Monitoring of Drought Event by Standard Precipitation Index (SPI) in Rajkot District, Gujarat, India

[1]Rahul Rachchh, [2]Neelkanth Bhatt
[1]P.G. Student, [2]Assistant Professor of Civil Engineering
[1]Department of Civil Engineering, L. E. College, Morvi, India
[2]Department of Civil Engineering, Government Engineering College, Rajkot, India
[1]rahulrachchh@gmail.com, [2]neelkanth78bhatt@gmail.com

***Abstract*- Drought is a slow onset phenomenon that affects people's socio-economic activities to a great extent. It is one of the most dangerous natural hazards because it is very difficult to identify its onset. In India, Gujarat is one of the states which face the drought generally once in three years. Therefore, monitoring of drought by various drought indices has a great potential in mitigation the future droughts. In this paper the Standard Precipitation Index (SPI) has been used to monitor drought in Rajkot district, Gujarat, India. The Standard Precipitation Index has been calculated for 3-month, and 6-month time scales to decide the effect of water scarcity on the various natural resources. The SPI value will give information about drought characteristics i.e. severity, frequency and spatial extent for Rajkot district. The monthly rainfall data of 5 rainfall stations named Morbi, Rajkot, Lodhika, Jasdan, Gondal, has been collected for the period of 1981-2010 to calculate the Standard Precipitation Index (SPI). The results suggest that the Rajkot region had felt severe drought in 1987 A.D. On an average there is a condition of drought in Rajkot district once in two years. It can be also concluded that since 2005 Rajkot district has not felt any major drought.**

***Index Terms*- Drought, Standard precipitation Index (SPI), Rainfall**

I. INTRODUCTION

It is very difficult to give the precise definition of drought due to its varying characteristics region by region. It is generally considered as a 'prolonged period of water scarcity' that adversely affects the social, economical, agricultural and other activities of the society to a great extent [1]. It is very difficult to find when it creeps in, how long it could last and also its severity cannot be predicted prior to its onset [2]. So, one of the way to mitigate drought is to decide its characteristics based on past drought events in a particular region and then have a preparedness plan. The Indian national commission on agriculture (1978) has categorized drought into three types, which are as under.

1. Meteorological drought
2. Hydrological drought
3. Agricultural drought

The drought is a recurrent disaster in India. On an average 28% of the geographical area of the India is vulnerable to drought [3]. Meteorologically, ±19% deviation of rainfall from the long term mean is considered 'normal' in India. Deficiency in the range 20-59% represents 'moderate drought', and more than 60% deviation is considered as 'severe' drought [3]. In India 68% of the net sown area is drought prone in varying degree, out of which 35% area, which receives rainfall between 750 mm and 1125 mm, is considered as drought-prone area, while another 33%, which receives less than 750 mm rainfall, is called chronically drought prone area [4]. In India drought- prone areas fall in three broad regions of the country: the plateau region, which embodies the state of Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Tamil Nadu, Bihar, West Bengal and Uttar Pradesh; the desert region, which embodies the states of Rajasthan and Gujarat; and a few districts in the states of Haryana and Jammu Kashmir [5].

Gujarat has long history of severe droughts. In 1999, as many as 98 out of a total of 225 blocks in the states received less than 50% of the season's expected rainfall. In 1999, Gujarat faced the worst drought of the past 100 years. Some 7,500 villages spread over 145 blocks in 15 districts were severely affected. The state has been hit by the worst drought in 100 years. More than 25 million people living in 9,000 villages of 17 of the 25 districts have been hit. Though Saurashtra has always been drought prone, this year the districts of Jamnagar, Rajkot, Junagadh, Amreli, Bhavnagar, Surendranagar and Porbandar have also been badly affected. Almost all water sources have dried up; there is no food for the people and no fodder for over 7 million cattle. The water table in drought affected Saurashtra, Kutch and northern Gujarat is said to be falling by 10-15 feet each year [7].

II. DROUGHT INDICES

Drought is generally recognized through its consequences. However it requires a scientific approach to decide quantitative shortage of water. A Drought index value is a single number used for decision making. There are several drought indices that measure on how much precipitation for a given period of time has deviated from historically established norms. Here we have used Standard Precipitation Index (SPI) used for meteorological drought.

