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Assessment and Characterization of Meteorological Drought using Standardized Precipitation Index in the Upper Luni River Basin, Rajasthan

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ABSTRACT: Drought is one of the most critical natural disaster that affects the human being as well as the animals and their impacts are being forced by the rise in water demand and the changeability in meteorological parameters due to climate change. Over the past decades, droughts are increasingly becoming a critical constraints. Therefore, it is essential to develop an appropriate drought assessment approach suitable for respective regions. The present work focuses on characterization of meteorological drought in the Upper Luni region of Rajasthan. It has been done on the basis of onset, persistence and severity of drought. SPI for overlapping period of 3 months has been used for defining and monitoring of metrological drought in 6 district of region over the period 1979-2008.The spatial maps of SPI were generated by interpolating monthly SPI values of all the 42 station using IDW interpolation. The drought maps depicted spatial patterns of metrological drought, its probability of occurrence in different month, severity, and persistence. The results of drought characterization revealed that the probability of occurrence of meteorological drought in the region varies from 0 to 50 % with highest probability of drought occurrence in the months of July and August.

I. INTRODUCTION

Drought is a natural disaster phenomenon that has signify-cant impact on socio-economic, agricultural, and environ-mental spheres. It is different from other natural hazards by its slow accumulation process and its indefinite commencement and termination (Bhuiyan, 2004). 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. Besides, the concept of drought varies among regions of differing climates (Dracup, Lee, & Paulson, 1980). In general, drought gives an impression of water scarcity resulted due to insufficient precipitation, high evapotranspiration, 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 parameter's, and identify and classify drought accordingly. How-ever, since these parameters are not linearly correlated with each other, correlation among various kinds of drought is also difficult. Rainfall has a direct impact on water re-sources, particularly in hard-rock hilly terrains like the Aravali of semi-arid western India where monsoon-rainfall is the only possible mean for ground water recharge. A continuous spell of poor rainfall in successive years in combination with high temperature affects ground water recharge and imparts stress on ground water resources leading to severe drought in many parts of this terrain. The present study aims to analyse the effects of precipitation on aquifer re-charge and vegetation of the Aravali terrain. In the present study, regional aspect of drought has been addressed. Spatiotemporal variation of seasonal drought patterns and drought severity in the Aravali Terrain has been analyzed using Geographical Information System (GIS) (McKee, Doesken, Kleist, & others, 1993) developed the Standardized Precipitation Index (SPI) to monitor the status of drought .This conclusion is based on the sensitivity of the SPI to emerging precipitation deficits at shorter time scales (e.g. 3 months).

Through their socio-economic impacts on affected areas, droughts are recognized as such when they become natural disasters.

However, they differ from most other natural dis-asters because their recurrences in drought-prone areas every few years is practically certain. They also differ by lacking sudden and easily identified onsets and termination. Droughts vary widely in degree of severity, duration and aerial extent. In order to predict the drought conditions at next moment of time one can use the rainfall datasets. In corporating spatial-temporal aspect, this study aims at studying the Spatial-temporal variation of drought patterns and drought severity using SPI Drought Index.

Assessment of Metrological Drought Index trough SPI Standardized Precipitation Index is an easy Process which required. Very less time for assessment because it requires Precipitation parameter only. Here an attempt is made to understand the Metrological Drought characterization and drought probability. The overall objective of the present study is to find the relation in past and future drought events which is find out with the help of drought severity, probability, persistence and events of drought.

Droughts are characterized into numerous aspects. Some of the drought elements include drought severity, duration, frequency, magnitude and spatial distribution. Although these terms may be described differently, the following definitions provide their precise meaning. Drought severity refers to the extent of precipitation deficit in terms of magnitude of impact result from precipitation deficit. In addition, Drought severity can be mathematically defined as a product of its magnitude and duration. Drought duration on the other hand refers to any continuous period of sequence with deficit of water below a defined level. Intensity is the ratio of the drought magnitude to its duration. Drought frequency also called return period of a drought is the mean time period between two consecutive drought events that have the same severity either equal or greater than a defined threshold. Magnitude refers to accumulated water deficit in terms of precipitation, soil moisture, runoff, stream flow, water reservoir levels and ground water below a certain threshold level for a given duration. Spatial distribution is the geographical extent in terms of areal coverage of drought which is variable during a drought event (Wambua, Makobe, Njue, & Nyende, 2011).

Assessment of Metrological Drought Using Standard Precipitation Index In The upper Luni river basin Rajasthan for Balotra region.

