ASSESSMENT OF METEOROLOGICAL DROUGHT DUE TO RAINFALL VARIABILITY IN KEONJHAR, ODISHA (INDIA)

RAY M.*, PATRO H. AND MISHRA N.

Regional Research and Technology Transfer Station [RRTTS] (OUAT), Keonjhar, Odisha - 758002
*Corresponding Author: Email-monikarayouat@gmail.com

Abstract- Rainfall is the most important but variable climatic parameter in suitable crop planning especially in the regions of rain fed agriculture. Rainfall data of 36 years (1980-2015) of Keonjhar district were analysed to find out the weekly, monthly, seasonal and yearly meteorological drought occurrence. The overall mean Annual Rainfall at Keonjhar district was worked out to be 892.53 mm, the maximum being 1859.9 mm is in the year 2011 and the minimum rainfall of the region is 455.3mm which was recorded in the year 1980. The highest drought frequency was observed in the 34th week and in the month of December to a tune of 21 and 25 times respectively. Based on Rainfall analysis, it was found that during 36 years no severe or extreme drought year was experienced. However, there were 9 moderate drought (1980, 1982, 1984, 1985, 1986, 1993, 2002, 2007, 2009) and 16 mild drought (1981, 1983, 1987, 1988, 1989, 1990, 1991, 1992, 1994, 1996, 1997, 1999, 2000, 2001, 2004, 2006) years.

Keywords- Meteorological Drought; Drought intensity; Dry spell; Rainfall Pattern; Drought Frequency; Keonjhar.

Introduction

Indian agriculture mainly depends on monsoon rain. Out of total cultivated area of our country, nearly 70 per cent of area is rain-fed which depends on characteristic of monsoon. Despite the progress, marginal and small farmers constituting 80% of agriculture income groups still depends on rain-fed farming [3]. In rain fed farming, rainfall determines the sowing time and other agricultural activities. Agricultural development largely depends upon the management of natural resources [11]. India receives adequate amount of rainfall annually through the four seasons south–west monsoon (74%), north east monsoon (3%), pre monsoon (13%) and post monsoon (10%) [2]. Therefore, in our country about 75% of rainfall occurs during June to September [8].The important characteristics of rainfall influencing production of rain fed farming are number of rainy days, drought, normal and excessive rainfall for week, month and year. Meteorologically a day is considered dry when it receives rainfall less than 2.5 mm, while agriculturally a dry day receives rainfall less than 6.3 mm are of no use for plant growth, as they will not wet the soil enough to supply moisture around roots [1]. [7] studied the application of rainfall analysis for planning soil and water conservation structures in semi-arid Gujarat. Researcher have made meteorological drought, agriculture drought based on rainfall data for different regions in India. [12, 14] analyzed the drought using the definition of drought month, drought week and drought year for different regions as receiving actual rainfall equals to the 50% of the average rainfall.

Water stresses are 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 [5]. Interpretation of climatic variables is essential because of these variations [15]. In this paper, we have attempted to work out the meteorological drought occurrence at Keonjhar district, Odisha using daily rain fall data.

Materials and Methods

Keonjhar, located at an elevation of 480 m above sea level is coming under the state of Odisha. From historic daily rainfall records (1980-2015) collected from India Meteorological Department (IMD) Pune, the drought frequency and intensity of Keonjhar district was analysed. 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; January to May-pre monsoon) and annual rainfall were analysed. For each week, month, season and year the average rainfall, variation and mean deviation was calculated. Total numbers of drought weeks, months, seasons and years were determined using the standard procedure [6].

Weekly drought: the amount of rainfall is equal to the half of the normal rainfall or less [10].

Monthly drought: the actual rainfall is less than 50% of the average monthly rainfall [13].

Seasonal drought: the seasonal rainfall is deficient by more than twice the mean deviation of the season[9]

Drought year: the annual rainfall is deficient by 20-60% of the average yearly rainfall and if the deficient is more than 60% of the average yearly rainfall it is known as scanty drought year [4]. Based on the percentage deviation of rainfall from its long term mean the yearly intensity of drought was determined using the criteria suggested by [6] and it is given by [Eq-1].

$$Di = \left(\frac{Pi - \mu}{\mu}\right) \times 100$$ [Eq-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 was done based on percentage departure of rainfall from normal and is presented in [Table-1]. The drought was then categorised using the percentage of deviation (D_i).