McKee et al. (1993) developed the Standardized Precipitation Index (SPI) for the purpose of defining and monitoring drought. The SPI assigns a single numeric value to the precipitation, which can be compared across regions and time scales with markedly different climates. SPI is calculated from the long term record of precipitation in each location (at least 30 years). Technically, the SPI is the number of standard deviations that the observed value would deviate from the long-term mean, for a normally distributed random variable. Since precipitation is not normally distributed, a transformation is first applied so that the transformed precipitation values follow a normal distribution.

The SPI was designed to quantify the precipitation deficit for multiple time scales. (McKee et al., 1993) originally calculated the SPI for 3, 6, 12, 24, and 48 month time scales. The drought time scales used in SPI calculation reflects effects on five water usable sources namely; soil moisture, streamflow, groundwater, snowpack and water in reservoirs. Meteorological and agricultural droughts, which have impact on precipitation and soil moisture respectively, are usually linked to short term time scale which are 3 and 6 month SPI's. The long term time scale which are 12-month SPI or more are associated with hydrological droughts which have an impact on streamflow and reservoir levels. The short term durations are important to agricultural interest while long terms are important to water supply management interest.

The 3-month SPI provides a comparison of the precipitation over a specific 3-month period with the precipitation totals from the same 3-month period for all the years included in the historical record For instance, a 3-month SPI for December uses the precipitation total of October, November and December in that particular year. A 3-month SPI reflects short and medium-term moisture conditions and provides a seasonal estimation of precipitation.

The 6-month SPI compares the precipitation for that period with the same 6-month period over the historical record. The 6-month SPI indicates medium-term trends in precipitation. A 6-month SPI can be very effective showing the precipitation over distinct seasons. Information from a 6- month SPI may also begin to be associated with abnormal stream flows and reservoir levels.

A 12-month SPI or longer is a comparison of the precipitation for 12 consecutive months with the same 12 consecutive months during all the previous years of available data. The SPI at these time scales reflect long-term precipitation patterns. Because these time scales are the cumulative result of shorter periods that may be above or below normal, the longer SPIs tend toward zero unless a specific trend is taking place. SPIs of these time scales are probably tied to streamflow, reservoir level, and even groundwater levels at the longer time scales.

Table 1: Standard Precipitation Index

SPI Value	Drought category
2.0 +	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 or less	Extremely dry

(Source: United States National Drought Mitigation Center)

III. STUDY AREA

As per the information provided by Rajkot District Panchayat, Rajkot district is one of the 26 districts of the State of Gujarat. The district is surrounded by Rann of Kutchh on north side, by Bhavnagar and Surendranagar districts on east side, by Junagadh and Amreli districts on the south side and by Jamnagar district on the west side. It is located at 20.57 north latitude to 23.07 east latitude and between 70.20 east longitude to 71.40 north longitude. The main sources of water in district are rivers and wells.

IV. METHODOLOGY

The SPI for 3-month, 6-month time scales was calculated for each station using the program developed by the United States National Drought Mitigation Center (NDMC) to calculate SPI. The monthly rainfall data for 5 stations were arranged according to format defined by the National Drought Mitigation Center to have input to SPI program.

V. V. SELECTION OF DROUGHT SENSITIVE STATION

Since the onset of monsoon starts generally from June in Gujarat, value of 3-month SPI for the month of August and value of 6-month SPI for the month of November for the period of 1981-2010 has been used for the selection of drought sensitive station.

VI. RESULT AND DISCUSSION

The SPI value for 3-month, 6-month and 12-month time scales has been calculated for all months for period of 1981-2010 for all 5 stations. Here 3-month SPI value for the month of August and 6-month SPI value for the month of November has been presented through graphs for all stations for period of 1981-2010.

