettest month is August, which receives 300 mm of rain on average. July, which receives 299.1 mm on average, is the second wettest month.

Table 2: Monthly Rainfall Characteristics (2011-2020)

Month	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
January	9.7	83.8	0	26.1	271.0	1.1
February	5.7	37	0	12.7	222.2	1.4
March	11.5	66	0	21.3	186.3	1.6
April	7.6	51.3	0	16.1	210.7	1.4
May	11.9	71.2	0	22.1	185.8	1.3
June	150.5	241.5	40	58.5	38.9	0.2
July	300.2	559.6	176	134.8	45.1	1.0
August	299.1	596.1	157.6	149.1	49.7	1.1
September	219.7	378	91.4	82.4	37.5	-0.2
October	50.6	97.2	0	39.4	77.9	-0.6
November	0	0	0	0	-	-
December	2.9	29.6	0	9.4	316.2	0.9

It is also abundantly evident that from June to October there will almost certainly be periods of significant rainfall. From the study of data spanning ten years, it is also discovered that the months of August and November have the highest and lowest average monthly rainfall values, which are 300 mm and 0 mm, respectively. Its dependability is demonstrated by the high standard deviation of 149.1 in the month of August and the low standard deviation of 0 in the month of November. The driest month is November, with an average rainfall of 0 mm. It displays the area's unpredictable rainfall pattern, as shown in table 2.

Seasonally Rainfall Distribution Pattern

Climatic Season: Pre-monsoon, monsoon, post-monsoon, and winter all have maximum rainfall amounts of 137.2, 1538.1, 97.2 and 83.8, respectively. The region's monsoon season saw the highest average rainfall of 969.28 mm, while the winter saw the lowest average rainfall of 15.36 mm. Runoff typically results in the loss of a sizeable portion of it, but this water can be saved by in-situ or ex-situ water harvesting facilities and used to water crops during the summer, Kharif and Rabi growing seasons. During dry spells of one to two weeks during the rainy season, which can be harmful to standing Kharif crops, it can also be used as a life-saving irrigation. The maximum rainfall for season pre monsoon, monsoon, post monsoon and winter are 137.2, 1538.1, 97.2 and 83.8, respectively. The highest average rainfall equal to 969.28 mm was observed in monsoon season of the region while the lowest of 15.36 mm was in the winter season. A significant portion of it is typically lost through runoff, which can be preserved by in-situ or ex-situ water harvesting facilities and used during the summer, Kharif and Rabi growing seasons for crops. It can also be used as life-saving irrigation, particularly during dry periods of one or two weeks during the rainy season, which can be detrimental to standing Kharif crops. The coefficient of variation, standard deviation and skewness of the monsoon season were 24.0%, 232.67 and 1.70 respectively, which indicates its dependability. The lower value of coefficient of variation depicted consistent occurrence of rainfall in monsoon season. While agriculture can be done by relying on soil moisture retention or irrigation due to unpredictability of rainfall, larger values of the coefficient of variation implied the unpredictable distribution of rainfall in winter, summer and post monsoon. Pre-monsoon rainfall of 30.01mm would be beneficial for sloughing.

Cropping season: Table 3 shows the quantitative measurements of the seasons (maximum, minimum, mean and standard deviation, coefficient of variation, skewness, and percentage deviation) based on the analysis and presentation of rainfall data for the cropping season. The average *Kharif* (Jul-October), rainfall of 189.43 mm accounts for 81.31% of annual rainfall with coefficient of variation of 27.55% and standard deviation of 239.51 mm indicating its dependability. A large portion of the rainfall in this season is lost as runoff, which can be stored in-situ or ex-situ water harvesting facilities and used to grow crops throughout the *Kharif/ Rabi/Zaid* season. It can also be used as life-saving irrigation, particularly during dry periods of one or two weeks during the rainy season, which can also have a negative impact on standing Kharif crops in the region. Rainfall during the Kharif season was consistently observed, as indicated by the decreased coefficient of variation. The maximum and minimum amounts of rainfall in *Kharif* season were 1437 mm and 301.8 mm, respectively. Higher coefficient of variation values, however, indicated that rainfall in Rabi was unpredictable, making it possible to practice agriculture by relying on irrigation or soil moisture that has already been present.

