Probability of occurrence of drought in various sub-divisions of India

K. C. SINHA RAY and M. P. SHEWALE
Meteorological Office, Pune-411005, India
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ABSTRACT. There are many studies dealing with interannual variability of rainfall in India. There are also studies available dealing with the reduction of food grain production during various drought years in India. Hence, there is a long felt need to know about chances whether the next year will be a drought year. It is also seen that during last 11 years when the country as a whole experienced normal rainfall, there were few sub-divisions almost in each year facing a drought situation. The objective of this paper is to find out with the help of nearly 125 years data the probability of occurrence of drought in various sub-divisions of India and the probability of a sub-division facing two or more consecutive droughts, many studies deal with deficiency in all India summer monsoon rainfall and their linkage with El Nino. Effort has also been made in this paper to find out if there is any linkage between El Nino events in Pacific and meteorological drought in various sub-divisions of India. It is seen that effect of El Nino on each sub-division of India is different.

It is also noticed that all El Nino years are not drought years and all drought years are also not El Nino years. During last 124 years there were 29 El Nino years. Out of these only 14 were drought years. Similarly there were 25 drought years during last 124 years out of which 11 drought years were not connected with El Nino.

Key words – Drought year, El Nino, Probability.

1. Introduction

India is mainly an agricultural country with limited irrigation and large dependence on the monsoon rainfall. Hence, the role of monsoon on Indian economy is very crucial. Drought is one of the major natural disasters which affects agriculture, industry and hydroelectric power generation. There are various definitions of drought. It is generally understood as the prolonged deficiency in rainfall over a place. Here we will consider meteorological drought which is defined by the India Meteorological Department as seasonal rainfall deficiency by more than 25 percent of the long term average value of rainfall. Further it is classified as moderate drought when deficiency is between 26 to 50 percent and severe drought when the deficiency is more than 50 percent. A year is considered as a drought year, in case the area affected by drought is more than 20 percent of the total area of the country.

Appa Rao (1986) studied probability of drought in various sub-divisions of India on the basis of rainfall data for the period 1975 to 1985. Considering the epochal nature of rainfall it is desirable to study probability of the occurrence of drought using data for long period so that the results may be unbiased. Mooley & Paolino (1989) have identified years of Pacific warming under two categories which was extended by De (1997) using recent
data. The authors have defined events when warming started in the eastern equatorial Pacific as EW and without eastern equatorial Pacific as E event. Their study indicated that occurrence of drought over the Indian sub-continent was more frequent during the years of EW events as compared to those occurring during E events. Mooley (1997) studied the variation of monsoon rainfall over India in El Nino years. His study shows that the rainfall over the country as well as over westernmost subdivisions were affected more during EW events compared to that of E events.

In this paper authors have studied drought over 35 sub-divisions of India during 1875 to 1998. Probability of occurrence of drought in each sub-division has been discussed. There are a few sub-divisions in India where there are chances of occurrence of two or more consecutive droughts. These have also been highlighted. The information will help the planners to take proper steps regarding food grains storage for those frequent drought affected areas and if possible, to plan for supplementary irrigation.

| S.No. | Year | Moderate drought | Severe drought | Total |
|-------|------|------------------|----------------|-------|
| 1     | 1877 | 30.6             | 28.9           | 59.5  |
| 2     | 1881 | 22.4             | 0.3            | 22.7  |
| 3     | 1899 | 44.1             | 24.3           | 68.4  |
| 4     | 1901 | 19.3             | 10.7           | 30.0  |
| 5     | 1904 | 17.5             | 16.9           | 34.4  |
| 6     | 1905 | 25.2             | 12.0           | 37.2  |
| 7     | 1907 | 27.9             | 1.2            | 29.1  |
| 8     | 1911 | 13.0             | 15.4           | 28.4  |
| 9     | 1913 | 24.5             | 0.0            | 24.5  |
| 10    | 1915 | 18.8             | 3.4            | 22.2  |
| 11    | 1918 | 44.3             | 25.7           | 70.0  |
| 12    | 1920 | 35.7             | 2.3            | 38.0  |
| 13    | 1925 | 21.1             | 0.0            | 21.1  |
| 14    | 1939 | 17.8             | 10.7           | 28.5  |
| 15    | 1941 | 35.5             | 0.0            | 35.5  |
| 16    | 1951 | 35.1             | 0.0            | 35.1  |
| 17    | 1965 | 38.3             | 0.0            | 38.3  |
| 18    | 1966 | 35.4             | 0.0            | 35.4  |
| 19    | 1968 | 21.9             | 0.0            | 21.9  |
| 20    | 1972 | 36.6             | 3.8            | 40.4  |
| 21    | 1974 | 27.1             | 6.9            | 34.0  |
| 22    | 1979 | 33.0             | 1.8            | 34.8  |
| 23    | 1982 | 29.1             | 0.0            | 29.1  |
| 24    | 1985 | 25.6             | 16.7           | 42.3  |
| 25    | 1987 | 29.8             | 17.9           | 47.7  |