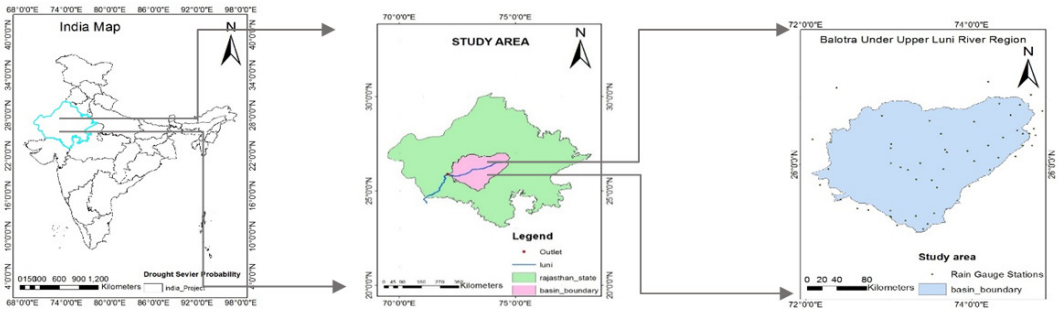
To develop a better understanding of past drought events in the region. Identify drought sensitive regions through characterization and probability analysis of historical climatological data. Research question is How to assess metrological drought? How to generate probability maps for droughts of different characteristics? How to quantify drought and rainfall datasets in terms of data descriptor? How to incorporate rainfall datasets? Which method should be used for drought estimation? Which method is required less data for drought estimation? Which method is easy and less time consuming and most suitable for drought estimation.

II. STUDY AREA

Rajasthan state is situated between 230 30' – 300 11' N and 690 29'- 780 17' E at the northwestern region of India, covering a widespread area of 3, 42,239 km2 (10.4% of the country). Part of Upper Luni River Balotra region. Balotra district is one of the districts of Rajasthan state in western. Which has Rain gauge Station name is Balotra, its Tehsil is Balotra & District is Barmer, State is Rajasthan. Latitude is 25°49′25″ N and Longitude is 72°13′24″ E having Altitude of 102.00m.Having Independent river Luni (Non Perennial) River width is 500 m, Catchment area is 19000.00km^2.

Data Sets Used. Cartosate DEM from www.bhuvan.govin , LULC map from (IGBP) (scale: 1:50,000), Meteorological data (Rainfall) From Rajasthan State Government Department over the period of (1979-2008).

Softwares Used. Arc GIS, MS Excel.



III. METHODOLOGY

To estimate the metrological drought with the help of SPI (Standard Precipitation Index) Using rainfall data as an in-put parameter, balotra region, there one active rain gauge station. Thirty years data (1979-2008) have been use for assessment of drought. Monthly precipitation data are selected for balotra region in. Methodology section includes the calculation of the rainfall declines and SPI index at 3 month. By the analysis we will get the drought prone years in particular regions. Also from the trend analysis we will get to know the starting and ending period of drought in particular region. The calculation of several drought indices, the widely used Standardized Precipitation Index (SPI). The common characteristic of the selected indices is that they require relatively small number of data for their calculation and the results can be easily interpreted and used in strategic planning and operational applications. For the calculation of the indices in monthly basis, data may be either annual or monthly, while for calculations in seasonal basis (monthly, 3-months some step), monthly data are required. Regarding the monthly data files. Based on the SPI developing concepts, for characterizing hydrological drought. Hydrological year is from June to august of every next year, and so four overlapping time periods (hereafter as reference periods) are utilized within each hydrological year: October–December, October–March, October–June, and October–September (one complete hydrological year)

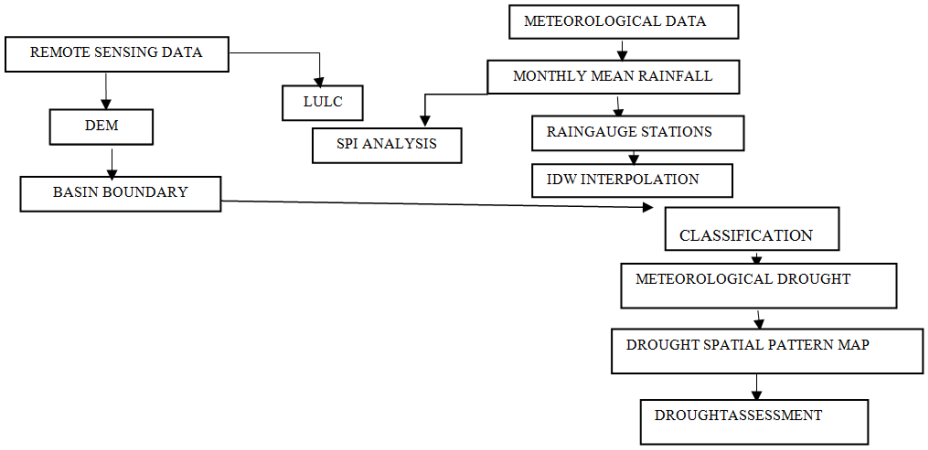


Fig. 1. Flowchart for drought assessment.

