Assessment of Meteorological Drought in Damoh District, M. P., India

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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 depend upon the amount and distribution of rainfall. For planning of agricultural operations weekly data are more useful than monthly, seasonal and annual rainfall.
According to Indian Meteorological Department (IMD), a meteorological subdivision (part of India) can be considered as affected by drought, if it receives total seasonal rainfall less than 75% of the normal value. The occurrence of drought on a continuous basis leads to reduced availability of fodder, decline in agricultural production, livestock wealth and badly affect the people inhabiting these areas. Drought produces both direct and indirect impacts. Direct or primary impacts are usually physical / material and include reduced agricultural production, increased fire hazards, deplete water level, higher livestock and wildlife mortality rates, and damage to wildlife and fish habitats. Even though drought affects large areas worldwide and has serious impacts on society, environment and economy; it is still one of the least understood of all the weather phenomena.

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). In spite of having good potential of rain water, Damoh faces the problem of water scarcity during the maximum part of year (Kumar and Rajput, 2013). Shrivastava et al., (2008) assessed meteorological drought in north Lakhimpur district of Assam and Lala I P Ray et al., in Barapani of Meghalaya. Kumar and Kumar (1989), Dabral (1996) analysed weekly, monthly, seasonally and yearly rainfall data for drought situation at Pantnagar and Ranchi station respectively. Damoh city is the district place of Madhya Pradesh state is located between 23° 50’20.59” North and 79°26’ 27.69” East. The average annual rainfall of Damoh district is 1196.0 mm. Damoh district received maximum rainfall during southwest monsoon period i.e. June to September. About 90.7% of the annual rainfall received during monsoon season. Only 9.2% of the annual rainfall takes place between October to May period. Thus, surplus water for ground water recharge is available only during the southwest monsoon period. The normal maximum temperature received during the month of May is 42.0°C and minimum during the month of December/January is 9.7°C. The normal annual means maximum and minimum temperatures of Damoh district is 32.6° and 18.9°C respectively. During the southwest monsoon season the relative humidity generally exceeds 88% (August month). In the rest of the year it is drier. The driest part of the year is the summer season, when relative humidity is less than 31%. May is the driest month of the year. It is at an average elevation of 595 meters (1,952 ft). The district of Damoh has an area of 7,306 square km (2,821 sq mi).

In maximum part of the district water scarcity is the major problem during maximum part of year (Khan Seraj, 2009, Kumar A and Rajput PS, 2013). Present study aims to analyses the trend of annual rainfall of vital important in all activities which is the only resources of renewable water resource and analyze the cause of scarcity of water.

**Materials and Methods**

In the study to analyze the cause of water scarcity (Map) (Fig. 1), yearly precipitation values of Damoh have been obtained from State Metrological Service for meteorological drought analysis. Record intervals of precipitation values are listed in Table 2. Drought year: the annual rainfall is deficient by 20-60 % of average yearly rainfall and if the deficient is more than 60 % of average yearly rainfall is known as scanty drought year (Dhar et al., 1979). Yearly intensity of drought was also determined using the criteria suggested by IMD (1971) which is based on percentage deviation of rainfall from its long term mean and it is given by (Eq.)
\[
D_i = \left(\frac{P_i - \mu}{\mu}\right) \times 100
\]

Where,

- \(D_i\) is the percentage deviation from the long term mean,
- \(P_i\) is the annual rainfall, mm
- \(\mu\) is the long term mean of 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 categories the drought. On the basis of percentage departure drought conditions are dividing into five categories as No drought (M0), Mild drought (M1), Moderate drought (M2), Severe drought (M3) and Extreme drought (M4).

**Results and Discussion**

Year wise, rainfall, long term mean, percent deviation and drought category is shown in table 2 and fig. 2. Meteorological records of Damoh district shows that maximum rain 1864 mm is in 1990 and minimum rainfall is 614 mm in 1993. Rainfall of 119 years has been studied and percentage deviation of rainfall is calculated and categorized as No Drought, Mild Drought, Moderate Drought, Severe Drought and Extreme Drought as respectively M0, M1, M2, M3 and M4. In 119 years, no drought/ normal rain years are 59, mild drought years are 45, moderate 15, severe and extreme is nil (Table 3 and Fig. 3). The decreasing trend in damoh district and coefficient of determination \(R^2=0.004\) indicating only 0.4% of the variation in annual rainfall can be explained by the regression model in fig. 4.

