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Drought Vulnerability Assessment in Jalna (Marathwada Region) using Standardized Precipitation Index

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Abstract: **-- Drought is a weather-related natural disaster affecting vast regions and causing significant structural and non-structural damages. Marathwada Region of Maharashtra, which is mainly located in the main drainage of Godavari River is facing severe drought every year. This region is characterized as a 'frequently drought-prone area', where drought can be expected every 6 to 10 years. Jalna District in Marathwada has a semi-arid climate with an average annual rainfall of 729.7 mm, and an average monsoon from June to September with rainfall of 606.4 mm. During the years 1875–2004, it has experienced drought 18 times, including the two years of successive drought in 1984 and 1985. Rainfall data for Jalna shows great year-to-year variability culminating in the extreme drought of 2012. In most cases, the drivers of droughts are context-specific, often inter-linked and act over different time scales. Therefore, the occurrence of drought must be understood and appropriate drought indices should be investigated for different goals such as agriculture practices, engineering practices and watershed management. This study aimed to identify the type of drought events, determination of drought severity, duration and spatiotemporal extension of drought for the planning of mitigation measures for farmers. Using the Standardized Precipitation Index (SPI) as an indicator of drought severity for the period from 1901 to 2002, the characteristics of droughts were examined. The multiple-time scaled SPI values were evaluated for June –October months in order to obtain severity of drought events over the years. The overall outcome of this study demonstrates that severe and extreme droughts were experienced from time to time across the study area leading to unfavourable results on agricultural practices and water resources in the area.**

Keywords **: - Drought, SPI, Marthawada, Rainfall analysis.**

I. INTRODUCTION

Drought is a period of time with less-than normal rainfall. Drought is a weather-related natural disaster. It affects vast regions for months or years. It has an impact on food production and it reduces life expectancy and the economic performance of large regions or entire country. Drought can also be defined as climatic anomaly, characterized by deficient supply of moisture resulting either from inadequate rainfall, erratic rainfall distribution, higher water need or a combination of all these factors. The escalating impacts of drought includes widespread crop failure, unreplenished ground water resources, depletion of water level in lakes/ reservoirs, leading to shortage of drinking water, reduced food and fodder availability etc.Hence, the occurrence of drought must be understood and appropriate drought indices should be investigated for different goals such as agriculture practices, engineering practices and watershed management. Marathwada Region of Maharashtra, which is facing severe drought every year. It has become the graveyard of farmers. Total number of suicides in January 2016 crossed 1,000 every week 25 to 30 farmers are committing suicide. This should be treated as the national epidemic. Due to less agricultural activities the economy of the nation is indirectly affected. Even if Jalna and the other parts of the Marathwada region has been reeling under chronic drought conditions since many decades, only socio-economic analysis of drought has been carried out till now. However, a more detailed technical analysis of the severity and duration of drought conditions using drought indices would give a better picture of drought scenario in this region.

A Drought Index (DI) is a prime variable for assessing the effect of drought and defining different drought parameters, which include intensity, duration, severity and spatial

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extent. It should be noted that a drought variable should be able to quantify the drought for different time scales for which a long time series is essential. The most commonly used time scale for drought analysis is a year, followed by a month. A number of different indices have been developed to quantify a drought based on precipitation, each with its own strengths and weaknesses. They include the Palmer Drought Severity Index (PDSI); (Palmer 1965), Rainfall Anomaly Index (RAI); (Van Rooy, 1965), Deciles (Gibbs and Maher, 1967), Crop Moisture Index (CMI); (Palmer, 1968) etc. Based on the studies for drought indices, practically all drought indices use precipitation either singly or in combination with other meteorological elements, depending upon the type of requirements, It was found that SPI (Mckee et al,1993) has following advantages over the other indices.

- SPI is spatially invariant in its interpretation, and probabilistic, so it can be used in risk and decision analysis.
- SPI is calculated by rainfall alone so that drought assessment is possible even if other meteor-hydrological measurements are not available.
- The SPI has the ability to quantify precipitation deficit for multiple time scales.
- SPI is standardized and can compare dry and wet periods on different locations.
- SPI is a better predictor of crop production, as it represents the moisture state of soil better.

Hence this study has been taken up to analyze the rainfall pattern and behavior and also to assess the intensity of drought in the Jalna region using Drought Indices with the following objectives.