IV. RESULT AND DISCUSSION

Drought years according to SPI value

According to SPI value the drought severity have been categories by three classes. i.e., Moderate, severe and extreme drought. In this paper the SPI value is found out at 3month.

After analyzing 3 month SPI value, the commonly occur severe drought was in AUGUST 1980,,AUGUST 1983,,JUNE 1986,JULY 1987,AUGUST 1983,AGUST 1980,JUNE 1985,JUNE 2001,JULY 2002 in maximum stations , extreme drought occurred in balotra region. Table 5.1 shown below:

SPI and drought. The interpolated maps of the SPI, for typical drought and wet years have been presented to show the pattern of SPI during these years (Figure 1 and 2). The 3-month SPI for the months of June, July and August. Show the temporal dynamics of below and above normal precipitation distribution in balotra region. It can be seen that during the drought years of 1980 to 2002, negative SPI values noticed, which indicate that there was rainfall deficit in the area during monsoon season, i.e. negative SPI values shows, with a majority of areas having an SPI value below −2.0. Thus, the spatiotemporal evolution of the SPI clearly indicates that 1980 was a severe drought year taking into account the magnitude, duration and extent of a negative SPI.

SPI and drought severity. The interpolated map of the 3-month SPI for the month of June, July and August was classified into severity classes (Table 7) for 1979 2008 years. The classified maps show that 1980 had a drought up to class 3, indicating severe drought, whereas 2002 had extreme drought. It is, therefore, inferred that the 3-month SPI for June, July and August is well suited to categorize the severity of seasonal drought in balotra. The usefulness of the SPI to characterize severity of seasonal and long-term drought is mainly attributed to an ability of the SPI to quantify dry spell and wet spell at multiple time scales. Many studies have also demonstrated that a short-term (3-month).

Apart from interpreting meteorological drought from the SPI, the effect of drought on production was also analyzed. The 3-month SPI for June, July August within each district.

Drought risk assessment based on the SPI. The 3-month SPI map of June, July and August for individual years provides information on the severity of seasonal drought only. Therefore, all 30 years of the 3-month SPI. **Drought severity**-It gives the severe drought events like (from the table 7) June1986, June1985, June2001, July1987, July2002, August 1980, August1983, August1983, August 1980 are the severe drought years.

Drought probability. It is the probability of the drought return like surpura station of Jodhpur district has 40% of drought probability.

Drought events. It is shown in the form of 0 or 1, like if drought occur that shows in 1, if drought is not than shows in 0, here drought events for the month of June (E1) July (E2) and August (E3) are shown in the table 3,5 and 6.

Drought persistence. It means for what period is drought persist more like here.

