

Analysis of regional droughts, magnitudes and comparison over Ballari district

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ABSTRACT : Drought generally initiates with the deficit of monsoon rains leading to meteorological drought and if prolonged, affects other sectors dependent on the water for its sustenance resulting in agricultural and hydrological droughts. The present study was conducted to analyse and compare meteorological drought occurrence over various stations of Ballari district, Karnataka. The rainfall data of 35 years (1978-2012) was considered for the present study. The various magnitudes of droughts (mild, moderate, severe and extreme) were analysed and compared by IMD and SPI criteria's. The drought frequency of one drought year was observed for every one and half year to two years.

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Indian agriculture continues to be a gamble of the vagaries of monsoon, rainfall being the most critical, nearly 70 per cent of the net sown area is still rain dependent (Narain *et al.*, 2006). The erratic trend, uneven distribution and uncertainty of rainfall in a region are responsible for creating moisture stress and crop failure. Even in a good monsoon year, a drought period of 19-25 days, which is common phenomenon in dryland region, affects crop yields (Jat *et al.*, 2005a). Gregory and Parthasarathy (1986) studied large scale droughts over India. The information on probability of drought is important in designing the storage capacity of reservoirs (Ray *et al.*, 1987) and selection of suitable crops for the region (Jat *et al.*, 2005). Several studies (Sarkar, 1997; Gore and Ray, 2002; Singh *et al.*, 2002; Singh 2005; Bhakar *et al.*, 2007; Jhajharia *et al.*, 2007; Pradhan *et al.*, 2011 and Neeraj and Patel,

2012) reported and analysed the meteorological droughts over various regions of the country.

Saha and Sarkar (2005) carried out the probability analysis on the basis of rainfall data, for the Umiam region to get the idea about the magnitude and frequency of meteorological drought. The study revealed that, the drought periods were concentrated in between November and March. Sadiq *et al.* (2014) analyzed the monthly precipitation data of the Sindh, Pakistan and used to calculate SPI for different time periods, viz., 3, 6, 9, 12, 24 and 48 months. The results revealed that long term drought of early 1960s and late 1970s impacted Sindh's region. Manikandan and Tamilmani (2013) studied the characteristics of droughts where the temporal and spatial characteristics of meteorological drought were investigated to provide a framework for sustainable water

resources management. Shikha *et al.* (2014) identified the drought years and characterized them and evaluated the relative departure index, as an indicator of the drought proneness of a region which indicated equal priorities for taking up drought relief measures during drought situations. In Ballari, the monsoon rainfall is the only possible mean for groundwater recharge. The rainfall distribution is extremely uneven and irregular as the district falls in the Northern Dry Zone region of Karnataka. Ballari has a semi-arid climate and it is situated in the north eastern part of Karnataka.

Objective:

To analyze, characterize and to compare the meteorological droughts.

EXPERIMENTAL METHODOLOGY

The meteorological droughts over different stations were analyzed using Indian Meteorological Department (IMD) and Standard Precipitation Index (SPI) criteria and comparison was made. The average annual rainfall of Ballari district was found to be 515.6 mm; the 12 stations *viz.*, Ballari, Chornur, Hagari Bommanahalli (HB Halli), Hacholi, Hadagali, Hagari, Kampli, Kottur, Kudligi, Kurikoppa, Mariamma Halli and Tekkalakote were selected for the study purpose and Considered 35 years (1978-2012) of rainfall data.

The various stations selected for the study purpose and the geographical locations of the stations are presented in Table A. The twelve stations which were selected for the study, are spread over entire district.

Meteorological drought analysis :

The meteorological drought analysis was carried out based on Indian Meteorological Department (IMD, Pune) criteria and Standardized Precipitation Index (SPI) method.

Meteorological drought analysis as per IMD criteria :

The drought was classified as mild, moderate, severe and extreme droughts based on percentage deviation of annual rainfall towards negative side from mean rainfall. If the deviation is less than 0 to -25 per cent, then it is considered as mild drought; if deviation lies between -25 to -50 per cent, it is designated as moderate drought year; if the deviation lies between -50 to -75 per cent, it is considered as severe drought and if the deviation is more than -75 per cent it is considered as extreme drought. The difference between annual rainfall and mean rainfall divided by mean rainfall is an indicator for drought (Pandey *et al.*, 1999; Reddy *et al.*, 2001 and Ray *et al.*, 2012).

Meteorological drought analysis as per SPI criteria:

The standardized precipitation index (SPI) calculation for any location is based on the long-term precipitation record for a desired period. The SPI is an index based on the probability of precipitation for any time scale. Positive SPI values indicate greater than median precipitation, while negative values indicate less than median precipitation. Since, the SPI is normalized, wetter and drier climates can be represented.