Figs. 1 (a&b). Probability of occurrence of (a) moderate drought (%) and (b) severe drought (%)

2. Data used

Rainfall data for the period 1875 to 1998 (June to September) for each sub-division of India have been considered. Proper care has been taken for reconstructing the data of Arunachal Pradesh, Assam and Meghalaya, Nagaland, Manipur, Mizoram and Tripura and hills of west Uttar Pradesh which are recently formed subdivisions.

3. Results and discussion

Table 1 gives the percentage area of the country affected by moderate and severe drought. It may be noted
| S.No. | Name of the sub-division                | Probability of occurrence of drought ($P_i$) | Probability of occurrence of two consecutive drought ($P_{ij}$) | Probability of occurrence of more than two consecutive drought |
|-------|----------------------------------------|---------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------|
| 1.    | Andaman & Nicobar Islands               | 13                                          | 2                                                            | 0                                                           |
| 2.    | Arunachal Pradesh                       | 8                                           | 0                                                            | 0                                                           |
| 3.    | Assam & Meghalaya                       | 2                                           | 0                                                            | 0                                                           |
| 4.    | Nagaland, Manipur, Mizoram & Tripura   | 10                                          | 3                                                            | 0                                                           |
| 5.    | Sub-Himalayan West Bengal               | 6                                           | 1                                                            | 0                                                           |
| 6.    | Gangetic West Bengal                    | 2                                           | 0                                                            | 0                                                           |
| 7.    | Orissa                                  | 4                                           | 0                                                            | 0                                                           |
| 8.    | Bihar Plateau                           | 4                                           | 0                                                            | 0                                                           |
| 9.    | Bihar Plains                            | 9                                           | 0                                                            | 0                                                           |
| 10.   | East Uttar Pradesh                      | 10                                          | 1                                                            | 0                                                           |
| 11.   | Plains of west Uttar Pradesh            | 8                                           | 0                                                            | 0                                                           |
| 12.   | Hills of west Uttar Pradesh             | 14                                          | 1                                                            | 0                                                           |
| 13.   | Haryana, Delhi and Chandigarh           | 17                                          | 3                                                            | 0                                                           |
| 14.   | Punjab                                  | 16                                          | 4                                                            | 0                                                           |
| 15.   | Himachal Pradesh                        | 16                                          | 3                                                            | 2                                                           |
| 16.   | Jammu & Kashmir                         | 21                                          | 6                                                            | 2                                                           |
| 17.   | West Rajasthan                          | 25                                          | 6                                                            | 0                                                           |
| 18.   | East Rajasthan                          | 16                                          | 2                                                            | 0                                                           |
| 19.   | West Madhya Pradesh                     | 10                                          | 1                                                            | 0                                                           |
| 20.   | East Madhya Pradesh                     | 6                                           | 1                                                            | 0                                                           |
| 21.   | Gujarat region                          | 21                                          | 2                                                            | 1                                                           |
| 22.   | Saurashtra & Kutch                      | 23                                          | 3                                                            | 1                                                           |
| 23.   | Konkan & Goa                            | 7                                           | 0                                                            | 0                                                           |
| 24.   | Madhya Pradesh                          | 7                                           | 1                                                            | 0                                                           |
| 25.   | Maharashtra                             | 15                                          | 1                                                            | 0                                                           |
| 26.   | Vidarbha                                | 12                                          | 1                                                            | 0                                                           |
| 27.   | Coastal Andhra Pradesh                  | 10                                          | 1                                                            | 0                                                           |
| 28.   | Telangana                               | 13                                          | 2                                                            | 0                                                           |
| 29.   | Rayalaseema                             | 18                                          | 1                                                            | 0                                                           |
| 30.   | Tamil Nadu & Pondicherry                | 8                                           | 0                                                            | 0                                                           |
| 31.   | Coastal Karnataka                       | 3                                           | 0                                                            | 0                                                           |
| 32.   | North interior Karnataka                | 6                                           | 1                                                            | 0                                                           |
| 33.   | South interior Karnataka                | 6                                           | 0                                                            | 0                                                           |
| 34.   | Kerala                                  | 7                                           | 2                                                            | 0                                                           |
| 35.   | Lakshadweep                             | 10                                          | 2                                                            | 0                                                           |

