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Analysis of Meteorological drought condition for Bijapur region in the lower Bhima basin, India

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Abstract— Drought is considered as one of the most dangerous natural hazards in the universe, associated with scarcity of water. In this paper, the Standard Precipitation index (SPI) for the different time scales is used to analyze (estimate) the rain fall characteristics for Bijapur region. The monthly precipitation data's from 1971 to 2005 (35 years) were used to calculate the SPI. The daily rain fall data were inputted to SPI tool to calculate the meteorological drought.

Validation has been done by the correlation between river discharge and SPI at multiple time scales was examined. And also found that the maximum correlation coefficient occurred at the time scale of 6 months. The result indicates that the Bijapur region faces more severe drought in the year 1984, 1986 and 2004 and Extreme drought in the year 1971, 1994 and 2003.

***Index Terms*—Drought, SPI, IMD, NMHS**

I. INTRODUCTION

The climate and weather condition is unpredictable and they are constantly changing over the time across the global due to global warming, it creates a significant effect on atmospheric occurrence, circulation and distribution. Hence it creates the problem directly or indirectly for the agricultural sector, health, ecosystem, social consequences and economy of that region.

Drought is nothing but the region receives the less rainfall than the actual requirement, when this phenomenon extends for the longer periods of time creates the significant effect to meets the need of human activities and for the environmental conditions.

The standardized precipitation index (SPI) is mainly used by all National Meteorological and Hydrological Services (NMHSs) around the world to characterize meteorological droughts, in addition to other drought indices since this SPI is very easy to calculate and convenient to apply and it requires only precipitation as input data and reduce the burden of calibration (Juan Du et al. 2012). SPI has already been widely used to consider dry and wet conditions in many countries; this can be seen by the literature review. Hayes M.J,et al.,(1996) .

The SPI is a tool that should be used operationally as part of a state, regional or national drought watch system in the United States. During the 1996 drought, the SPI detected the onset of the drought at least 1 month in advance of the PDSI. Guttman(1999) states that the Standardized Precipitation Index (SPI) is a probability index that was developed to give a better representation of abnormal wetness and dryness than the Palmer indices and the Pearson type III distribution is the "best" universal model.

Khan et al., (2008) a Standard Precipitation Index (SPI) is employed to track drought and assess the impact of rainfall on shallow groundwater levels in three selected irrigation areas of the Murray- Darling Basin in Australia. Shi et al. (2012) analysis of dry/wet conditions using SPI index and its potential in Hunan region. Moumita et al., (2013) severity and spatial pattern of meteorological drought was analyzed in the Puruliya District, West Bengal, India using multi-temporal SPI.

II. STUDY REGION AND MATERIALS

The present study considers the precipitation station located near Bijapur district for to study the drought and subsequently this station comes under Bhima basin**.**

Bijapur district is located in the Western part of Northern Karnataka. It lies between 15 x 50 and 17 x 28 North Latitude and 74 x 54 and 76 x 28 East Longitude Bijapur district receives average annual rainfall of 553 mm with 37.2 rainy days. The monsoon generally breaks in the district during June and lasts till October. The highest mean monthly rainfall is

149 mm in the month of September and lowest is 3 mm in February. The district is also not rich in fauna.The monthly precipitation data from 1971 to 2005 are used in this study area and it is collected from IMD grid data form one rain gauge station in lower Bhima basin. The distribution of the rain gauge stations is shown in fig 2.1. Daily river discharge data from hydrological stations were considered for the validation purpose.

Fig.2.1: Location of Hydrologic stations used in this study

Fig.2.2: Map of Bijapur District

Table.2.1 Precipitation properties of hydrologic stations in the region of North Karnataka

Station	Latitude	Longitude	Mean Precipitation(mm)
765175	17.5	76.5	651.551

III. METHODOLOGY

As per Mckeet et al,. (1993) standard procedure has followed to calculate the Standardized Precipitation Index (SPI).