McKee *et al.* (1993) used SPI classification system

Sr. No.	Station name	Latitude (°N)	Longitude (°E)
1.	Ballari	15° 08' 22. 07" N	76° 55' 17. 69" E
2.	Chornur	14° 53' 27. 51" N	76° 32' 12. 19" E
3.	HB Halli	15° 02' 22. 52" N	76° 12' 00. 19" E
4.	Hacholi	15° 45' 27. 00" N	76° 59' 40. 87" E
5.	Hadagali	15° 00' 57. 46" N	75° 56' 09. 97" E
6.	Hagari	15° 08' 14. 19" N	77° 03' 36. 73" E
7.	Kampali	15° 24' 22. 03" N	76° 36' 18. 65" E
8.	Kottur	14° 49' 00. 62" N	76° 13' 02. 33" E
9.	Kudligi	14° 54' 17. 40" N	76° 23' 23. 24" E
10.	Kurikoppa	15° 12' 14. 61" N	76° 39' 49. 04" E
11.	Mariamma Halli	15° 09' 35. 90" N	76° 21' 43. 61" E
12.	Tekkalakote	15° 32' 04. 56" N	76° 52' 42. 52" E

for drought analysis for classifying drought intensities and also defined the criteria for a “drought event” for any of the time scales. When SPI values lies in between 0 to -0.99, -1.00 to -1.49, -1.50 to -1.99 and -2.00 and less, then drought intensities are designated as mild, moderate, severe and extreme droughts, respectively.

EXPERIMENTAL FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Meteorological drought as per IMD criteria :

The annual meteorological drought as per IMD criteria was evaluated and the results are presented in the Table 1. The results revealed that, during the study period of 35 years (1978–2012) Hadagali and Kudligi have experienced 16 mild drought years; followed by 12 years at Mariammana Halli; 11 years at HB Halli and Kurikoppa; 10 years at Kottur; 9 years at Tekkalakote; 8 years at Ballari; 7 years at Chornur and Kampli; 6 years at Hagari; 5 years at Hacholi, respectively.

Similarly, the various magnitudes of drought such as moderate and severe drought were also experienced by different stations. The Chornur station has experienced 11 moderate drought years followed by 9 years at Kampli and Tekkalakote; 8 years at Hacholi; 7 years at Ballari, Hagari and Kottur; 6 years at HB Halli and Kudligi; 5 years at Kurikoppa and Mariammana Halli; and 4 years at Hadagali, respectively.

Similarly, 5 severe drought years were experienced at Hacholi; 4 years at Hagari; 3 years at Kampli; 2 years at Ballari, Kottur and Kurikoppa; one year at Chornur, Mariammana Halli and Tekkalakote, respectively. The stations HB Halli, Hadagali and Kudligi were not experienced any severe drought years during the study period.

Regarding extreme drought, out of the 12 stations, only one station (Kottur) has experienced one extreme drought.

Combining the effect of different magnitudes of drought (mild, moderate, severe and extreme), out of 35 years of study, the drought years varied from 17 years (49% drought years) at Ballari, HB Halli and Hagari to 22 years (63% drought years) at Kudligi.

Table 1 : Annual meteorological drought (1978-2012) as per IMD criteria over different stations of Ballari district

Station	Mild	Moderate	Severe	Extreme	Drought Yr
Ballari	1982,86,85, 2000-01,06,11-12 (8)	1979-80,84,94, 97,2002,04 (7)	1985,2003 (2)	-	17 (49)
Chornur	1980,83-84,86-87,89,2002 (7)	1979,89,93- 95,97,2003,06,08,11-12 (11)	2007 (1)	-	18 (51)
HB Halli	1980,89,91- 93,95,97,2000,04,08,12 (11)	1983-85,94,2002-03 (6)	-	-	17 (49)
Hacholi	1980,85-86,2002-03 (5)	1979,82,89,91,94-95,2004,12 (8)	1984,97,2006,08, 11 (5)	-	18 (51)
Hadagali	1982,84-85,90-92,94-95,97- 98,2001,04-06,11-12 (16)	1989,99,2002-03 (4)	-	-	20 (57)
Hagari	1984,89,95,99, 2002,07 (6)	1979,80,85,97,2005,11-12 (7)	1994,2003-04,06 (4)	-	17 (49)
Kampli	1982,84,86,87, 2000,07-08 (7)	1978,80,89,94,2002-04,06,11 (9)	1979,85,97 (3)	-	19 (54)
Kottur	1978-79,82, 92-94,96-98,2001 (10)	1980,84,95,99, 2003,11-12 (7)	1983,85 (2)	2002 (1)	20 (57)
Kudligi	1980,86-93,95,97,2000,01,07- 08,12 (16)	1985,94,2002, 03,06,11 (6)	-	-	22 (63)
Kurikoppa	1979-81,83,89- 90,95,2002,04,11-12 (11)	1982,84,94,99,2003 (5)	1985,97 (2)	-	18 (51)
Mariammana Halli	1983-84,86- 87,94,97,2001,03,06-08,11 (12)	1985,95,2002, 04,12 (5)	1980 (1)	-	18 (51)
Tekkalakote	1984,88,89,93,94,99,2002,06,09 (9)	1979,85,95,97, 2003,08,10-12 (9)	1980 (1)	-	19 (54)

Values in the parentheses of the columns 2 to 5 indicates number of drought year

Values in the parentheses of the last column indicate percentage of drought year

Meteorological drought as per SPI criteria :

The results of mild, moderate, severe and extreme drought are presented in the Table 2. It also presents the total number of drought years for the period of study (1978–2012) for individual stations along with its percentage of occurrence.