that during the complete 124 years period there were three occasions i.e., in 1877, 1899 and 1918, when the percentage area of the country affected by drought was more than 60%. It may be noted that during last 80 years there was no occasion when the percentage area of the country affected by drought was more than 50%. It also confirms the finding of Sen and Sinha Ray (1997), which showed a decreasing trend in the area affected by drought in the country.
TABLE 3
Sub-division wise years of occurrence of drought where drought probability is more than 15%

| S.No. | Haryana | Punjab | Himachal Pradesh | Jammu & Kashmir | Rajasthan | East Rajasthan | Gujarat region & Kutch | Saurashtra & Kutch | Marathwada | Rayalseema |
|-------|---------|--------|------------------|-----------------|-----------|----------------|-------------------------|-------------------|------------|------------|
| 1.    | 1877    | 1899   | 1877             | 1878            | 1877      | 1877           | 1877                    | 1877              | 1877       | 1876       |
| 2.    | 1883    | 1904   | 1883             | 1879            | 1883      | 1898           | 1885                    | 1877              | 1885       | 1884       |
| 3.    | 1898    | 1905   | 1899             | 1883            | 1885      | 1899           | 1888                    | 1889              | 1899       | 1891       |
| 4.    | 1899    | 1911   | 1902             | 1884            | 1891      | 1901           | 1892                    | 1890              | 1905       | 1896       |
| 5.    | 1905    | 1915   | 1905             | 1885            | 1891      | 1905           | 1899                    | 1894              | 1907       | 1899       |
| 6.    | 1907    | 1918   | 1907             | 1886            | 1899      | 1907           | 1901                    | 1899              | 1912       | 1901       |
| 7.    | 1913    | 1920   | 1911             | 1887            | 1901      | 1911           | 1904                    | 1901              | 1918       | 1904       |
| 8.    | 1915    | 1921   | 1918             | 1889            | 1902      | 1913           | 1911                    | 1904              | 1920       | 1907       |
| 9.    | 1918    | 1928   | 1928             | 1891            | 1904      | 1915           | 1915                    | 1905              | 1925       | 1911       |
| 10.   | 1920    | 1929   | 1965             | 1895            | 1905      | 1918           | 1918                    | 1911              | 1929       | 1918       |
| 11.   | 1928    | 1938   | 1968             | 1896            | 1911      | 1925           | 1920                    | 1915              | 1939       | 1920       |
| 12.   | 1929    | 1939   | 1972             | 1898            | 1913      | 1928           | 1923                    | 1918              | 1941       | 1922       |
| 13.   | 1938    | 1951   | 1979             | 1900            | 1915      | 1939           | 1925                    | 1923              | 1972       | 1923       |
| 14.   | 1939    | 1964   | 1981             | 1902            | 1918      | 1941           | 1936                    | 1925              | 1974       | 1934       |
| 15.   | 1941    | 1965   | 1982             | 1911            | 1920      | 1951           | 1939                    | 1931              | 1984       | 1941       |
| 16.   | 1951    | 1969   | 1983             | 1918            | 1925      | 1965           | 1948                    | 1939              | 1985       | 1948       |
| 17.   | 1965    | 1972   | 1984             | 1920            | 1938      | 1966           | 1951                    | 1948              | 1993       | 1951       |
| 18.   | 1968    | 1974   | 1986             | 1937            | 1939      | 1972           | 1957                    | 1951              | 1997       | 1971       |
| 19.   | 1979    | 1979   | 1987             | 1949            | 1951      | 1987           | 1960                    | 1968              | 1972       | 1972       |
| 20.   | 1986    | 1987   | 1989             | 1951            | 1963      | 1991           | 1965                    | 1969              | 1985       | 1985       |
| 21.   | 1987    | 1965   | 1968             | 1971            | 1969      | 1972           | 1972                    | 1972              | 1993       | 1993       |
| 22.   | 1983    | 1971   | 1971             | 1972            | 1971      | 1982           | 1982                    | 1982              | 1993       | 1993       |
| 23.   | 1979    | 1979   | 1974             | 1982            | 1980      | 1985           | 1985                    | 1985              | 1995       | 1995       |
| 24.   | 1982    | 1982   | 1982             | 1991            | 1981      | 1987           | 1987                    | 1987              | 1995       | 1995       |
| 25.   | 1985    | 1985   | 1985             | 1986            | 1986      | 1987           | 1987                    | 1987              | 1995       | 1995       |
| 26.   | 1986    | 1986   | 1986             | 1991            | 1991      | 1991           | 1991                    | 1991              | 1995       | 1995       |
| 27.   | 1987    | 1987   | 1987             | 1991            | 1991      | 1991           | 1991                    | 1991              | 1995       | 1995       |