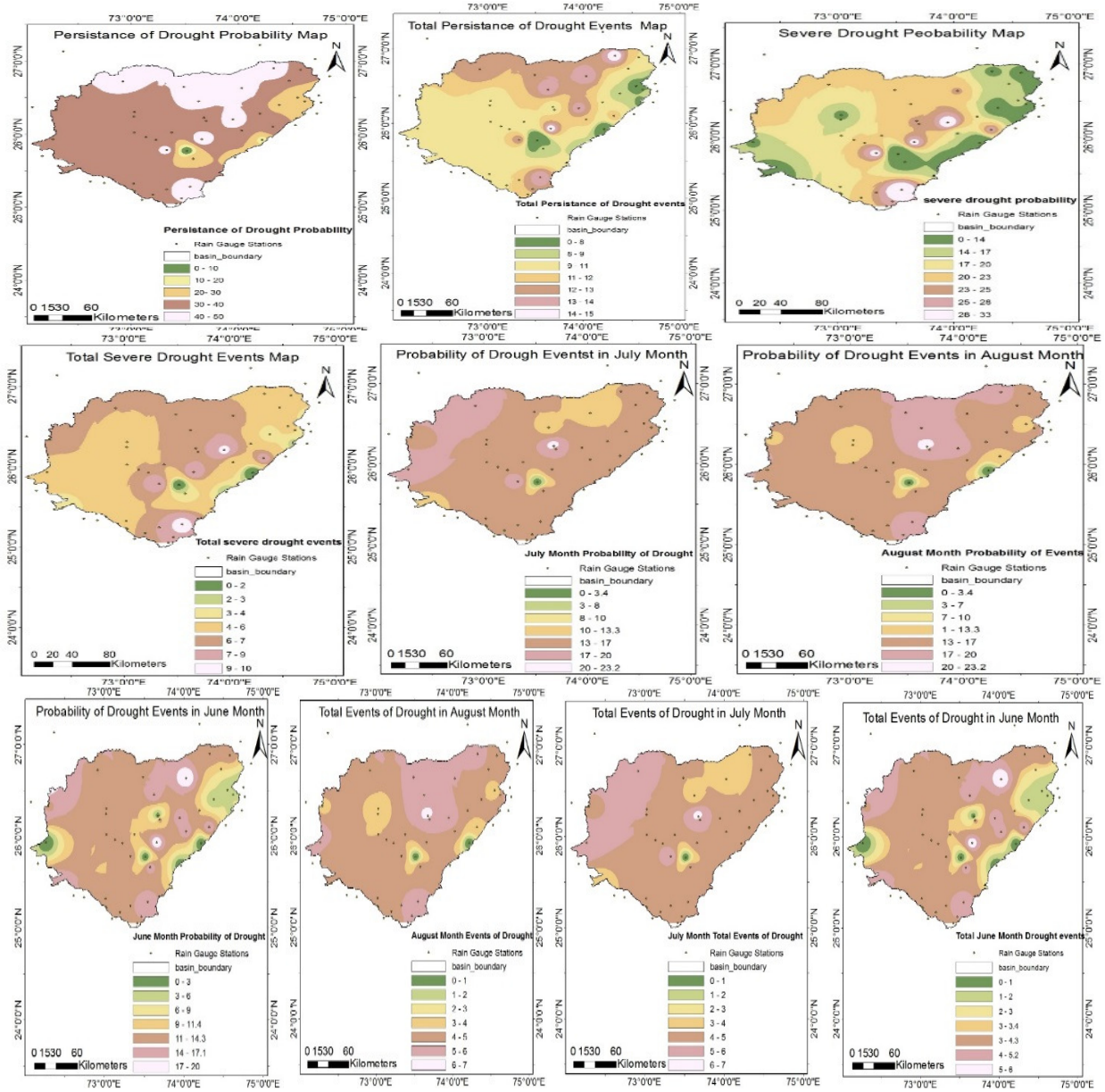


Fig. 2. Persistence & Severity total Event and Probability Map and Probability and Events Map of June July and August or Drought assessment of 1997-2008 drought in balotra region using SPI 3-month.

