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METEOROLOGICAL DROUGHT ASSESSMENT IN RAIPUR DISTRICT OF CHHATTISGARH STATE, INDIA

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Abstract

In rainfed agriculture, rainfall has a crucial role to play for suitable crop planning. Forty three years (1971-2013) annual rainfall data has been analysed to find out weekly, monthly, seasonal and yearly meteorological drought occurrence at Labhandi station of Indira Gandhi Krishi Vishwavidhyalaya, Raipur (Chhattisgarh), India. The average annual rainfall of Raipur worked out to be 1202 mm. The observed frequency of drought was the highest in 38th week to the tune of 23 times; month of December to the tune of about 32 times. Based on rainfall analysis, it was found that during 43 years no severe and extreme drought year was experienced. However, there was 9 moderate drought (1974, 1979, 1987, 1988, 1991, 1992, 2000, 2002 and 2008) and 10 mild drought (1972, 1976, 1978, 1982, 1995, 1996, 1998, 1999, 2001 and 2004) years.

Key words : Meteorological drought, drought year, dry spell, rainfall analysis.

Introduction

Rainfall is the most important natural hydrologic event and is a unique phenomenon varying both in space and time. Rainfall distribution is very uneven and it not only varies considerably from place to place but also fluctuates from year to year. It is one of the most important and governing factor in the planning and operation strategies of any agricultural programme for any given area. Agricultural development largely depends upon the management of natural resources. India receives adequate amount of rainfall annually through the four seasons *viz*, south–west monsoon (74%), north-east monsoon (3%), pre-monsoon (13%) and post-monsoon (10%) (Dabral *et al.*, 2009). In rainfed farming, the crop planning and its success depends upon the amount and distribution of rainfall. For planning agricultural operations weekly data are more useful than monthly, seasonal and annual rainfall.

Chhattisgarh state, situated in eastern India stretches between 80° 15' to 84° 24' E longitude & 17° 46' to 24° 5' N latitude. It covers total geographical area of about 13.5 million hectare. Rice crop is grown in 3.7 million hectares and rainfed rice production has always remained a challenge in this region. This state has three agro climatic zones *viz*., Chhattisgarh plains, Bastar plateau and Northern hills region. Its climate is of dry sub-humid type. Under wide range of farming situations and soil conditions, except upland light soil, rice is widely accepted and grown by the farmers depending upon their socio-economic conditions. During *kharif*, growing of rice is a tradition and is widely accepted depending upon farmers socio-economic conditions. While, in *rabi*, there are fewer options for the stakeholders to take profitable and/or suitable crops. Under these circumstances, they generally follow rice – wheat, rice – mustard and rice – winter vegetables under partially or assured irrigation and rice-fallow, rice – utera (*Lathyrus*, chickpea and linseed) under rainfed situation.

The availability of rainfall is not well assured at all the place and time. More than 60% of the cultivable rice area in India is rainfed. Rainfed agriculture still remains a voracious water user. Hence, its major share has to be met from the rainfall available in less than four months (Ray *et al*., 2012). Extreme situations are also observed in certain years. Floods and droughts are the results of extremes of rainfall distribution. Deficiency of rainfall is the basic cause of drought. As such no general method is available which can be applied for the drought prediction (Salas, 1986). Meteorological drought is the condition when a region receives less than half the amount of normal precipitation (IMD, 1971). The meteorological drought analysis is mostly done based on point rainfall data as reported by several researchers earlier. Sharma

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et al. (1979, 1987a and 1987b) analysed the rainfall for crop planning to overcome drought like scenario. Shrivastava *et al.* (2008) assessed meteorological droughts in North Lakhimpur district of Assam. Sinha (1986) and Ray *et al.* (1987) studied drought occurrence at Gopalpur station, Odisha. Kumar and Kumar (1989), Dabral (1996) analysed weekly, monthly, seasonal and yearly rainfall data for drought situation at Pantnagar and Ranchi station respectively. Tiwari *et al.* (2007) characterize the meteorological drought indices using the daily rainfall data of Hazaribagh station. Similar meteorological drought analysis was done by various researchers (Ramdas and Malick, 1948; Sharma *et al.*, 1979).

Water stresses are a common feature during growth cycle of crops. Although, water in form of precipitation is available freely and right at the site where it is to be used, yet so tenuous and delicate is the balance between the demand for water by crops and its supply by precipitation that even short term deficit periods often reduce the production significantly (Gupta *et al.*, 1990). Interpretation of climatic variables is essential because of these variations (Subramaniam and Raju, 1988). An attempt has been made in this paper, to work out the meteorological drought occurrence at Labhandi Station, IGKV, Raipur using daily rainfall data.

Materials and Methods

The study place, Raipur is located at 21^{0}16' North Latitude and 81^{0}36' East Longitude with an altitude of 289.5 m above mean sea level. The average annual rainfall of Raipur is 1202 mm.