It has been noticed that out of the 124 years, the probability of occurrence of drought is maximum, i.e., 25 percent in west Rajasthan followed by Saurashtra and Kutch, Jammu and Kashmir and Gujarat region with 23, 21 and 21 percent probabilities respectively (Table 2). It has also been noticed that some sub-divisions have probabilities of occurrence of drought in two consecutive years. Few sub-divisions have some chances of occurrence of droughts in more than two consecutive years also. Maximum probability of occurrence of two consecutive years of drought is noticed in Jammu & Kashmir and west Rajasthan i.e., once in 16 years followed by Punjab, where probability of occurrence of consecutive years of drought is once in 25 years. While in the sub-divisions like Arunachal Pradesh, Assam & Meghalaya, Gangetic West Bengal, Orissa, Bihar plateau, Bihar plains and plains of west Uttar Pradesh, Konkan and Goa, Tamil Nadu & Pondicherry, coastal Karnataka and south interior Karnataka, the probability of occurrence of two consecutive years is nil. Probability of occurrence of droughts in more than two consecutive years is nil except in Himachal Pradesh and Jammu &

TABLE 4
El Nino and drought years during 1875 to 1998

| El Nino Years | Drought years in India |
|---------------|------------------------|
| 1877          | 1880 1884 1877 1891   |
| 1887          | 1891 1896 1901 1904   |
| 1889          | 1902 1905 1907 1911   |
| 1911          | 1914 1918 1915 1918   |
| 1923          | 1925 1929 1925 1930   |
| 1930          | 1932 1939 1951 1965   |
| 1941          | 1951 1953 1968 1972   |
| 1957          | 1965 1969 1979 1982   |
| 1972          | 1976 1982 1987         |

Underlined years are El Nino years

Kashmir, Saurashtra & Kutch and Gujarat region. In Himachal Pradesh and Jammu & Kashmir the chances of occurrence of droughts for three or more consecutive years is once in 50 years. Whereas, the occurrence of the
TABLE 5
Droughts for different sub-divisions of India during 1875-1999