- To examine the influence of rainfall, water-levels and temperature on drought perceptions.
- To carry out the spatio-temporal extension of drought occurrence using Drought Indices.
- To suggest suitable measures to cope with drought conditions.

II. STUDY AREA

Maharashtra state has a geographical area of 3,07,713 sq.km and is bounded by North latitude 15°40' and and East longitude 22°00' and East Longitudes 72°30' and 80°30'. The State has 35 districts and 353 talukas. Administratively, the State has six divisions with Headquarters at Konkan (New Bombay), Pune, Nasik, Aurangabad, Amravati and Nagpur. The population of the State is 112.3 million as per 2011 Census out of which 41 million is urban and 55.7 million rural. Out of total area of the State, 73 %, i.e., 2.25 lakh, sq. km of area is cultivable and 17.6 % is under forest.

Marathwada Region,which is mainly located in the main drainage of Godavari River is facing severe Drought. Actually, the region is facing the recurrent droughts with constant variations of rains and prolonged gaps. However, the water scarcity this year, especially in Jalna(Bhokardan, Badnapur), Aurangabad, Beed and Osmanabad districts is altogether different from the femine of 1972.

Local perceptions of recent climate trends among farmers and officials in Jalna are that temperature has increased, rainfall has been decreasing, the onset of the monsoon has become delayed and erratic, and the number of rainy days has decreased. Jalna district in Marathwada has a semi-arid climate with an average annual rainfall of 729.7 mm, and an average monsoon from June to September with rainfall of 606.4 mm.

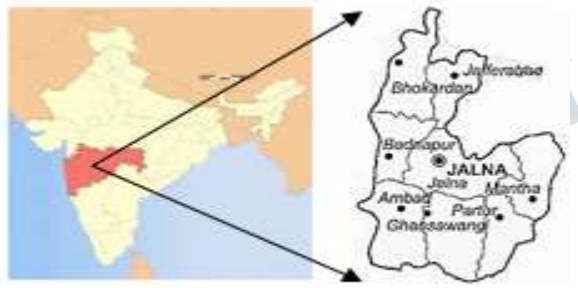

Fig. 1. Location map of Study area (Jalna)

III. METHODOLOGY

In this study, the monthly rainfall data for a period of 1901-2002 was collected from Indian water portal (IMD). Rainfall analysis as well as drought analysis was carried out using the rainfall data.

Rainfall Analysis: The rainfall analysis is done for the purpose of hydrological data processing is not primarily hydrological analysis. However, various kinds of analysis are required for data validation and further analysis may be required for data presentation and reporting. As well as following consideration:

Computation of basic statistics.

Analysis of monthly and annual rainfall.

Drought Assessment Using SPI: A deficit of precipitation impacts on soil moisture, stream flow, reservoir storage, and ground water level, etc. on different time scales. McKee et al., (1993) developed the SPI to quantify precipitation deficits on multiple scales. The nature of the SPI allows an analyst to determine the rarity of a drought or an

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anomalously wet event at a particular time scale for any location in the world that has a precipitation record. A drought event occurs at the time when the value of SPI is continuously negative. The event ends when the SPI becomes positive. Table no.1 provides a drought classification based on SPI. SPI can be calculated using the following mathematical expression. The SPI is calculated by taking the difference of the precipitation from the mean for a particular time scale, then dividing it by the standard deviation.

$$SPI = (Xik - Xi)/ói$$

Where,

ói = Standardized deviation for the "i" th station

Xik = Precipitation for the "i" th station and " k" th observation

Xi = Mean precipitation for the "i" th station

Table no.1:Drought categories using SPI

SPI values	Drought Category
0 to – 0.99	Mild drought
-1.00 to -1.49	Moderate drought
-1.50 to -1.99	Severe drought
-2.0 or more	Extreme drought

IV. RESULTS AND DISCUSSION

Rainfall Analysis: The rainfall analysis is carried out using mothly rainfall data for the period 1901-2002,It is also used for annual, seasonal and monthly analysis and are shown in figures 2-8. The figure 2 shows that the average mean rainfall is 719.34 mm which is shown by the red line. 50% of year was above the average annual rainfall and the remaining 50% was below the average mean rainfall and also the trend is very uncertain.