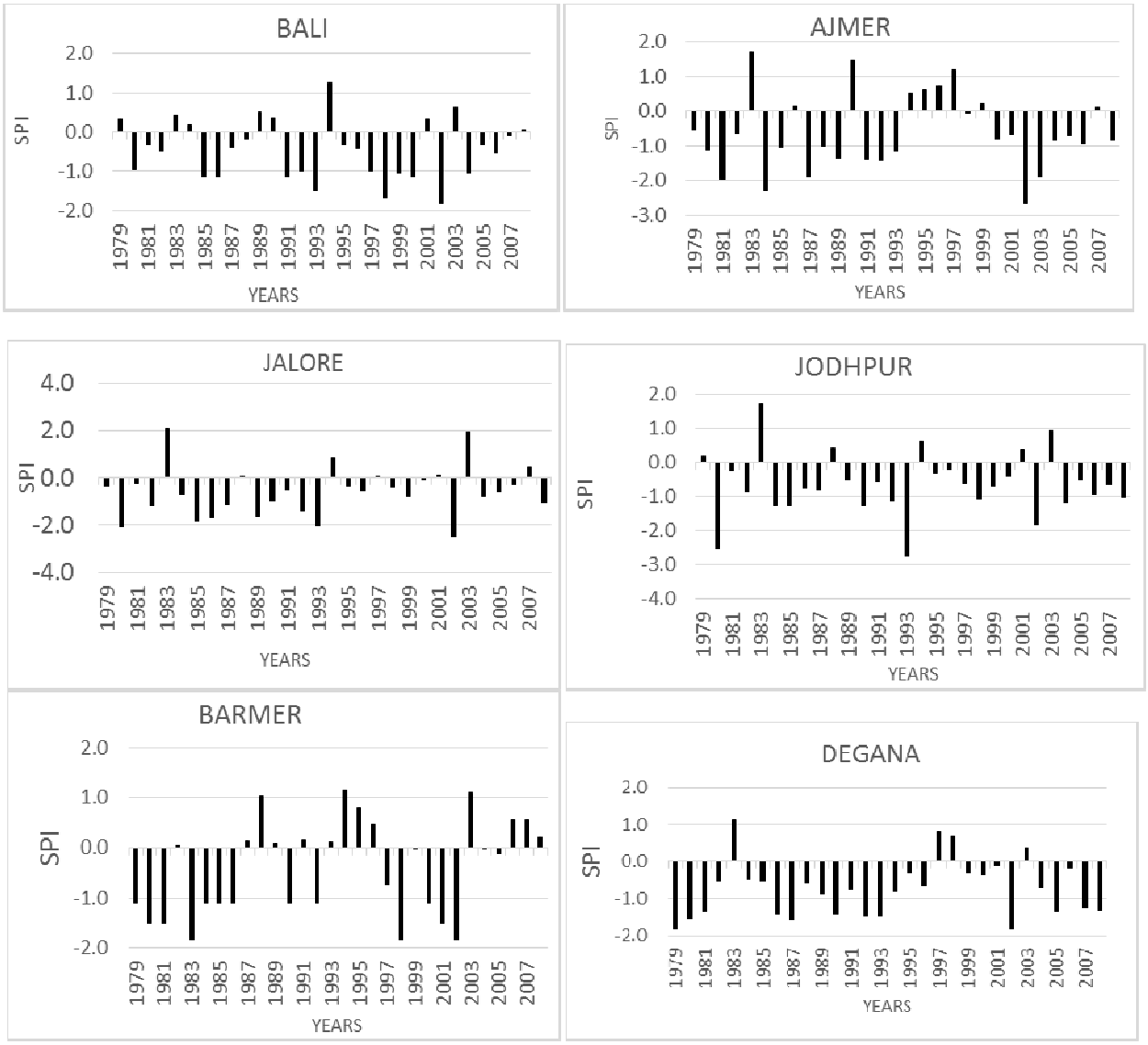
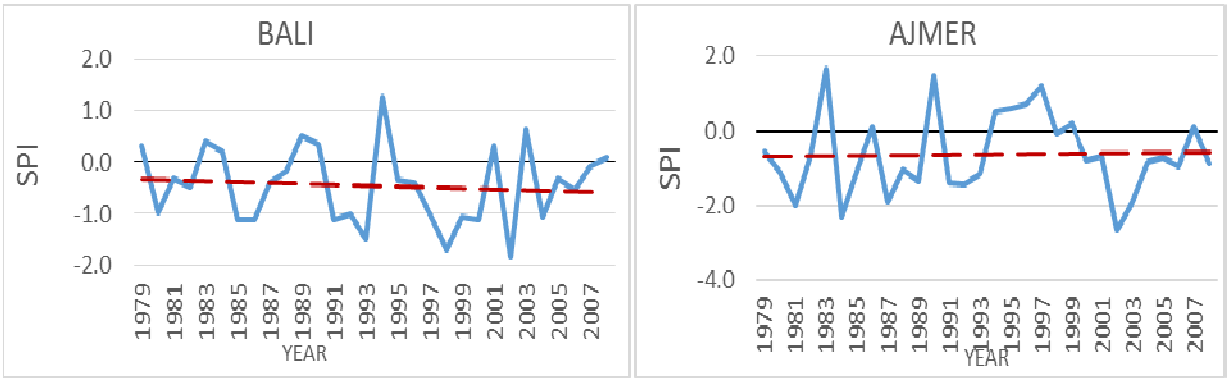


Fig. 3. Bar chart showing the Time Series of 3 month SPI of all stations for the Period of 1979-2008.