| State/Metropolitan District                  | Year Range         |
|---------------------------------------------|--------------------|
| Andaman & Nicobar Islands                   | 1886 1892 1893 1899 1900 1907 1915 1919 1924 1925 1927 1979 1984 1990 1993 1999 |
| Arunachal Pradesh                           | 1937 1942 1961 1971 1992 1994 |
| Assam & Meghalaya                           | 1884 1896 |
| Nagaland, Manipur, Mizoram & Tripura        | 1884 1887 1888 1889 1895 1896 1899 1907 1972 1980 1981 1986 |
| Sub Himalayan West Bengal                   | 1890 1891 1896 1904 1908 1972 1994 |
| Gangetic West Bengal                        | 1895 1966 |
| Orissa                                      | 1878 1901 1924 1974 1987 |
| Bihar plains                                | 1903 1966 1979 1982 1992 |
| Bihar plains                                | 1877 1891 1901 1908 1932 1951 1959 1966 1972 1982 1992 |
| East Uttar Pradesh                          | *1877 1883 1896 1907 1913 1918 1928 1932 1959 1965 1966 1979 1987 |
| Plains of west Uttar Pradesh                | *1877 1883 1905 1907 1913 1918 1928 1941 1979 1987 |
| Hills of west Uttar Pradesh                 | *1877 1883 1905 1907 1913 1918 1941 1951 1953 1965 1972 1976 1980 1982 1987 1991 1992 1997 |
| Haryana, Chandigarh & Delhi                 | *1877 1883 1898 *1899 1905 1907 1913 1915 *1918 1920 1928 1929 1938 1939 1941 1951 1965 1966 1979 1986 *1987 |
| Punjab                                      | *1899 1904 1905 *1911 1915 1918 1920 1921 1928 1929 1938 1939 1951 1964 1965 1969 1972 1974 *1979 *1987 |
| Himachal Pradesh                            | 1872 1883 1899 1902 1905 *1907 1911 *1918 1928 1965 1968 1972 1979 1981 1982 1983 1984 1986 *1987 1989 |
| Jammu & Kashmir                             | 1878 *1879 *1883 *1884 *1885 1886 1887 *1889 *1891 1895 1896 1898 1900 1902 1911 1918 1920 1937 1949 1951 1965 1971 1972 1979 1982 1992 |
| West Rajasthan                              | *1877 1883 1885 1887 1891 *1899 *1901 1902 *1904 *1905 *1911 1913 *1915 *1918 1920 1925 1938 *1939 1951 1963 1968 *1969 1971 1974 1980 1981 1982 1985 1986 *1987 1991 |
| East Rajasthan                              | *1877 1898 1899 1901 *1905 1907 1911 1913 *1915 *1918 1925 1928 1939 1941 1951 1965 1966 1972 *1987 1991 |
| West Madhya Pradesh                         | 1877 1889 1905 1907 1918 1920 1940 1951 1965 1966 1979 1987 |
| East Madhya Pradesh                         | 1878 1899 1941 1962 1965 1966 1974 1998 |
| Gujarat region                              | *1877 1885 1888 1892 *1899 1901 *1904 *1911 *1915 *1918 1920 1923 1925 1936 1939 *1948 1951 1957 1960 1965 1972 *1974 1982 *1985 *1986 *1987 |
| Saurashtra & Kutch                          | 1875 *1877 1889 1890 1894 *1899 *1901 *1904 1905 *1911 *1915 *1918 *1923 1925 1931 *1939 1948 1951 1966 1969 *1972 *1974 1982 *1985 1986 *1987 1991 1993 1995 *1999 |
| Konkan & Goa                                | 1877 1889 1905 1918 1920 1941 1968 1972 1986 |
| Madhya Maharashtra                         | 1877 *1899 1904 1905 *1911 *1918 1972 1985 1987 |
| Marathwada                                  | 1872 1885 1899 1905 1907 1912 1918 *1920 1925 1929 1939 1941 1972 1974 1984 1985 1993 1997 |
| Vidarbha                                    | 1877 *1899 1902 1904 1918 1920 1950 1952 1965 1971 1972 1974 1982 1985 1987 |
| Coastal Andhra Pradesh                      | 1877 1888 1899 1904 1920 1952 1968 1972 1973 1979 1984 1987 |
| Telangana                                   | 1876 1877 1881 1888 1899 1918 1920 1939 1941 1952 1968 1971 1972 1977 1985 1997 |
| Rayalaseema                                 | 1876 1884 1891 1896 1899 1901 *1904 1907 1911 1913 1918 1920 *1922 1923 1934 1941 1948 1952 1971 1972 1985 1993 |
| Tamil Nadu & Pondicherry                    | 1884 1891 1899 1904 1918 1934 1952 1969 1980 1982 1999 |
| Coastal Karnataka                           | 1881 1899 1918 1972 |
| North interior Karnataka                    | 1876 1891 1899 1905 1937 |
| South interior Karnataka                    | 1875 1881 1884 1905 1918 1976 1985 |
| Kerala                                      | 1881 1899 1918 1944 1951 1952 1965 1966 1976 |
| Lakshadweep                                 | 1901 1918 1927 1928 1934 1941 1948 1952 1956 1957 1969 1980 |

Underlined years are El Nino years
Years with asterisk (*) are severe drought years
same in Gujarat region and Saurashtra & Kutch is once in 100 years.