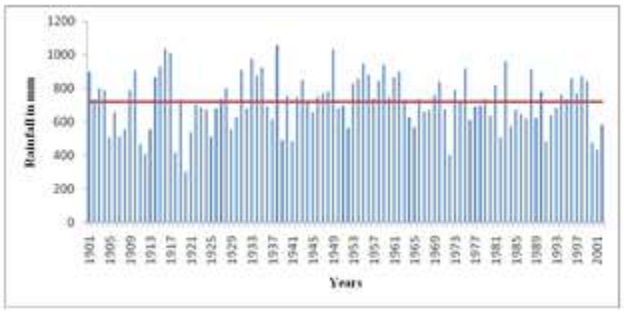

Figure 2 Analysis of annual mean rainfall (1901-2002)

The figure 3 shows that the maximum average monthly rainfall was observed in the year 1938 which was 87.94 mm. The minimum average annual rainfall was found in the year 1920 which was 25.46 mm. The maximum rainfall was found in September which was 196.753 mm and the minimum rainfall was found in February which was 3.706 mm.

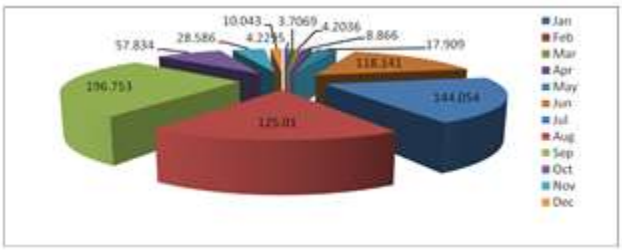

Figure 3 Analysis of average monthly rainfall in Jalna (1901-2002)

Drought Analysis using SPI: A more detailed monthly drought analysis was done using SPI to have a clear picture of agricultural drought during crop growth period (June-September). The figure 4 shows that the graphical data it was found that the most extreme drought was occurred in the year 1920 i.e (SPI index was -2.61) which comes in to the category of Extreme drought condition and its standard range is n > -2.Severe Drought Conditions was observed for 7 years in the study area whose SPI range lie between -1.5 to -2.For Moderate Drought Condition 10 years were observed whose range lie between -1 to -1.5.For Mild Drought Condition 30 years were observed whose range lie between 0 to -1.

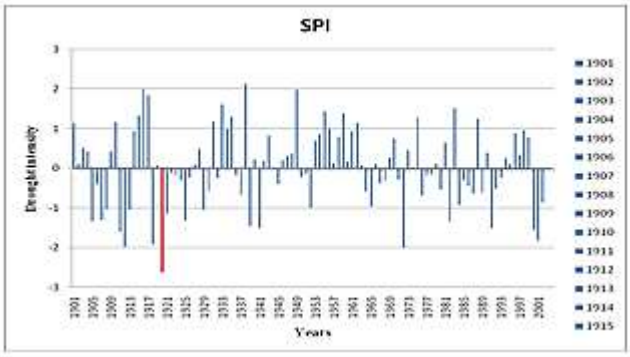

Figure 4 Analysis of annual SPI in Jalna (1901-2002)

It was found that the most extreme drought was occurred in the year 1941 i.e (SPI index was -2.09) which comes in to the category of Extreme drought condition and its standard range is n > -2.Severe Drought Condition was observed for 4 years whose SPI range lie between -1.5 to -2. For Moderate Drought Condition 10 years were observed whose

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range lie between -1 to -1.5.For Mild Drought Condition 36 years were observed whose range lie between 0 to -1.Almost 54 years were drought affected.

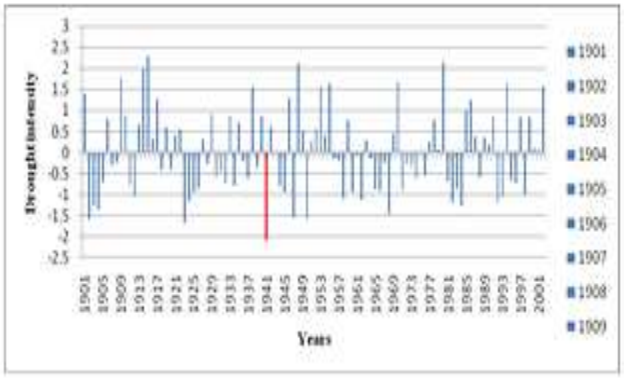

Figure 5 Analysis of SPI June (1901-2002)

The figure 6 shows that the most extreme drought was occured in the year 1971 i.e (SPI index was -2.34) which comes in the category of Extreme drought condition and its standard range is n > -2. Severe Drought Condition was observed for 8 years whose SPI range lie between -1.5 to -2. Moderate Drought Condition 3 years were observed whose range lie between -1 to -1.5. Mild Drought Condition for 32 years were observed whose range lie between 0 to -1. Almost 52 years were drought affected.