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_0
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

Result and Discussion

Weekly analysis of drought for 24th to 39th standard week was done which coincides with the monsoon period of this region is presented in [Table-2]. It is found that the average rainfall of different weeks has a variation from 50.30 mm in 31st week to 27.56 mm in the 26th week. The minimum quantum of drought in 30th week has been recorded 13 times while drought in the 34th week has been observed to be a maximum of 21 times. The weekly variation of rainfall from standard week 24th to 39th week and the drought occurred during these week is show in [Fig-1]. About 75 % of annual rainfall occurred during the monsoon season [Table-3]. The wettest months having the minimum drought frequency of 8 and 7 are July and August respectively. The maximum monthly rainfall of 191.48 mm occurred in the month of August followed by 179.99 mm in July. The starting and ending month of monsoon seasons are June and September respectively. October, November, December, January, February and March received very less rainfall being the dry months of a calendar year with mean rainfall of 96.12, 25.27, 4.13, 7.35, 8.37 and 23.05 respectively. The drought frequencies in these months are 12, 21, 25, 23, 24 and 19 respectively [Table-3]. It is clear from the seasonal rainfall analysis that during pre monsoon 12% of rainfall was received, 74% during monsoon and 14% during post monsoon season [Fig-2]. During pre monsoon, the drought frequency was 11, 1 during the monsoon and 12 during the post monsoon season [Fig-3]. Year wise rainfall, long term mean percent deviation and drought category for number of years of different categories in 36 years is shown in [Table-4]. The drought analysis of Keonjhar year wise is presented in [Fig-1]. There are 16 mild drought years and 9 moderate drought years in 36 years. No severe or extreme drought year were observed [Fig-4].

Table-2 *Weekly rainfall analysis for drought*

Standard week	Average rainfall, mm	Half of the average rainfall, mm	No. of drought week
24(11th to 17th June)	43.74	21.87	15
25(18th to 24th June)	30.66	15.33	14
26 (25th to 1st July)	27.56	13.78	15
27 (2nd to 8th July)	35.55	17.78	15
28(9th to 15th July)	38.30	19.15	17
29(16th to 22nd July)	42.29	21.15	15
30(23rd to 29th July)	47.98	23.99	13
31(30th to 5th August)	50.30	25.15	14
32(6th to12th August)	47.03	23.51	16
33(13th to 19th August)	34.84	17.42	12
34(20th to 26th August)	41.41	20.70	21
35(27th to 2nd September)	39.20	19.60	16
36(3rd to 9th September)	39.66	19.83	14
37(10th to 16th September)	35.76	17.88	18
38(17th to 23rd September)	47.42	23.71	15
39(24th to 30th September)	28.55	14.27	17

Table -3 *Monthly and seasonal analysis of rainfall for drought*

Name of month	Average rainfall, mm	Half of the average rainfall, mm	No. of drought month	Percentage of drought months
Jan	7.35	3.7	23	64
Feb	8.37	4.2	24	67
Mar	23.05	11.5	19	53
Apr	28.01	14.0	14	39
May	38.60	19.3	14	39
Jun	128.06	64.0	9	25
Jul	179.99	90.0	8	22
Aug	191.48	95.7	7	19
Sep	162.12	81.1	12	33
Oct	96.12	48.1	12	33
Nov	25.27	12.6	21	58
Dec	4.13	2.1	25	69
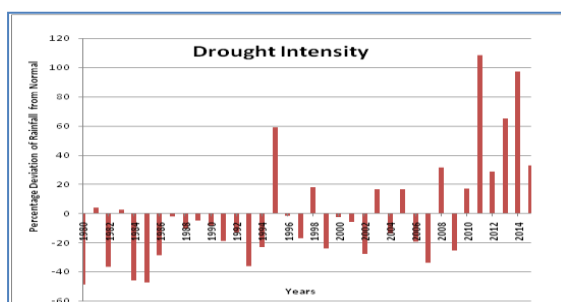
Fig-1 Monthly rainfall variation during the year 1980 and 2015 at Keonjhar, Odisha
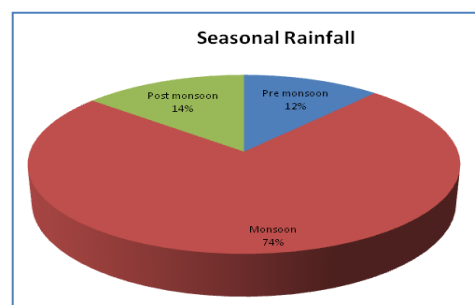
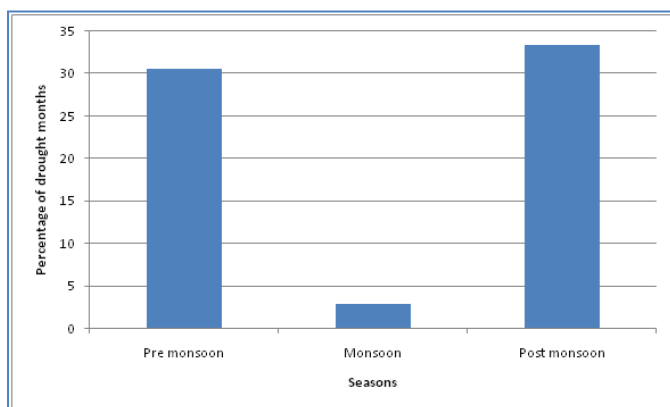**Fig-2 Frequency of seasonal rainfall for Keonjhar, Odisha**