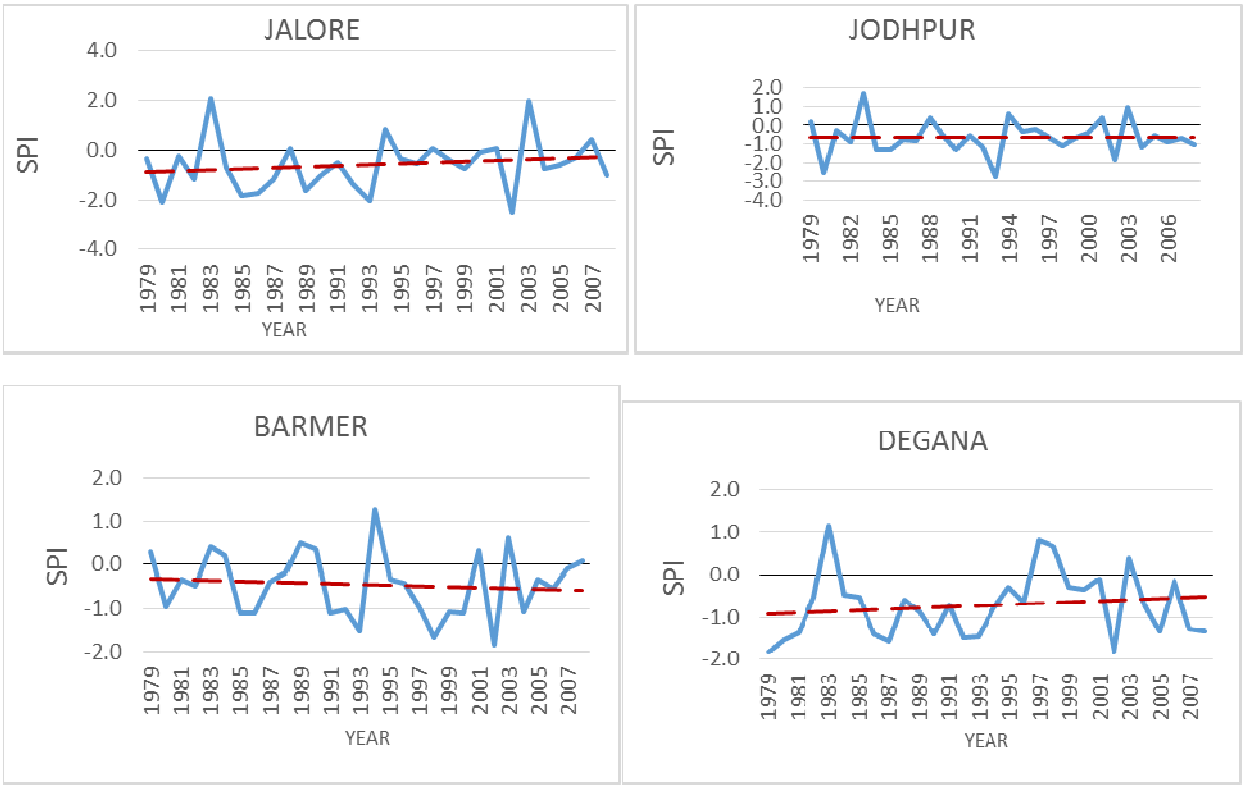


Fig. 4. Line Graph all Districts or Three-month SPI for drought years and wet years, it's showing Mild Drought, Where blue line is showing the variation in SPI values with respect to years (from 1979 to 2008) and maroon line is showing the trend line of this graph.

V. CONCLUSSION

This study estimated hydrological droughts by using the standardized drought index in balotra region over the period 1979–2008. Fig.5.1 Showed that the probability distribution for the drought. Furthermore, analysis based on the SPI for 3 month periods indicated that almost all the stations experienced extreme droughts during the study period. The extreme drought events occurred mainly in the last years from 1980 to 2002, were the driest years during the examined period. Metrological Drought Assessment in Balotra region. The performance of SPI at various time scales in representing drought identification dry periods. For this study, it is better to use SPI 3 month index for analysis of drought. There was more extreme drought situation in balotra region. Therefore, there is need to allocate more water resources to balotra region. Drought analysis shows that there was no. of significant view observed and also dry periods are there.

According to drought analysis in all stations there was rainfall much below normal during July and august months. As per map and SPI values analysis, drought period was observed from 1980 to 2002 in balotra region because Severity of drought is increasing from 1980 to 2002. From the above study it is concluded that SPI index are useful for assessment of drought and can be utilized drought situation. The SPI at a 3-month time-scale was found effective in capturing seasonal drought patterns. This is evident from the unique ability of the SPI to categorize year 1979 to 2008 as 1980 and 2002 the worst drought in the last 30 years. Further, the present study concludes that the 3-month SPI of June, July and August, is a good indicator in drought prone areas. However, the 3- month SPI has short period of rainfall data used to derive the SPI.

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