A. Calculation of SPI

The SPI was developed by Mckee et al,. (1993) to quantify the precipitation deficit for multiple timescales. These timescales reflect the impact of drought on the availability of the different water resources. This advantage is crucial because it can reflect the natural logs in the response of different water resources, such as river discharge and storage; to precipitation anomalies (Paulo et al.2003).

- The SPI calculation for any location is based on the long-term precipitation record for a desired period.

- This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution
- Fitting a Gamma probability density function to a given frequency distribution of precipitation totals for a station
- Estimation of parameters of gamma probability density function for given frequency (1, 3, 6, 9, & 12 months)

$$g(x,\alpha,\beta)=\frac{1}{\beta^{\alpha}*\Gamma(\alpha)}x^{\alpha-1}*e^{-x/\beta}$$

β

are shape & scale parameters and $\Gamma(\alpha)$ –

$$\hat{\alpha}=\frac{1}{4A}\left(1+\sqrt{\frac{4A}{3}}\right)\qquad \hat{\beta}=\frac{\overline{x}}{\hat{\alpha}}\qquad A=\ln(\overline{x})-\frac{\sum \ln(x)}{n}$$

n=number of observations

Integrating the probability density function with respect to x and attach α and β parameters yields the cumulative probability distribution function G(x):

$$G(x)=\int_0^x g(x)\,dx=\frac{1}{\hat{\beta}^{\hat{\alpha}}\Gamma(\hat{\alpha})}\int_0^x x^{\hat{\alpha}}e^{-x/\hat{\beta}} \qquad \ldots(2)$$

Substituting t for $-x/\beta$ yields the incomplete gamma function:

$$G(x)=\frac{1}{\Gamma(\hat{\alpha})}\int_0^x t^{\hat{\alpha}-1}e^{-t}\,dt \qquad \ldots(3)$$

The gamma distribution is undefined for x=0 and q=P(x=0)>0, where P(x=0) is the probability of zero (null) precipitation. Thus, the cumulative probability distribution function becomes:

$$H(x)=q+(1-q)*G(x) \qquad \ldots(4)$$

The cumulative probability distribution function is converged into the standard normal cumulative distribution function so that both of them have the same probability. To avoid the solution derived directly from the pertinent distributions graphs, the Drought classification based on SPI values.

Table.3.1 Drought classification based on SPI values

SPI values	Drought type
SPI> -0.5	Wet
-1.0<SPI≤ -0.5	Mild
-1.5<SPI≤ -1.0	Moderate
-2.0<SPI≤ -1.5	Severe
SPI≤ -2.0	Extreme

IV Results

A. *Drought analysis*

The drought index at multiple scales could reflect drought severity and duration much more effectively than that at monthly scale (Patel et al., 2007). The regional time series of the SPI value is calculated using the mean areal rainfall over the region of Bijapur. The time series of SPI_1, SPI_3, SPI_6, SPI_9 and SPI_{12} are calculated and Graph is plotted as shown in Fig.4.2

Fig.4.2 shows that in Bijapur region extreme drought occurred during 1971,1994 and 2003 and severe drought occurred in 1984,1986 and 2004, and also the different severities even occurred several times in one year, and the droughts and flood took place alternately.

The drought is classified mainly as summer, autumn, spring and winter (Wen and Pang, 2005; Zhai and Wen, 2005; Wen and Jiang, 2007).Table 4.1 shows the extreme drought frequency for different drought types (with SPI values smaller than -2.0 at multiple timescales) in the Bijapur region. It can be observed that the amount of drought in winter and autumn is low compared to spring and summer.

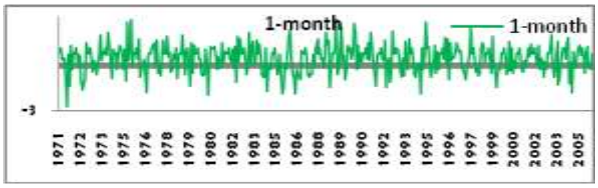
The SPI_1 indicates most of the extreme droughts, followed by SPI_3.SPI at scales larger than 9 months identified most of the extreme spring and summer droughts.

