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Study on rainfall distribution pattern for agricultural planning in Bhatapara region of Chhattisgarh plain

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Abstract
The amount and distribution of rainfall holds the key of the success for agriculture production. Weekly, monthly and seasonal rainfall data are very useful for planning agricultural operations. In view of this, an attempt has been made to evaluate rainfall distribution patterns i.e. weekly, seasonal and annual rainfall, based on 20 years (2000-2019) data of Bhatapara, Chhattisgarh in the year of 2020 at DKS College of Agricultural and Research Station, Indira Gandhi Krishi Vishva Vidylay, Bhatapara, Chhattisgarh. The analysis showed that amongst various weeks of monsoon season, the 26th week received highest rainfall amount equal to 420.00 mm. However, average rainfall as 99.60 mm was found to be highest for 29th week. From the monthly rainfall analysis, it was found that maximum value of average monthly rainfall (349.50 mm) and minimum value (2.0 mm) were recorded in the months of July and March, respectively amounting to 30.44% and 0.27% of the average annual rainfall with CV of 33.60% and 238.05%, respectively. On the basis of crop (Kharif) seasons received the highest rainfall 908.57 mm and contributing 78.57% of the total average annual rainfall. The highest average rainfall equal to 1070.90 mm was observed in monsoon season of the region while the lowest of 21.81 mm was in the winter season. 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 varies from 695.00 to 1585.00 mm with an average value of 1135.15 mm. The percentage deviation over mean annual rainfall ranged in between (-) 41.33% and (+) 26.50% at rained region of Bhatpara during period under investigation. Hence the valuable information obtained from the analysis of rainfall in present study can be used for crop planning, designing of soil and water conservation structure in the Bhatapara region.

Keywords: Rainfall, standard deviation, coefficient of variation, Bhatapara, Chhattisgarh

Introduction
The primary source of water for agricultural production for most of world is rainfall. Rainfall is one of the most important factors in crop production programme, of all the climatic factors. The variation of monsoonal and annual rainfall in space and time are well known and this inter-annual variability of monsoonal rainfall has considerable impact on agricultural production, water management and energy generation. Analysis of annual, seasonal and monthly rainfall of a region is useful to design well cropping system, cropping pattern, designing drainage and water harvesting structure. Knowledge of average monthly, seasonal and annual rainfall is helpful in understanding the general picture of the particular region but the weekly rainfall data analysis gives more useful and precise information's for the rainfall based crop (Biswal *et al.*, 2019) [2].

Agriculture, especially in developing countries, is a sector which is vulnerable to risks of various types. Most importantly, weather related risks play a major role in affecting agricultural income. These would include extreme rainfall events which result in floods/droughts, as well as extreme temperature events. Poor and small farmers are especially susceptible to income variability because of weather – related risks to their crops. Rainfall, being considered as the prime input for agriculture has its own erratic behavior in terms of amount and distribution. For better crop planning, a detailed study on rainfall behaviour is vital. The state of Chhattisgarh is dominated by tribal and backwards.

Rice is the main crop of the state. The productivity is very low (1.34 t/ha) as compared to the national average (1.88 t/ha). The state receives fairly high amount of rainfall, 1200 to 1600 mm annually. But the shortage of water at critical growth stages is often experienced due to uneven distribution of rainfall resulting in frequent terminal droughts in wide spread areas leading to large scale migration of farm labours and farmers to other potential areas (Anonymous, 2006) [1]. More than 80% of the average annual rainfall of Bhatapara occurs during South West monsoon. Due to uneven distribution of rainfall and absence of suitable in-situ rainwater harvesting practices, the district is affected by water scarcity during rabi and summer seasons every year. However, analysis of rainfall data for computation of expected rainfall for the desired frequency and consequent excess rainfall is required for the safe design of any structure.

The rainfall data need to be analyzed in different ways depending on the problem under consideration. While magnitude of rainfall values are of great importance for hydrological design of different soil and water conservation structures *viz*., contour trenches, contour bunds, spillways of different water harvesting structures and check dams etc., analysis of consecutive days rainfall is more relevant for drainage design of agricultural lands. Moreover, analysis of weekly rainfall data is more useful for planning cropping pattern as well as water management practices than that of monthly, seasonal and annual data. Biswal *et al.* (2019) [2], Ravi *et al*. (2017) [3], Sharma and Dubey (2013) [4], Dahiya *et al*. (2013), Shrivastav and Shrivastav (2014) [5] have suggested the use of daily, weekly, monthly, seasonal and annual rainfall distribution for crop planning. Keeping this in view, an effort was made in the present investigation in 2020 to interpret daily, weekly, monthly, seasonal and annual rainfall of 20 years (2000-2019) data of Bhatapara, Chhattisgarh in simple and meaningful form to make it more useful.