**Fig.1 Location map study area (Damoh District)**
Table 1. Category of drought codification based on percentage deviation of rainfall from normal value (IMD, 1971)

| Percentage departure of rainfall from normal | Category Intensity of Drought | Code |
|---------------------------------------------|-------------------------------|------|
| 0.0 or above                                 | No drought                    | M0   |
| 0.0 to -25.0                                 | Mild drought                  | M1   |
| -25.0 to -50.0                               | Moderate drought              | M2   |
| -50.0 to -75.0                               | Severe drought                | M3   |
| -75.0 to less                                | Extreme drought               | M4   |

Table 2. Yearly intensity of drought for Damoh (Source: Ashwini et al., 2007)

| Year | Annual | Normal | Dev. (%) | Category        | Code |
|------|--------|--------|----------|-----------------|------|
| 1901 | 1179.7 | 1196.0 | -1.4     | Mild Drought    | M1   |
| 1902 | 976.8  | 1196.0 | -18.3    | Mild Drought    | M1   |
| 1903 | 1181.6 | 1196.0 | -1.2     | Mild Drought    | M1   |
| 1904 | 1093.9 | 1196.0 | -8.5     | Mild Drought    | M1   |
| 1905 | 856.4  | 1196.0 | -28.4    | Mild Drought    | M1   |
| 1906 | 1212.2 | 1196.0 | 1.4      | No Drought      | M0   |
| 1907 | 963.3  | 1196.0 | -19.5    | Mild Drought    | M1   |
| 1908 | 1154.8 | 1196.0 | -3.4     | Mild Drought    | M1   |
| 1909 | 1093.6 | 1196.0 | -8.6     | Mild Drought    | M1   |
| 1910 | 1094.9 | 1196.0 | -8.5     | Mild Drought    | M1   |
| 1911 | 1092.1 | 1196.0 | -8.7     | Mild Drought    | M1   |
| 1912 | 986.7  | 1196.0 | -17.5    | Mild Drought    | M1   |
| 1913 | 824.5  | 1196.0 | -31.1    | Moderate Drought| M2   |
| 1914 | 1025.6 | 1196.0 | -14.2    | Mild Drought    | M1   |
| 1915 | 1302.0 | 1196.0 | 8.9      | No Drought      | M0   |
| 1916 | 1274.9 | 1196.0 | 6.6      | No Drought      | M0   |
| 1917 | 1386.9 | 1196.0 | 16.0     | No Drought      | M0   |
| 1918 | 878.9  | 1196.0 | -26.5    | Moderate Drought| M2   |
| 1919 | 1512.7 | 1196.0 | 26.5     | No Drought      | M0   |
| 1920 | 965.6  | 1196.0 | -19.3    | Mild Drought    | M1   |
| 1921 | 1130.7 | 1196.0 | -5.5     | Mild Drought    | M1   |
| 1922 | 1266.1 | 1196.0 | 5.9      | No Drought      | M0   |
| 1923 | 1429.4 | 1196.0 | 19.5     | No Drought      | M0   |
| 1924 | 1069.7 | 1196.0 | -10.6    | Mild Drought    | M1   |
| 1925 | 1325.3 | 1196.0 | 10.8     | No Drought      | M0   |
| 1926 | 1337.7 | 1196.0 | 11.8     | No Drought      | M0   |
| 1927 | 1189.3 | 1196.0 | -0.6     | Mild Drought    | M1   |
| Year | Precipitation | Temperature | Drought Type | Index |
|------|---------------|-------------|--------------|-------|
| 1928 | 1021.2        | 1196.0      | -14.6        | M1    |
| 1929 | 1424.4        | 1196.0      | 19.1         | M0    |
| 1930 | 1094.0        | 1196.0      | -8.5         | M1    |
| 1931 | 1402.5        | 1196.0      | 17.3         | M0    |
| 1932 | 1207.1        | 1196.0      | 0.9          | M0    |
| 1933 | 1211.2        | 1196.0      | 1.3          | M0    |
| 1934 | 1699.0        | 1196.0      | 42.1         | M0    |
| 1935 | 1340.5        | 1196.0      | 12.1         | M0    |
| 1936 | 1245.7        | 1196.0      | 4.2          | M0    |
| 1937 | 1275.0        | 1196.0      | 6.6          | M0    |