Table 4.1 Extreme drought frequency for different drought types

Region	winter	Spring	summer	Autumn
765175	**4**	**8**	**6**	**5**

B. Graphs

a)



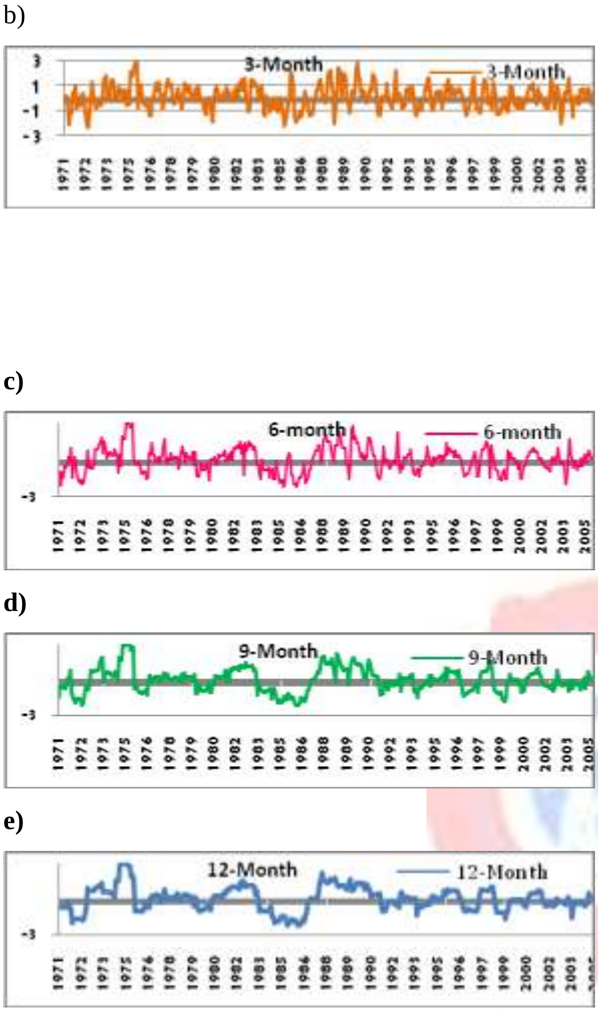


Fig.4.2 SPI time series in Bijapur region of North Karnataka.

C. Correlation coefficient of SPI values with River discharge values

Correlation coefficient of SPI values with River discharge values are mainly done manually in excel sheet with the mathematical equation that is written below

$$R= \frac{[(n(xy)-(x)*(y)]}{\sqrt{[n(\Sigma x^2)-(\Sigma x)^2 * n(\Sigma y^2)-(\Sigma y)^2]}}$$

Where R=Correlation coefficient, x=river discharge value and y= SPI of different time series (1, 3, 6, 9 and 12).

According to Table 4.3 the main conclusions are: Correlation coefficient of SPI values of different time series (1, 3, 6, 9 and 12) with river discharge values are done, correlation coefficient of all the time series values are acceptable, among this results Correlation coefficient of SPI_6 values are greater compare to other SPI time series.

Table 4.3: Correlation coefficient of SPI values with River discharge values

	765175-Kulalwadi
SPI	Correlation
1	0.68
3	0.52
6	0.8
9	0.65
12	0.61

V. Conclusion

In this paper, the standardized precipitation index (SPI) is used to quantitatively evaluate the drought situation based on monthly precipitation dataset of one hydrologic station in Bijapur region.

The main conclusions based on this study are:

A. The SPI1 was found to be effective in revealing
Most droughts over space and time in Bijapur region where as SPI of the larger scales (more than nine months) identified most summer and Summer-autumn droughts.

B. The Bijapur region faces more severe drought in the year 1984, 1986 and 2004 and extreme drought in the year 1971, 1994 and 2003.

C. A high frequency of drought occurrences can be observed in Bijapur region. The study in this paper provides valuable information to regional water resource management and support to the future water allocation.

V .References

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