Probability of occurrence of moderate drought in various sub-divisions of India is shown in Fig. 1 (a). It is noticed that maximum probability of occurrence of moderate drought is over Jammu & Kashmir, west Rajasthan and Rayalaseema, whereas, the maximum probability of occurrence of severe droughts is over Saurashtra & Kutch, where there is a chance of occurrence of severe drought once in 9 years [Fig. 1 (b)].

The years of occurrence of drought in sub-divisions where probability of occurrence of drought is more than 15% is given in Table 3. It may be noted that during last 124 years drought occurred in 31 years, in west Rajasthan and in 29 years over Saurashtra & Kutch i.e., about once in 4 years. Occurrence of drought over Gujarat region and Jammu & Kashmir is also very high.

During the period from 1875 to 1998 there were 29 ENSO years and there were 25 drought years in India (Table 4). Out of these 25 drought years there was El Nino in 14 years as underlined in column two of Table 4. Remaining 11 drought years were not connected with El Nino events. Similarly among the El Nino years indicated in Table 4 there were only 14 years affected by drought situation over the country as a whole i.e., 15 El Nino years were not associated with drought.

Drought years of different sub-divisions of India are indicated in Table 5. The years with El Nino event are underlined. Occasions of drought during 124 years in sub-divisions with more than 15% probability of drought occurrence and its association with El-Nino for those sub-divisions are described below:

Haryana, Chandigarh and Delhi had drought on 21 occasions of which 10 were associated with El Nino events, i.e., on 48% cases droughts were associated with El Nino events. Punjab had drought on 20 occasions of which 11 were El Nino years, i.e., on 55% cases droughts were associated with El Nino events. Himachal Pradesh also had drought on 20 occasions of which 10 were associated with El Nino events, i.e., on 50% cases droughts were associated with El Nino events. Jammu & Kashmir had drought on 26 years of which 11 were El Nino years, i.e., on 42% cases droughts were associated with El Nino events. West Rajasthan had maximum occurrence of drought on 31 years of which 13 were El Nino years, i.e., on 42% cases droughts were associated with El Nino events. East Rajasthan had drought on 20 years of which 12 were El Nino events, i.e., on 58% cases droughts were associated with El Nino events. Gujarat region had drought on 26 years of which 13 were El Nino events, i.e., on 50% cases droughts were associated with El Nino events. Saurashtra & Kutch had second largest number of drought years, i.e., there were 29 drought years during the period of which 13 were associated with El Nino events, i.e., on 45% cases drought were associated with El Nino events. Marathwada had drought on 18 occasions of which 10 were El Nino events, i.e., on 55% cases droughts were associated with El Nino events. Rayalaseema had drought on 22 occasions of which 9 were associated with El Nino events, i.e., on 41% cases droughts were associated with El Nino events.

4. Conclusions

(i) Probability of occurrence of drought was found to be maximum in Saurashtra & Kutch, followed by Jammu & Kashmir and Gujarat region.

(ii) Maximum probability of occurrence of two consecutive years of drought was in Jammu & Kashmir and west Rajasthan.

(iii) During last 124 years there were 29 ENSO events out of which only 14 years were associated with drought over India.

(iv) During last 124 years there were 25 years with drought over India out of which 11 were non El Nino years.

(v) El Nino affects summer monsoon rainfall in various sub-divisions of India differently.

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References

Appa Rao, G., 1986, “Drought Climatology”, Jal Vigyan Sameeksha, National Institute of Hydrology, Roorkee, India, Vol. I, 43-53.

De, U.S., 1997, “ENSO and monsoon”, presented in INTROMET 1997.

Mooley, D.A. and Paolino, D.A., 1989, “The response of Indian monsoon associated with the change in sea surface temperature over the eastern south equatorial Pacific”. *Mausam*, 40, 4, 369-380.

Mooley, D.A., 1997, “Variation of summer monsoon rainfall over India in El Nino”. *Mausam*, 48, 3, 413-420.

Scn. A.K. and Sinha Ray, K.C., 1997, “Recent trends in drought affected areas in India”, presented in “INTROMET 1997.”