Materials and Methods

Balodabazar-Bhatapara district was established on 01.01.2012. This district is divided from Raipur district. The geographical location of Balodabazar Nagar is 270m height from sea level between 21.300 54 ‘to 31.450 14’ North Latitude and 42.020 17 ‘to 82.290 07’ East longitude. District Balodabazar-Bhatapara belongs to Raipur division. The border of Balodabazar-Bhatapara district touches Bemetara, Bhatapara, Bilaspur, Janjgir, Raigarh, Mahasamund and Raipur districts (fig 1). According to the prevalent tradition in relation to the naming of the Balodabazar in the past, the traders of Gujarat, Haryana, Maharashtra, Orissa, Barar etc. used to gather in the market buffaloes of the city to sell the buffalo, buffalo (Boda). As a result, its name became popular in the name of the bullboda market and in the form of the Baloda Bazar. Bhatapara has a tropical wet and dry climate, temperatures remain moderate throughout the year, except from March to June, which can be extremely hot. The winter commences from November and last till the end of February. The summer season beings from March and continues till the second week of June. Monsoon season commences from middle of June and remains till the end of the September.

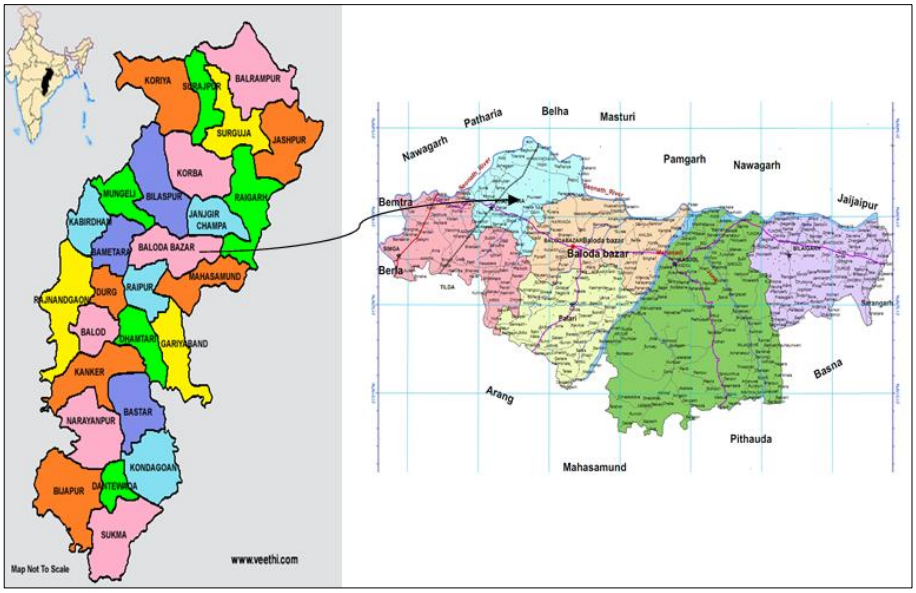

Fig 1: Map of study area under Balodabazar- Bhatapara district of Chhattisgarh

The daily rainfall data of the study area was collected from Tehsil office Bhatapara. This was a 24 hours rainfall data measured with the help of non-recording and recording type rain gauge installed in nearby area. The daily rainfall data pertains to a period of past 20 years, *viz.* 2000 – 2019. Weekly rainfall data, monthly, seasonally and annually were obtained by summing up the daily rainfall values as per recommendation of IMD.

Analysis of Rainfall Data

An analysis of rainfall characteristics involved determination of statistical parameters such as maximum, minimum, mean, standard deviation, coefficient of variation, skewness and percentage deviation of weekly, monthly, seasonal and annual value of rainfall were also computed by using computer programme in MS excel. The maximum and minimum value of rainfall was determined on accounting the highest and lowest rainfall in the respective week, month, season and year.