| 1938 | 1371.0        | 1196.0      | 14.6         | M0    |
| 1939 | 1237.9        | 1196.0      | 3.5          | M0    |
| 1940 | 1274.6        | 1196.0      | 6.6          | M0    |
| 1941 | 766.1         | 1196.0      | -35.9        | M2    |
| 1942 | 1377.3        | 1196.0      | 15.2         | M0    |
| 1943 | 1263.6        | 1196.0      | 5.6          | M0    |
| 1944 | 1684.2        | 1196.0      | 40.8         | M0    |
| 1945 | 1369.7        | 1196.0      | 14.5         | M0    |
| 1946 | 1255.4        | 1196.0      | 5.0          | M0    |
| 1947 | 1668.3        | 1196.0      | 39.5         | M0    |
| 1948 | 1541.4        | 1196.0      | 28.9         | M0    |
| 1949 | 1387.8        | 1196.0      | 16.0         | M0    |
| 1950 | 1065.6        | 1196.0      | -10.9        | M1    |
| 1951 | 1224.0        | 1196.0      | 2.3          | M0    |
| 1952 | 1088.5        | 1196.0      | -9.0         | M1    |
| 1953 | 1065.5        | 1196.0      | -10.9        | M1    |
| 1954 | 1160.1        | 1196.0      | -3.0         | M1    |
| 1955 | 1582.9        | 1196.0      | 32.4         | M0    |
| 1956 | 1693.2        | 1196.0      | 41.6         | M0    |
| 1957 | 1041.2        | 1196.0      | -12.9        | M1    |
| 1958 | 1257.7        | 1196.0      | 5.2          | M0    |
| 1959 | 1360.8        | 1196.0      | 13.8         | M0    |
| 1960 | 1465.8        | 1196.0      | 22.6         | M0    |
| 1961 | 1550.3        | 1196.0      | 29.6         | M0    |
| 1962 | 1515.8        | 1196.0      | 26.7         | M0    |
| 1963 | 1327.2        | 1196.0      | 11.0         | M0    |
| 1964 | 1092.3        | 1196.0      | -8.7         | M1    |
| 1965 | 792.0         | 1196.0      | -33.8        | M2    |
| 1966 | 861.9         | 1196.0      | -27.9        | M2    |
| 1967 | 1297.2        | 1196.0      | 8.5          | M0    |
| 1968 | 980.8         | 1196.0      | -18.0        | M1    |
| Year | Precipitation | Reference Year | Temperature | Classification  |
|------|---------------|----------------|-------------|----------------|
| 1969 | 1324.5        | 1196.0         | 10.7        | No Drought     |
| 1970 | 1359.4        | 1196.0         | 13.7        | No Drought     |
| 1971 | 1403.1        | 1196.0         | 17.3        | No Drought     |
| 1972 | 1005.0        | 1196.0         | -16.0       | Mild Drought   |
| 1973 | 1513.6        | 1196.0         | 26.6        | No Drought     |
| 1974 | 1080.7        | 1196.0         | -9.6        | Mild Drought   |
| 1975 | 1179.5        | 1196.0         | -1.4        | Mild Drought   |
| 1976 | 1196.8        | 1196.0         | 0.1         | No Drought     |
| 1977 | 1377.8        | 1196.0         | 15.2        | No Drought     |
| 1978 | 1458.5        | 1196.0         | 22.0        | No Drought     |
| 1979 | 956.9         | 1196.0         | -20.0       | Mild Drought   |
| 1980 | 1286.7        | 1196.0         | 7.6         | No Drought     |
| 1981 | 986.9         | 1196.0         | -17.5       | Mild Drought   |
| 1982 | 1530.7        | 1196.0         | 28.0        | No Drought     |
| 1983 | 1437.8        | 1196.0         | 20.2        | No Drought     |
| 1984 | 915.6         | 1196.0         | -23.4       | Mild Drought   |
| 1985 | 1319.6        | 1196.0         | 10.3        | No Drought     |
| 1986 | 967.7         | 1196.0         | -19.1       | Mild Drought   |