The weekly rainfall from 24th to 39th standard meteorological weeks (that coincides with the monsoon period of this region), monthly rainfall; seasonal rainfall (*i.e.* June to September- monsoon; October to December- post monsoon; winter (January-February) and pre-monsoon (Mar-May) and annual rainfall were analyzed. The average weekly, monthly, seasonal and yearly rainfall values were worked out. The variation of rainfall for each week, month, season and year from the mean was determined and the mean deviation for the seasons was calculated. Total number of drought weeks, months, seasons and years were determined using the standard procedure (IMD, 1971). Weekly drought: the amount of rainfall is equal to the half of the normal rainfall or less (Ramdas and Mallik, 1948). Monthly drought: the actual rainfall is less than 50% of the average monthly rainfall (Sharma *et al.*, 1979). Seasonal drought: the seasonal rainfall is deficient by more than twice the mean deviation of the season. The yearly intensity of drought was also

Table 1 : Drought codification based on percentage departure of rainfall from normal value (IMD,1971).

Percentage departure of rainfall from normal	Intensity of drought	Code
0.0 or above	No drought	M_o
0.0 to - 25.0	Mild drought	M_1
-25.0 to - 50.0	Moderate drought	M_2
-50.0 to - 75.0	Severe drought	M_3
-75.0 or less	Extreme drought	M_4

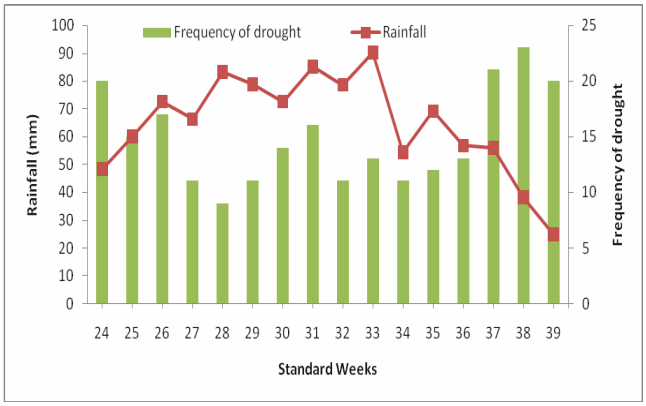

Fig. 1 : Variation in weekly rainfall and frequency of drought at Labandi station.

Table 2 : Weekly drought occurrence.

Standard week	Average rainfall (mm)	Half of the average rainfall (mm)	No. of drought week
24 (11th to 17th June)	48.3	24.2	20
25 (18th to 24th June)	60.0	30.0	15
26 (25th to 1st July)	72.5	36.2	17
27 (2nd to 8th July)	66.2	33.1	11
28(9th to 15th July)	83.2	41.6	9
29(16th to 22nd July)	78.7	39.4	11
30(23rd to 29th July)	72.5	36.3	14
31(30th to 5th August)	85.1	42.5	16
32(6th to12th August)	78.6	39.3	11
33(13th to 19th August)	90.2	45.1	13
34(20th to 26th August)	54.2	27.1	11
35(27th to 2nd September)	69.1	34.6	12
36(3rd to 9th September)	56.7	28.4	13
37(10th to 16th September)	55.8	27.9	21
38(17th to 23rd September)	38.1	19.1	23
39(24th to 30th September)	24.7	12.4	20

determined using the criteria suggested by IMD (1971) which is based on the percentage deviation of rainfall from its long term mean and it is given by Equation 1.

$$D_i = \frac{P_i - \mu}{\mu} \times 100 \quad (1)$$

Where,

D_i is the percentage deviation from the long-term mean,

P_i is the annual rainfall, mm and

μ is the long term mean of the annual rainfall, mm

Drought codification based on percentage departure of rainfall from normal is presented in table 1. The percentage of deviation (D_i) is then used to categorize the drought.

Results and Discussion

The weekly analysis of drought (24th to 39th standard week) is presented in table 2, It is found that the average rainfall of different weeks has a variation from 85.08 mm in the 31st week to 24.74 mm in the 39th week.

The minimum number of drought has recorded 9 times in 28th week while the maximum number of drought was observed 23 times in 38th week. The weekly variation of rainfall from standard week 24th to 39th week, and the frequency of drought occurred during these weeks is shown in fig. 1. The monthly drought analysis is presented in table 3. The highest rainfall of 337.81 mm was observed in the month of August and the lowest average rainfall of 6.1 mm occurs in the month of December. The frequency of drought was observed to be the highest at a magnitude of 32 times in 43 years in December and lowest 3 times at month of August. From the seasonal rainfall analysis, it is evident that 2.26% of rainfall was received during winter, 4.39% during summer, 87.67% during southwest monsoon and 5.61% during northeast monsoon. No drought was observed during south-west monsoon and the frequency of drought was 36, 35 and 33 during winter, summer and post-monsoon season, respectively. The yearly intensity of drought is presented in table 4. The years are codified according to IMD specification as described in the table 1. It is found from the table 4 that there was 9 moderate and 10 mild drought years. However, there is no severe/extreme drought year according to the rainfall record of the Labandi station.