Results and Discussion

Analysis of Rainfall Characteristics

The characteristic of the rainfall of the region was evaluated on the basis of quantitative measures such as maximum, minimum, mean, standard deviation, and coefficient of variation, skewness and percentage deviation of weekly,

monthly, seasonal and annual value of rainfall. The results of quantitative measures are discussed as under:

1. Weekly rainfall distribution pattern

The analysis of weekly rainfall data of 20 years (2000-2019) reveals that there was marked variation among the rainfall in Standard Meteorological Weeks (SMW) of the different years. SMW 23rd to 40th were found as monsoon weeks in which period greater concentration of higher rainfall was found. It can be clearly observed from the weekly rainfall distribution that 90% of rainfall occurs during 23rd to 40th SMW. It is clear from the data that the highest average rainfall of 99.60 mm was observed in the 29th SMW which was 8.77% of the average rainfall of monsoon weeks, while the lowest value 14.50 mm was recorded in 40th SMW shown in Table 1. The variation in standard deviation (SD) was ranged from 22.83 to 89.73, whereas, coefficient of variation (CV) varied in between 55.95% and 180.74%, respectively. Higher value of standard deviation and lower value of coefficient of variation indicates dependability. This also shows the uniform and consistent rainfall pattern during the weeks. Skewness found to be varied in between 0.65 to 3.43. This analysis shows there is wide variations in quantitative measures which indicates that the rainfall received in region are highly erratic.

2. Monthly rainfall distribution pattern: Monthly rainfall analysis (Table 2) clearly depicts this region receives more than 96 percent of annual rainfall during the month of June to October. July is the wettest month with an average of 349.50 mm rainfall and the 2nd highest month is August having an average of 312.20 mm rainfall. It is also very much clear that the chances of heavy rainfall during June to October are assured. It is also found from the analysis of 20 years data that the maximum and minimum value of average monthly rainfall of 349.50 and 2.00 mm are found in July and March, respectively amounting to 30.79% and 0.17% of the average annual rainfall with coefficient of variation of 62.32% and 276.73%, respectively. High value of standard deviation of 120.77 in the month of July and minimum value of standard deviation of 5.53in the month of March indicates its dependability. The variation in minimum monthly rainfall was observed in the range of 0.0 to 127.00 mm. The highest value of coefficient of variation shows the erratic pattern of rainfall of the region presented in table 2. Further from the analysis, it is also observed that the skewness parameter showed the positive and negative value. This means the distribution of the data is positively skewed in almost months (except July and August) means the tendency of rainfall above the average and negatively skewed in July and August which mean the tendency of rainfall distribution below the average

Table 1: Variation of rainfall on weekly basis for year (2000-2019)

SMW	Avg (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
23	21.30	74	0	22.83	107.20	1.00
24	57.70	199	0	56.68	98.23	1.25
25	48.95	163	2	45.17	92.28	1.31
26	72.45	420	2	89.73	123.85	3.31
27	56.35	155	0	37.47	66.49	0.71
28	77.65	288	14	61.34	78.99	2.19
29	99.60	245	5	75.78	76.08	0.67
30	80.95	235	0	58.64	72.44	0.65
31	85.60	283	0	75.18	87.82	1.38
32	78.55	181	17	43.95	55.95	0.74
33	67.95	165	7	44.64	65.70	0.87
34	67.00	180	0	57.77	86.23	0.65
35	58.90	201	0	45.08	76.54	1.77
36	56.70	188	2	46.82	82.58	1.30
37	38.90	260	0	56.69	145.74	3.43
38	48.25	187	0	49.40	102.39	1.41
39	32.55	246	0	58.83	180.74	2.82
40	14.50	108	0	24.87	171.53	3.06

3. Seasonally Rainfall distribution*:* pattern

Climatic season: It is evident from the analysis (Table 2) that the Bhatapara region receives 1070.90 mm, 46.81 mm, 21.81 mm and 220.81 mm of average rainfall during the monsoon (June-Sept.), post monsoon (Oct.-Nov.) winter (Dec.-Feb) and summer (Mar.-May) season, respectively and contributes 94.34%, 4.12%, 1.92%, 19.45% of the average annual rainfall, respectively.