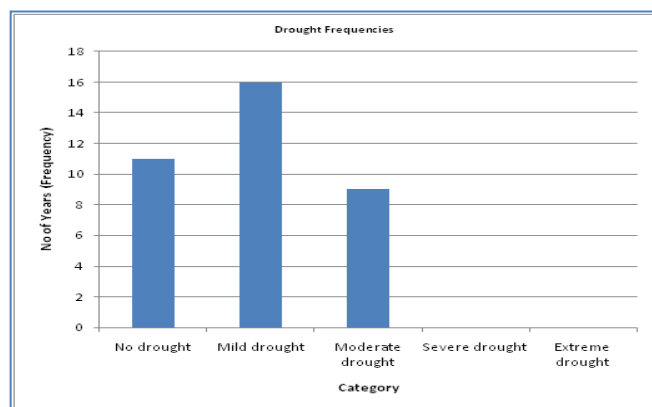Fig-3 Percentage of seasonal drought in Keonjhar, Odisha

Fig-4 Drought frequencies of Keonjhar, Odisha

Table-4 *Yearly intensity of drought for Keonjhar, Odisha*

Year	Annual rainfall, mm	Mean Rainfall, mm	% deviation	Category	Intensity of Drought
1980	455.3	892.53	-48.99	M_2	Moderate drought
1981	925.4	892.53	3.68	M_1	Mild drought
1982	567	892.53	-36.47	M_3	Moderate drought
1983	916.4	892.53	2.67	M_1	Mild drought
1984	480.9	892.53	-46.12	M_2	Moderate drought
1985	470.4	892.53	-47.30	M_2	Moderate drought
1986	634.9	892.53	-28.87	M_2	Moderate drought
1987	872.3	892.53	-2.27	M_1	Mild drought
1988	796.7	892.53	-10.74	M_1	Mild drought
1989	849.4	892.53	-4.83	M_1	Mild drought
1990	816.3	892.53	-8.54	M_1	Mild drought
1991	722.6	892.53	-19.04	M_1	Mild drought
1992	777.9	892.53	-12.84	M_1	Mild drought
1993	568.1	892.53	-36.35	M_2	Moderate drought
1994	686.5	892.53	-23.08	M_1	Mild drought
1995	1420.4	892.53	59.14	M_0	No drought
1996	877.6	892.53	-1.67	M_1	Mild drought
1997	741.1	892.53	-16.97	M_1	Mild drought
1998	1050.1	892.53	17.65	M_0	No drought
1999	678.4	892.53	-23.99	M_1	Mild drought
2000	869.4	892.53	-2.59	M_1	Mild drought
2001	840	892.53	-5.89	M_1	Mild drought
2002	643	892.53	-27.96	M_2	Moderate drought
2003	1041.6	892.53	16.70	M_0	No drought
2004	768	892.53	-13.95	M_1	Mild drought
2005	1040.6	892.53	16.59	M_0	No drought
2006	720.3	892.53	-19.30	M_1	Mild drought
2007	590.9	892.53	-33.80	M_2	Moderate drought
2008	1174.3	892.53	31.57	M_0	No drought
2009	663.2	892.53	-25.69	M_2	Moderate drought
2010	1045.7	892.53	17.16	M_0	No drought
2011	1859.9	892.53	108.38	M_0	No drought

The maximum rainfall of Keonjhar district was observed to be 1859.9 mm in the year 2011. The data that has been obtained clearly depicts the number of drought years (1980-2015) of different drought intensity in [Table-4]. The percentage of number of drought years that are above the normal average rainfall is 30.55%. The different intensities of drought years are M_1- 44.44%, M_2-25%, M_3 and M_4 Nil. Annual drought intensities showed that the first two decades had mild to moderate drought and adjacent decade showed no to mild drought.

Conclusion
Drought analysis based on 36 years of rainfall record showed that 34th week had maximum frequency of drought, while it was lowest in the 30th week. Month wise maximum frequency of drought is observed in December followed by February and January month. The frequency of drought occurrence when the rainfall

analysis was done in a seasonal basis during pre monsoon, monsoon and post monsoon season was 11, 1 and 12 respectively. During 36 years of rainfall analysis there was 9 moderate(1980, 1982, 1984, 1985, 1986, 1993, 2002, 2007, 2009) 16 mild (1981, 1983, 1987, 1988, 1989, 1990, 1991, 1992, 1994, 1996, 1997, 1999, 2000, 2001, 2004, 2006) years and there was no severe and extreme drought year experienced at Keonjhar station, Odisha.

Conflict of Interest: None declared

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