The average annual rainfall of Labandi station is worked out to be 1202.0 mm with a maximum of 1651.2 mm corresponding to the year 1980 and a minimum of 709.1 mm corresponding to the year 1988. The mean monthly rainfall of the place is 16.2, 23.8, 188.8, 336.8, 337.8, 191.1 and 48.0 mm for the months of April, May, June, July, August, September and October, respectively. The highest rainfall is received during the month of August (337.8 mm) and the lowest average rainfall is received during the month of December (6.1 mm).

Conclusion

Drought analysis based on 43 years rainfall record showed that 38th week, had maximum frequency of

Table 3 : Monthly and seasonal drought occurrence.

Month/ Season	Name of month/ season	Average rainfall (mm)	Half of the average rainfall (mm)	No. of drought (month/season)
	Jan	14.3	7.1	24
	Feb	13	6.5	17
	Mar	12.9	6.4	21
	Apr	16.2	8.1	19
	May	23.8	11.9	15
	Jun	188.8	94.4	8
Month	Jul	336.8	168.4	5
	Aug	337.8	168.4	3
	Sep	191.1	95.6	11
	Oct	48	24.0	17
	Nov	13.5	6.7	26
	Dec	6.1	3.1	32
			(Twice of the mean deviation value, mm)	
	Winter : Jan-Feb	27.2	13.6	36
Season	Summer : Mar-May	52.9	26.4	35
	Southwest monsoon : Jun-Sep	1054.6	527.3	0
	Northeast monsoon : Oct-Nov	67.5	33.8	33

Table 4 : Drought Categorization on yearly basis.

Year	Annual rainfall (mm)	Mean rainfall (mm)	% deviation	Category	Intensity of drought
1971	1434.4	1202.0	19.3	M0	No drought
1972	1089.3	1202.0	-9.4	M1	Mild drought
1973	1284.1	1202.0	6.8	Mo	No drought
1974	859.7	1202.0	-28.5	M2	Moderate drought
1975	1287.6	1202.0	7.1	Mo	No drought
1976	1036.6	1202.0	-13.8	M1	Mild drought
1977	1231.8	1202.0	2.5	Mo	No drought
1978	1122.2	1202.0	-6.7	M1	Mild drought
1979	744.4	1202.0	-38.1	M2	Moderate drought
1980	1651.2	1202.0	37.3	Mo	No drought
1981	1277.3	1202.0	6.2	Mo	No drought
1982	1036.5	1202.0	-13.8	M1	Mild drought
1983	1393.8	1202.0	15.9	Mo	No drought
1984	1213.9	1202.0	1.0	Mo	No drought
1985	1577.7	1202.0	31.2	Mo	No drought
1986	1397.5	1202.0	16.2	Mo	No drought
1987	850.8	1202.0	-29.2	M2	Moderate drought
1988	709.1	1202.0	-41.0	M2	Moderate drought
1989	1310.3	1202.0	9.0	Mo	No drought
1990	1236.2	1202.2	2.8	Mo	No drought
1991	843.3	1202.0	-29.9	M2	Moderate drought
1992	825.5	1202.0	-31.3	M2	Moderate drought
1993	1327.9	1202.0	10.5	Mo	No drought
1994	1638.2	1202.0	36.3	Mo	No drought
1995	1188.7	1202.0	-1.1	M1	Mild drought
1996	1123.0	1202.0	-6.6	M1	Mild drought
1997	1221.2	1202.0	1.6	Mo	No drought
1998	1088.0	1202.0	-9.5	M1	Mild drought
1999	1021.2	1202.0	-15.1	M1	Mild drought
2000	784.9	1202.0	-34.7	M2	Moderate drought
2001	1023.2	1202.0	-14.9	M1	Mild drought
2002	767.2	1202.0	-36.2	M2	Moderate drought
2003	1511.0	1202.0	25.7	Mo	No drought
2004	1026.9	1202.0	-14.6	M1	Mild drought
2005	1597.9	1202.2	32.9	Mo	No drought
2006	1266.4	1202.0	5.3	Mo	No drought
2007	1507.3	1202.0	25.4	Mo	No drought
2008	840.2	1202.0	-30.1	M2	Moderate drought
2009	1296.8	1202.0	7.9	Mo	No drought
2010	1247.2	1202.0	3.7	Mo	No drought
2011	1468.1	1202.0	22.1	Mo	No drought
2012	1716.7	1202.0	42.8	Mo	No drought
2013	1618.8	1202.0	34.7	Mo	No drought

drought, while lowest in 28th week. Month-wise, maximum frequency of drought is observed in December followed by November and January month. When the rainfall records are analysed on seasonal basis, there was no drought was observed during south west monsoon and the frequency of drought occurrence was 36, 35 and 33 during winter, summer and northeast monsoon season, respectively. During 43 years of rainfall analysis, there was 9 moderate (1974, 1979, 1987, 1988, 1991, 1992, 2000, 2002 and 2008) and 10 mild drought (1972, 1976, 1978, 1982, 1995, 1996, 1998, 1999, 2001 and 2004) years and there was no severe/extreme year experienced at Labandi station, Raipur.

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