Table 2: Monthly and Seasonally Rainfall characteristics

Month	Avg (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
January	8.30	75	0	19.59	236.00	2.84
February	4.70	40	0	9.36	199.13	2.38
March	2.00	21	0	5.53	276.73	2.36
April	8.80	96	0	22.48	255.45	3.50
May	4.65	45	0	11.49	247.01	2.94
June	197.10	569	49	122.83	62.32	1.30
July	349.50	553	101	120.77	34.56	-0.01
August	312.20	465	127	104.05	33.33	-0.23
September	195.15	348	62	98.68	50.56	0.06
October	39.60	166	0	46.54	117.54	1.37
November	5.40	53	0	13.66	253.02	2.88
December	7.75	57	0	17.84	230.25	2.33

Climatic season						
Summer	220.81	569	53	123.68	56.01	1.13
Monsoon	1070.90	1436	666	220.94	20.63	0.27
Post Monsoon	46.81	166	0	47.58	101.66	0.99
Winter	21.81	80	0	26.66	122.24	1.01
Cropping season						
Zaid	220.81	569	53	123.68	56.01	1.13
Kharif	908.571	1224	488	239.28	26.34	-0.15
Rabi	26.9524	90	0	30.52	113.23	0.77

The maximum rainfall for season monsoon, post monsoon, winter and summer are 1436.0, 166.0, 80.0 and 569.0 mm, respectively. The highest average rainfall was observed in monsoon season of the region while the lowest was in the winter season. 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 coefficient of variation, standard deviation and skewness of the monsoon season were 20.63%, 220.94, and 0.27 respectively, which indicates its dependability. The lower value of coefficient of variation and skewness and higher value of standard deviation depicted consistent occurrence of rainfall in monsoon season. However, the higher value of coefficient of variation inferred the erratic distribution of rainfall in winter, summer and post monsoon in which agriculture can be practiced by depending on soil residual moisture or irrigation due to uncertainty of rainfall. Summer season or pre monsoon rainfall amounting 220.81mm would be helpful for summer ploughing.

Cropping season

The rainfall data of cropping season was analyzed and presented in Table 2 which depicts the variations of the quantitative measures (maximum, minimum, mean, standard deviation, and coefficient of variation, skewness) of the seasons. The average kharif (Jul-October), rainfall of 908.57 mm accounts for 80.04% of annual rainfall with coefficient of variation of 26.34% and standard deviation of 239.28 mm indicating its dependability. A major part of rainfall in this season generally lost through runoff, which can be stored through in-situ or ex- situ water harvesting structures and used during kharif/rabi/zaid 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 in the region. The maximum and minimum amounts of rainfall in kharif season were 1224.0 mm and 488.0 mm, respectively.

The lower value of coefficient of variation depicted consistent occurrence of rainfall in kharif season. However, higher value of coefficient of variation inferred the erratic distribution of rainfall in *Rabi*, where agriculture can be practiced by depending on soil residual moisture or irrigation due to uncertainty of rainfall.

4. Yearly distribution: **pattern**:

The analysis of rainfall data of Bhatapara region on annual basis showed a significant variation of average rainfall (Table 3) in the range of 695.0 mm to 1585.0 mm with an average rainfall of 1135.15 mm. It can be observed that the annual rainfall showed high standard deviation and coefficient of variation the highest average annual rainfall of 1585.0 was observed in the year 2013, whereas, it was found lowest average annual rainfall of 695.0 in the year 2002. About 35% of the total years received highest rains than that of the average annual rainfall and 65% of the total years received lesser rains than that of the average annual rainfall as shown in fig 2. It is evident from the figure 3 that percentage deviation over mean annual rainfall (1135.15 mm) ranged in between (-) 41.33% and (+) 26.50% at rained region of Bhatapara during period under investigation. Although the annual rainfall over twenty years (2000-2019) was in no particular trend and distribution is erratic and irregular.

Table 3: Yearly Rainfall Characteristics (2000-2019)

Year	Annual Rainfall (mm)	Average annual rainfall	Percentage deviation
2000	786	1135.15	-30.76
2001	1085	1135.15	-11.82
2002	695	1135.15	-41.33
2003	1292	1135.15	3.25
2004	930	1135.15	-23.97
2005	1360	1135.15	2.54
2006	989	1135.15	-16.84
2007	1340	1135.15	16.99
2008	985	1135.15	-16.22
2009	1042	1135.15	-17.28
2010	1154	1135.15	-10.76
2011	1483	1135.15	17.52
2012	1507	1135.15	26.50
2013	1585	1135.15	22.01
2014	1413	1135.15	14.96
2015	891	1135.15	-21.51
2016	977	1135.15	-16.84
2017	1004	1135.15	-13.23
2018	1070	1135.15	-17.81
2019	1115	1135.15	-8.47

