Analysis of drought using drought management manual 2016 for south Gujarat

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ABSTRACT : Assessment of drought is one of the most important steps in risk management of drought analysis. The basis of drought indices is often based on measuring the deviation from normal rainfall. On the basis of new drought management manual 2016 for rainfall deviation, past 116 years of data of Navsari, Surat, Bharuch, Valsad and Dang districts drought was analyzed. In case of normal deviation of rainfall Navsari district showed highest normal rainfall events in 81 years with a frequency of 1.43 followed by Bharuch district 80 years with a frequency of 1.45. Deficient rainfall event at Valsad and Dang districts reveals that higher number of years with deficient events of rainfall viz. 56 and 48 with occurrence of 2.07 and 2.38 years, respectively. The Valsad district showed highest large deficient condition of drought, district showed four times large deficient in the past 116 years data with a frequency of 29 year which was followed by Bharuch and Surat districts. Drought is mostly the result of a decrease in precipitation in comparison with the mean value and would affect the quantities of soil moisture and water resources.

Key words: Drought, drought management 2016 manual, Normal and deficit rainfall, Rainfall deviation

Drought declaration signifies the beginning of Government response to conditions representing a drought situation. The decision to declare drought over a specified administrative unit (District/ Taluka/Tehsil/ Block/Gram Panchayat level) should be guided by objective parameters made without undue delay so that relief assistance and concessions can be provided to the drought affected people in time. There is substantial variance in the quality of drought monitoring due to methodology and parameters adopted in the declaration of drought among States. Many States still continue to rely on the traditional practice such as the annewari/ paisewari/ girdawari systems of eye estimation and crop cutting experiments to assess if the extent of damage to crops warranted a declaration of drought. In such cases, the final annewari/ paisewari/ girdawari estimates for kharif crops are generally available by December or after, whereas those for rabi crops are available not before March. Relief operations are mounted in drought affected areas by the State Governments after the notification of drought using, inter alia, funds available under the State Disaster Response Fund (SDRF). In the event of drought of a severe nature, the State Government may seek assistance from the Central Government including financial assistance from National Disaster Response Fund (NDRF).

The drought is a natural hazard that has significant impact on Indian economy which affects the agricultural production resulting in growth rate (GDP) fall in recent years was observed that in Indian economy is affected as agricultural drought as well as meteorological drought. The western regions of India (Rajasthan and Gujarat provinces) have suffered with severe droughts at many times in the past. The frequent occurrence of drought in these regions is due to poor and untimely monsoon, abnormally high temperature especially in the summer and various other unfavorable meteorological conditions. Further, due to growing use of water with growing population, the ground water level is found to be continuously declining. Drought is a disastrous natural phenomenon that has significant impact on socio-economic, agricultural, and environmental spheres. It differs from other natural hazards by its slow accumulating process and its indefinite commencement and termination. Being a slow process although drought often fails to draw the attention of the world community, its impact persists even after ending of the event. A single definition of drought applicable to all spheres is difficult to formulate since concept, observational parameters and measurement procedures are different for experts of different fields. Beside, the concept of drought varies among regions of differing climates (Dracup *et al.,* 1980).

In general, drought gives an impression of water scarcity resulted due to insufficient precipitation, high evapo-transpiration, and over-exploitation of water resources or combination of these parameters. There are various methods and indices for drought analysis and they measure different drought-causative and drought-responsive parameters, and identify and classify drought accordingly. However, since these parameters are not linearly correlated with each other, correlation among various kinds of drought is also difficult. Meteorological drought is the earliest and the most explicit event in the process of occurrence and progression of drought conditions. Rainfall is the primary driver of meteorological drought. There are numerous indicators based on rainfall that are being used for drought monitoring (Smakhtin and Hughes, 2007; Kumar and Patel, 2012; Kumar *et al*., 2015a; Kumar *et al*., 2015b). Deviation of rainfall from normal i.e. long term mean is the most commonly used indicator for drought monitoring. On the basis of rainfall deviations, four categories are used in India for monitoring and evaluating the rainfall patterns across the country during the monsoon season; ±20% deviation as normal, -20 to -60% deviation as deficit, less than -60% deviation as scanty and greater than 20% deviation as excess (www.imd.gov.in). Meteorological drought is declared based on rainfall deviations measured using the season's total actual rainfall and long term mean rainfall. If the total season's rainfall is less than 75% of the long term mean, the meteorological sub-division is categorized to be under drought. Severe drought occurs when the season's rainfall is less than 25% of normal (www.imd.gov.in). The deviation criteria for declaring drought vary.