During the study period of 35 years (1978 – 2012), Kudligi station has experienced 19 mild drought years followed 15 at Hadagali; Kampli and Mariamma Halli; 13 at Chornur, Hacholi, Kottur, Kurikoppa and Tekkalakote; 11 at HB Halli; 10 at Ballari and Hagari, respectively.

Similarly, the various magnitudes of drought such as moderate, severe and extreme drought were also experienced by different stations. Ballari, Chornur, Hagari, Kottur and Tekkalakote had experienced 5 moderate drought years followed by 4 at HB Halli, Hacholi and Kampli; 3 at Hadagali and Kurikoppa; 2 years at Kudligi and Mariamma Halli, respectively.

Similarly, 2 severe drought years were experienced at Ballari, HB Halli, Hadagali, Hagari and Kottur; one at Chornur, Hacholi, Kudligi, Kurikoppa, and Tekkalakote respectively. The Kampli and Mariamma Halli stations

were not experienced any severe drought years during the study period.

Regarding extreme drought, out of the 12 stations, only 2 stations have experienced one year extreme drought at Kurikoppa and Mariamma Halli.

Combining the effect of different magnitudes of drought (mild, moderate, severe and extreme) out of 35 years of study, the drought years varied from 17 years (49% drought years) at Ballari, HB Halli and Hagari to 22 years (63% drought years) at Kudligi.

Comparison of droughts by IMD criteria and SPI criteria :

The results of annual meteorological droughts derived by IMD (Table 1) were compared with SPI criteria (Table 2) and it was observed that, the total number of drought years remained unchanged for all the stations by both criteria (IMD and SPI methods) except Chornur where drought years were 18 by IMD criteria analysis against 19 years by SPI criteria.

However, in critical comparison about magnitudes of drought (mild, moderate, severe and extreme) revealed that, the mild drought years appeared to be less in IMD

Table 2: Annual meteorological drought (1978-2012) as per SPI criteria over different stations of Ballari district

Station	Mild	Moderate	Severe	Extreme	Drought Yr
Ballari	1979,82,86,95,2000,01-02,06,11-12 (10)	1980,84,94,97,2004 (5)	1985, 2003 (2)	-	17(49)
Chornur	1979-80,83-84,86-87,89,93,95,2002,08,11-12 (13)	1985,94,97,2003,06 (5)	2007 (1)	-	19(54)
HB Halli	1980,89,91-93,95,97,2000,04,08,12 (11)	1983-84,94,2003 (4)	1985, 2002 (2)	-	17(49)
Hacholi	1979-80,82,85-86,89,91,94-95,2002-04,12 (13)	1997,2006,08,11 (4)	1984 (1)	-	18(51)
Hadagali	1982,84,90-92,94-95,97-98,2001,04-06,11-12 (15)	1985,89,99 (3)	2002-03 (2)	-	20(57)
Hagari	1979,84,89,95,97,99,2002,07,11-12 (10)	1980,85,94,2004-05 (5)	2003,06 (2)	-	17(49)
Kampali	1978,80,82,84,86-87,89,94,2000,02,04,06-08,2011 (15)	1979,85,97,2003 (4)	-	-	19 (54)
Kottur	1978-80,82,84,92-98,2001 (13)	1985,99,2003,11-12 (5)	1983,2002 (2)	-	20(57)
Kudligi	1980,85-93,95,97,2000-01,06-08,11-12 (19)	1994, 2003 (2)	2002 (1)	-	22(63)
Kurikoppa	1979-83,89-90,94-95,2002,04,11-12 (13)	1984,99,2003 (3)	1985 (1)	1997 (1)	18(51)
Mariammana Halli	1983-87,94-95,97,2001,03-04,06-08,2011 (15)	2002,12 (2)	-	1980 (1)	18(51)
Tekkalakote	1979,84,88-89,93-95,99,2002-03,06,08-09 (13)	1985,97,2010-12 (5)	1980 (1)	-	19(54)

Values in the parentheses of the columns 2 to 5 indicates number of drought year
Values in the parentheses of the last column indicate percentage of drought year

criteria in comparison to SPI criteria and same years (calendar years) have appeared in one or the other magnitudes of drought in both methods accounting to same number of drought years by both the methods. The drought frequency of one drought year was observed for every one and half year to two years.

Conclusion :

The variation in the number of drought years was not observed (including particular calendar years) when comparison was made between IMD and SPI criteria. However, critical comparison about magnitudes of droughts (mild, moderate, severe and extreme droughts) indicated that, mild drought years appeared to be less in IMD criteria in comparison to SPI criteria.

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