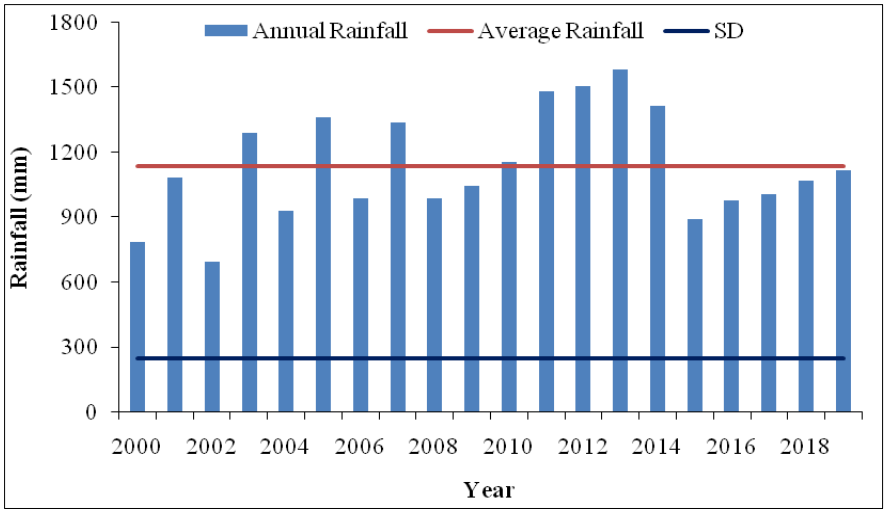

Fig 2: Year wise Distribution of Rainfall

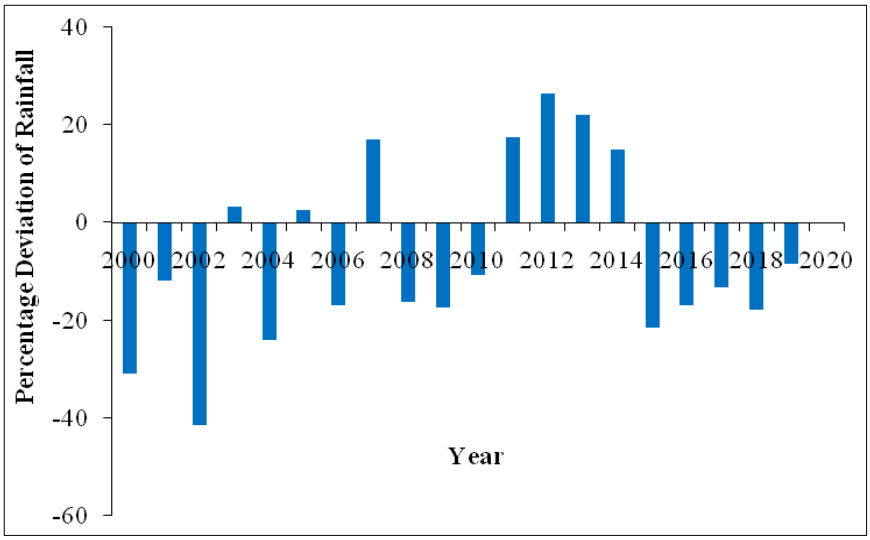

Fig 3: Percentage deviation of rainfall for Bhatapara during the year of 2000-2019

Conclusions

The impacts of rainfall on agricultural sustainability vary from economic condition of countries, regions and over a period of time. The crops in Chhattisgarh are heavily influenced by rainfall variation as rainfall variation among the months and locality fluctuate too high to be conducive for paddy production. The agriculture sector could be affected either by low rainfall or excessive rainfall for any particular time within the crop cycle and any possible combination of timing for crop cycle. Based on the above analysis, it can be concluded that the region could be made to increase the crop production per unit area under rainfed conditions. About 94.34 percent (1070.90 mm) of the total average annual rainfall (1135.15 mm) coincides with the monsoon season and is received during a short time span of two to three months between June to September due to south-west monsoon. Rainfall (220.81 mm) received during summer (March - May) season can be utilized for summer ploughing to make the land ready for final field preparation. The major portion of monsoon rainfall is generally lost through runoff which can be stored through the construction of suitable water harvesting structures as on-farm reservoirs which could be utilized for life saving irrigation for rabi crops.

Hence the valuable information obtained from the analysis of rainfall in present study can be used for crop planning, designing of soil and water conservation structure in the Bhatapara region.

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