The Central Government dispatches inter-ministerial teams to carry out assessment of drought and recommend the quantum of relief only after the State Government issues a notification of drought and submits a Memorandum for financial assistance from the NDRF. Therefore, delay on the part of State Governments in making the determination and declaration of drought on account of the preference for extensive field surveys and crop cutting experiments over other quicker means, is likely to set a train of delays in motion, making it difficult for the much needed relief to reach the affected population in time. The Government of India revised its norms in 2015 to lower the eligibility threshold from 50% loss to 33% loss to sown crops on account of drought to qualify for relief assistance. It was, however, noticed that some States still continue to recognize a minimum loss/ damage of 50% to sown crops (*i.e*, annewari /paisewari/ girdawari less than 50%) for the declaration of an area as drought affected.

Technological advances have to a large extent, obviated the need for complete and sole dependence on crop loss assessment based on annewari / paisewari / girdawari or crop cutting assessments in the determination of drought. It is possible to arrive at an objective, timely and accurate assessment of drought through the establishment of an elaborate scientific drought monitoring system. Meteorological, remote sensing and hydrological data can be accessed by the State Governments from Central and State agencies, and processed quickly to arrive at fairly credible inferences on the emergence and intensification of drought-like conditions in any part within their territories. It is acknowledged that a combination of carefully chosen indicators and indices derived from satellite / hydrological observations is capable of identifying areas with drought like propensities which will be discussed in the course of this Chapter. However, it needs to be conceded that drought, as opposed to most other calamities, is a highly complex phenomenon, and available technology not only has inherent limitations but the shortcomings are sometimes compounded by poor availability of reliable data. State Governments are expected to develop monitoring systems at the smallest administrative unit levels (e.g. Hobli/ sub-division/ Tehsil/ Taluk/ Block/Mandal/ Gram Panchayat etc.), to enable generation of sharper and credible observation data that are reflective of ground realities. In addition, agencies of Central and State Governments would be required to streamline and strengthen data collection system for drought variables. In addition, Standard Operating Procedures need to be considered for collection, updation of data related to the drought variables.

MATERIALS AND METHODS

In south Gujarat five locations were selected for assessment of rainfall intensity and frequency (1) Navsari (23.15°N and 69.49°E, Altitude 11.0m) (2) Bharuch (22.98° N and 70.21°E, Altitude 3.0 m) (3) Surat (22.98° E and 70.21°E, Altitude 3.0 m) (4) Valsad (22.35° N and 72.35°E, Altitude 6.10 m) and (5) Dangs (20.51° N and

70.21°E, Altitude 440 m). The historical monthly and annual rainfall data were used of 115 years (1901-2016).

Rainfall Deviation

The rainfall deviation (RFdev) which is expressed in percentage terms is calculated as below:

$$RFdev = \{(RFi - RFn)/RFn\}*100$$

Where, RFi is current rainfall for a comparable period (in mm) and RFn is the normal rainfall (at least 30 years average) for the same period (in mm). The drought management 2016 manual of rainfall deviation is given in Table 1.

Table 1: Categories of Rainfall Deviations (As per Drought Manual 2016)

Deviation from Normal Rainfall (%)	Category
+ 19 to -19	Normal
-20 to -59	Deficient
-60 to -99	Large Deficient
-100	No Rain

RESULTS AND DISCUSSION

Drought analysis based on rainfall deviation

Rainfall deviation is a probability index for monitoring drought. This drought index is developed to detect drought and wet period for different time scale in various region of the world. On the basis normal rainfall of 115 past years of Dangs, Valsad, Surat, Navsari and Bharuch district were analyzed.