| 1987 | 889.5         | 1196.0         | -25.6       | Moderate Drought|
| 1988 | 885.5         | 1196.0         | -26.0       | Moderate Drought|
| 1989 | 855.0         | 1196.0         | -28.5       | Moderate Drought|
| 1990 | 1847.6        | 1196.0         | 54.5        | No Drought     |
| 1991 | 752.2         | 1196.0         | -37.1       | Moderate Drought|
| 1992 | 720.8         | 1196.0         | -39.7       | Moderate Drought|
| 1993 | 614.6         | 1196.0         | -48.6       | Moderate Drought|
| 1994 | 1599.0        | 1196.0         | 33.7        | No Drought     |
| 1995 | 1053.8        | 1196.0         | -11.9       | Mild Drought   |
| 1996 | 1063.5        | 1196.0         | -11.1       | Mild Drought   |
| 1997 | 1026.6        | 1196.0         | -14.2       | Mild Drought   |
| 1998 | 1182.8        | 1196.0         | -1.1        | Mild Drought   |
| 1999 | 1282.4        | 1196.0         | 7.2         | No Drought     |
| 2000 | 1002.5        | 1196.0         | -16.2       | Mild Drought   |
| 2001 | 1031.9        | 1196.0         | -13.7       | Mild Drought   |
| 2002 | 903.5         | 1196.0         | -24.5       | Mild Drought   |
| 2003 | 1593.6        | 1196.0         | 33.2        | No Drought     |
| 2004 | 1048.7        | 1196.0         | -12.3       | Mild Drought   |
| 2005 | 1666.8        | 1196.0         | 39.4        | No Drought     |
| 2006 | 806.0         | 1196.0         | -32.6       | Moderate Drought|
| 2007 | 888.9         | 1196.0         | -25.7       | Moderate Drought|
| 2008 | 1259.4        | 1196.0         | 5.3         | No Drought     |
| 2009 | 927.3         | 1196.0         | -22.5       | Mild Drought   |
| Year | Rainfall | Normal | Deviation | Drought Category | Code |
|------|----------|--------|-----------|-----------------|------|
| 2010 | 1254.8   | 1196.0 | 4.9       | No Drought      | M0   |
| 2011 | 1346.4   | 1196.0 | 12.6      | No Drought      | M0   |
| 2012 | 1110.9   | 1196.0 | -7.1      | Mild Drought    | M1   |
| 2013 | 1721.9   | 1196.0 | 44.0      | No Drought      | M0   |
| 2014 | 850.8    | 1196.0 | -28.9     | Moderate Drought| M2   |
| 2015 | 914.6    | 1196.0 | -23.5     | Mild Drought    | M1   |
| 2016 | 1707.3   | 1196.0 | 42.8      | No Drought      | M0   |
| 2017 | 757.5    | 1196.0 | -36.7     | Moderate Drought| M2   |
| 2018 | 949.8    | 1196.0 | -20.6     | Mild Drought    | M1   |
| 2019 | 1160.9   | 1196.0 | -2.9      | Mild Drought    | M1   |

**Fig. 2** Deviation Percentage of rainfall from normal for Damoh, M. P.

**Fig. 3** Drought frequencies for Damoh, M. P.
Obtained data clearly shows that out of 119 years, number of drought years of different drought intensity is shown in Table 3 and represented in Figure 3. No drought (M0) years which are above the normal average rainfall are 50%. No of years of different intensities of drought are M1 38%, M2 13%, M3 and M4 Nil. Within 10 years (every decade) 3 to 4 years face good rain (no drought) & 4 to 5 years are faces normal / near normal rain (Mild drought) and 1 to 2 year face Severe to extreme drought (Table 3).

Conclusion of the study is as follows:

In Damoh district annual rainfall equally deviates ±25% from normal average yearly rainfall. The yearly rainfall is good but scarcity of water during maximum part of the year and flood situation during monsoon needs proper management of water resources

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