Yearly Distribution Pattern

When the yearly rainfall statistics for the Gariyaband district were analyzed (Table 3), it was found that the average rainfall, which ranged from 795.1 mm to 1593.1 mm with a mean of 1069.23 mm. The yearly rainfall was observed to have a large standard deviation and coefficient of variation.

Table 3: Seasonally and yearly rainfall characteristics (2011-2020)

Season	Mean (mm)	Max. (mm)	Min. (mm)	SD (mm)	CV (%)	Skewness
Climatic season						
Pre-Monsoon	31.0	137.2	0	47.4	152.8	1.7
Monsoon	969.2	1538.1	708.2	232.7	24.0	1.7
Post Monsoon	53.6	97.2	0	36.2	67.6	-0.4
Winter	15.3	83.8	0	27.9	181.8	2.0
Cropping season						
Zaid	181.5	354.6	40	82.4	45.4	0.5
Kharif	869.4	1437	601.8	239.5	27.6	1.5
Rabi	18.3	83.8	0	27.7	151.1	1.7
Annual						
Yearly	1069.2	1593.1	795.1	242.4	22.6	1.2

The figure 2 clearly indicates that during the investigation period, the percentage deviation over the mean annual rainfall fluctuated between (-) 25.4% to (+) 24.64%. Although the annual rainfall over sixteen years (2011-2020) was in no particular trend, however, annual average rainfall of years from 2013 to 2019 showed the decreasing trend while 2011, 2012 and 2020 years of annual average showed the increasing trend.

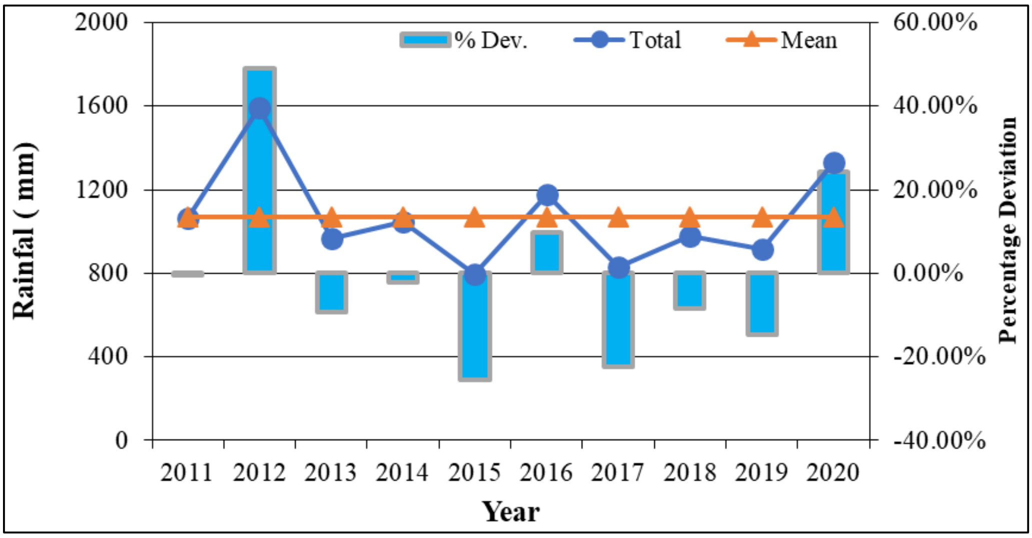

Fig 2: Year wise total annual rainfall distribution & percentage deviation

Conclusion

Based on the analysis of rainfall data of Gariyaband, it can be concluded that the highest value of average rainfall of 313.8 mm was found in the 29th SMW of the monsoon weeks which was 32.37 percentage of the average rainfall of monsoon season, while the lowest average rainfall of 0 mm was observed in the 44th SMW. July is the wettest month with an average rainfall of 300.20 mm followed by August of 299.10 mm while November is the driest month with an average rainfall of 0.00 mm. On the basis of climatic (*monsoon*) season received the highest rainfall 969.2 mm and contributing 90.64 percentage of the total average annual rainfall. The highest average rainfall equal to 869.40 mm was observed in *Kharif* season of the region. A major part of it generally lost through runoff, which can be stored through in-situ or ex-situ water harvesting structures and can be used during *Kharif/Rabi/summer* season for growing crops. It can also be utilized as Life Saving irrigation particularly in dry period of one or two weeks in rainy season also adversely affect standing Kharif crops. The annual rainfall ranges from

795.1 to 1593.1 mm, with an average of 1069.23 mm.

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