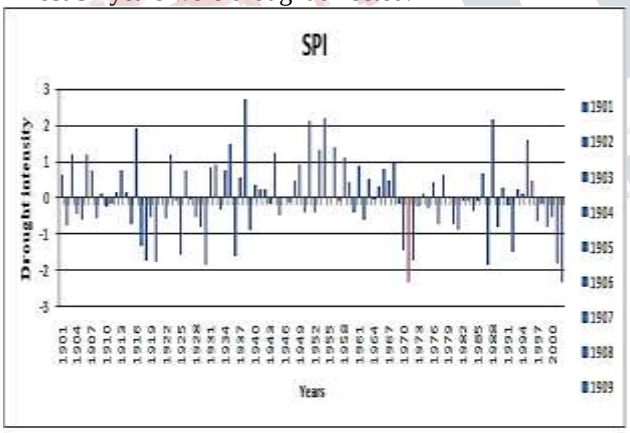

Figure 6 Analysis of SPI July (1901-2002)

No extreme drought was found in July month(Figure 6). However, severe drought Condition was observed for 2 years with SPI range between -1.5 to -2. For Moderate Drought Condition 17 years were observed whose range lie between -1 to -1.5.For Mild Drought Condition 32 years were observed whose range lie between 0 to -1. Almost 61 years were drought affected.

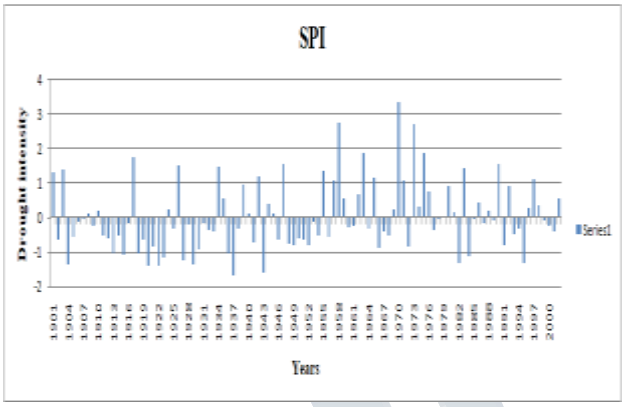

Fig.7 Analysis of SPI August (1901-2002)

The figure 8 shows that the graphical data it was found that the no extreme drought was found for Extreme drought condition. Severe Drought Condition was observed for 2 years whose SPI range lie between -1.5 to -2. For Moderate Drought Condition 18 years were observed whose range lie between -1 to -1.5. For Mild Drought Condition 32 years were observed whose range lie between 0 to -1. Almost 55 years were drought affected.

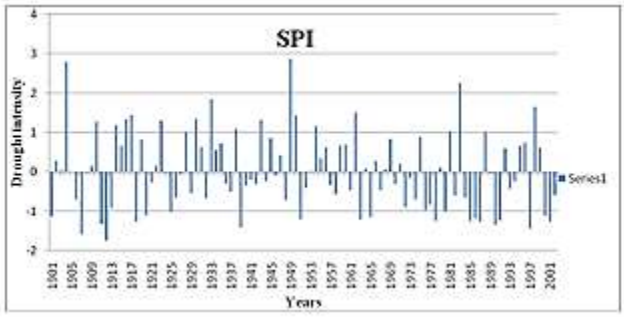

Figure 8 Analysis of SPI September (1901-2002)

V. CONCLUSION

The present study concerned the assessment of drought index and the spatio-temporal behavior of SPI in a chronically drought prone region (Jalna district) of Aurangabad, India. The SPI maps revealed that drought in both the pre-monsoon and post-monsoon periods varies from extreme drought conditions to mild drought conditions in all most all the years under observation.

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