Normal (Rainfall deviation +19 to -19)

Positive rainfall deviations were found to be associated with Rainfall deviation (-19 to +19%) indicating wetness in annual rainfall. At Navsari district highest normal rainfall events were observed in years in 81 years with the frequency of 1.43 followed by Bharuch district 80 years with frequency of 1.45 (table 3). Similarly, at Dang, Valsad and Surat districts showed normal event of rainfall for 65, 56 and 74 years with the occurring frequency of 1.75, 2.07 and 1.57, respectively (Table 2).

Deficient (Rainfall deviation -20 to -59)

In case of the events of deficient rainfall Valsad and Dang districts were reveals that higher number of years for the deficient events of rainfall *viz.* 56 and 48 with the occurring frequency of 2.07 and 2.38 years, respectively. At Surat, Bharuch and Navsari districts showed less deficient years compared to previous two districts. These districts showed number of 40, 33 and 34 years with the occurring frequency with 2.90, 3.52 and 3.41 years, respectively (Table 2 and 3).

Large deficient (Rainfall deviation -60 to -99)

The rainfall deviation was observed that on the large deficient events of drought. The Valsad district showed highest large deficient in condition of drought, district showed four times large deficient in the past 116 years data with the occurring frequency of 29.0 year. The frequencies of occurrence of large deficient events of drought are one times in past 116 years in case of Dang and Navsari districts. In case of Bharuch and Surat districts showed 2 times and 3 times large deficient event in past 116 years with occurring frequency of 58.0 and 38.67 years, respectively (Table 2 and 3).

CONCLUSION

Drought is a slow-onset, creeping natural hazard and recurrent phenomenon in the arid and semi-arid regions of Gujarat (India). In this study drought are classified by new criteria of rainfall deviation given by the Indian Meteorological Department. In case of normal deviation of rainfall Navsari district showed highest normal rainfall events were observed in years in 81 years with the frequency of 1.43 followed by Bharuch district 80 years with frequency of 1.45. Deficient rainfall event at Valsad and Dang districts were reveals that higher number of years for the deficient events of rainfall *viz*. 56 and 48 with the occurring frequency of 2.07 and 2.38 years, respectively. The Valsad district showed highest large deficient in condition of drought, district showed four times large deficient in the past 116 years data with the occurring frequency of 29.0 year which was followed by Bharuch and Surat districts.

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Table 2: Rainfall deviation (%) and frequency occurrence at Dang, Valsad and Surat for 1901 to 2016.

Category	Deviation from Normal rainfall (%)	Years	Total years	Frequency
Dang				
Normal	+ 19 to -19	1912, 1914, 1917, 1919, 1927, 1931, 1932, 1933, 1934, 1935, 1937, 1938, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947, 1949, 1950, 1953, 1954, 1955, 1956, 1958, 1959, 1963, 1964, 1967, 1968, 1969, 1970, 1976, 1977, 1979, 1980, 1981, 1983, 1984, 1988, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2010, 2011, 2012, 2013, 2014, 2016	65	1.75
Deficient	-20 to -59	1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1913, 1915, 1916, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1928, 1929, 1930, 1936, 1939, 1948, 1951, 1952, 1957, 1960, 1961, 1962, 1965, 1966, 1971, 1972, 1973, 1974, 1975, 1978, 1982, 1985, 1986, 1987, 1989, 1990, 1991, 2009, 2015	48	2.38
Large Deficient	-60 to -99	1918	01	114.0
CV				587.3
SD				30.2
		Valsad		
Normal	+ 19 to -19	1912, 1913, 1914, 1917, 1921, 1926, 1937, 1938, 1940, 1942, 1944, 1945, 1946, 1949, 1950, 1953, 1954, 1956, 1958, 1959, 1960, 1963, 1964, 1966, 1969, 1970, 1973, 1975, 1976, 1977, 1979, 1980, 1981, 1983, 1988, 1989, 1991, 1992, 1993, 1994, 1998, 1999, 2000, 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2013, 2014, 2016	56	2.07
Deficient	-20 to -59	1901, 1902, 1903, 1906, 1907, 1908, 1909, 1910, 1915, 1916, 1918, 1919, 1920, 1922, 1923, 1924, 1925, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1936, 1939, 1941, 1943, 1947, 1951, 1952, 1955, 1957, 1961, 1962, 1965, 1967, 1968, 1971, 1972, 1974, 1978, 1982, 1984, 1985, 1986, 1987, 1990, 1995, 1996, 1997, 2002, 2012, 2015	56	2.07
Large Deficient	-60 to -99	1904, 1905, 1911, 1948	04	29.0
SD				556.1
CV				29.1
		Surat		
Normal	+ 19 to -19	1902, 1903, 1908, 1909, 1910, 1912, 1913, 1914, 1916, 1917, 1919, 1921, 1922, 1924, 1926, 1927, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1937, 1938, 1940, 1942, 1944, 1945, 1946, 1947, 1949, 1953, 1954, 1955, 1956, 1958, 1959, 1960, 1961, 1963, 1964, 1968, 1970, 1971, 1973, 1975, 1976, 1977, 1978, 1979, 1981, 1983, 1988, 1990, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2013, 2014, 2016	74	1.57
Deficient	-20 to -59	1901, 1904, 1905, 1906, 1907, 1911, 1915, 1920, 1923, 1925, 1928, 1936, 1939, 1941, 1943, 1948, 1950, 1952, 1957, 1962, 1965, 1966, 1967, 1969, 1972, 1974, 1980, 1982, 1984, 1985, 1986, 1987, 1989, 1991, 1999, 2000, 2001, 2002, 2012, 2015	40	2.90
Large Deficient	-60 to -99	1918, 1951	02	58.0
SD				432.7
CV				35.1

Table 3: Rainfall deviation (%) and frequency occurrence at Bharuch and Navsari districts for 1901 to 2016.

Category	Deviation from Normal rainfall (%)	Years	Total years	Frequency
Normal	+ 19 to -19	1902, 1903, 1906, 1907, 1908, 1909, 1910, 1912, 1913, 1914, 1916, 1917, 1919, 1921, 1922, 1924, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947, 1949, 1950, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1963, 1964, 1967, 1968, 1969, 1970, 1971, 1973, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1983, 1984, 1988, 1990, 1992, 1993, 1994, 1996, 1998, 2003, 2005, 2006, 2007, 2010, 2011, 2013, 2014	80	1.45
Deficient	-20 to -59	1901, 1904, 1905, 1911, 1915, 1918, 1923, 1920, 1925, 1948, 1951, 1952, 1961, 1962, 1965, 1966, 1982, 1985, 1986, 1987, 1989, 1991, 1995, 1997, 1999, 2000, 2002, 2004, 2008, 2009, 2012, 2015, 2016	33	3.52
Large Deficient	-60 to -99	1972, 1974, 2001	03	38.67
SD				303.5
CV				37.0
		Navsari		
Normal	+ 19 to -19	1901, 1902, 1903, 1906, 1907, 1908, 1909, 1910, 1912, 1913, 1914, 1915, 1916, 1917, 1919, 1921, 1922, 1923, 1924, 1926, 1929, 1930, 1931, 1932, 1933, 1934, 1937, 1938, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947, 1949, 1950, 1953, 1954, 1955, 1956, 1958, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1969, 1970, 1971, 1973, 1975, 1976, 1977, 1978, 1979, 1983, 1984, 1988, 1992, 1993, 1994, 1998, 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2013, 2014, 2016	81	1.43
Deficient	-20 to -59	1904, 1905, 1911, 1918, 1920, 1925, 1927, 1928, 1935, 1936, 1939, 1948, 1951, 1952, 1957, 1968, 1972, 1974, 1980, 1981, 1982, 1985, 1987, 1989, 1990, 1991, 1995, 1996, 1997, 1999, 2000, 2002, 2012, 2015	34	3.41
Large Deficient	-60 to -99	1986	01	116.0
SD				546.9
CV				32.4

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