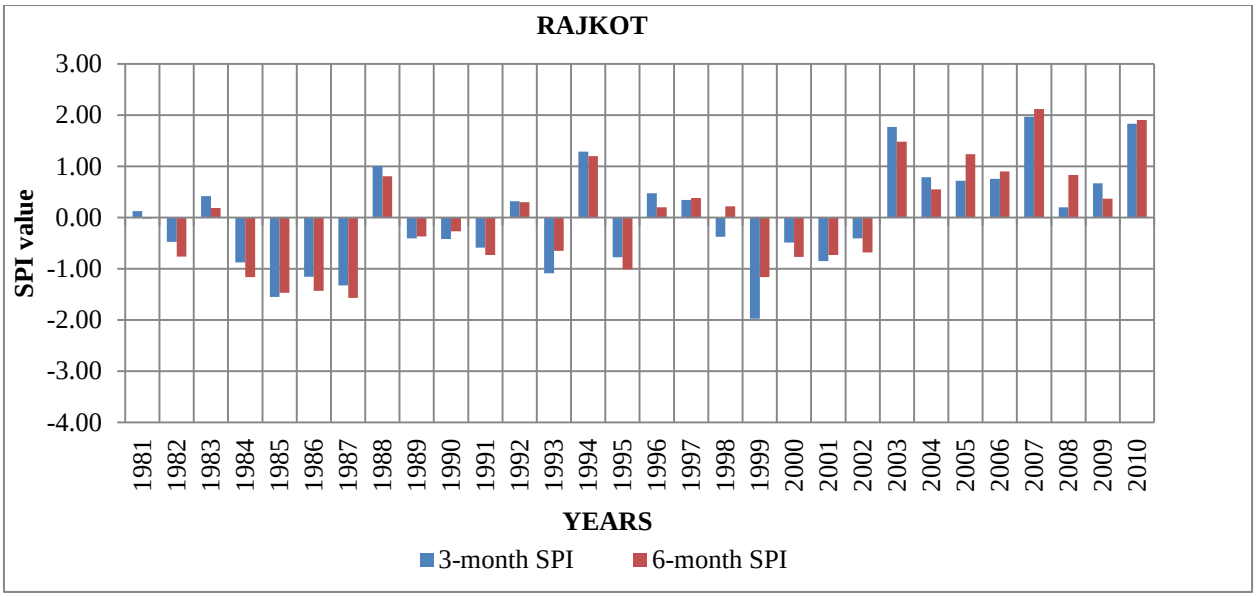

Fig. 1 SPI values for Rajkot station for period 1981-2010.

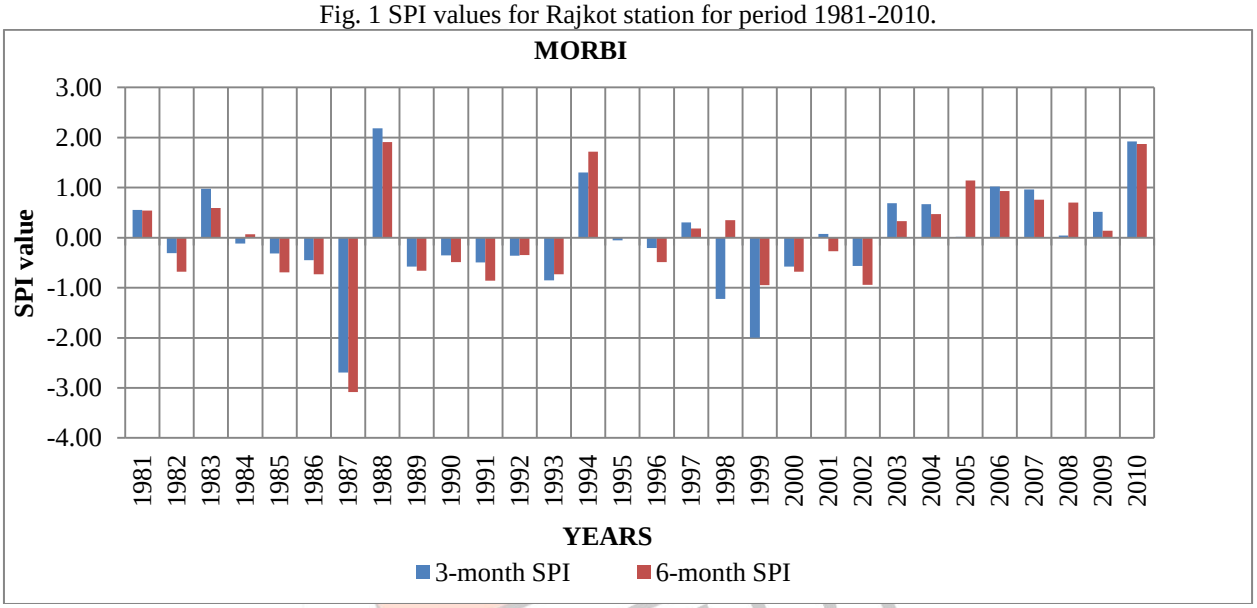

Fig. 2 SPI values for Morbi station for period 1981-2010.

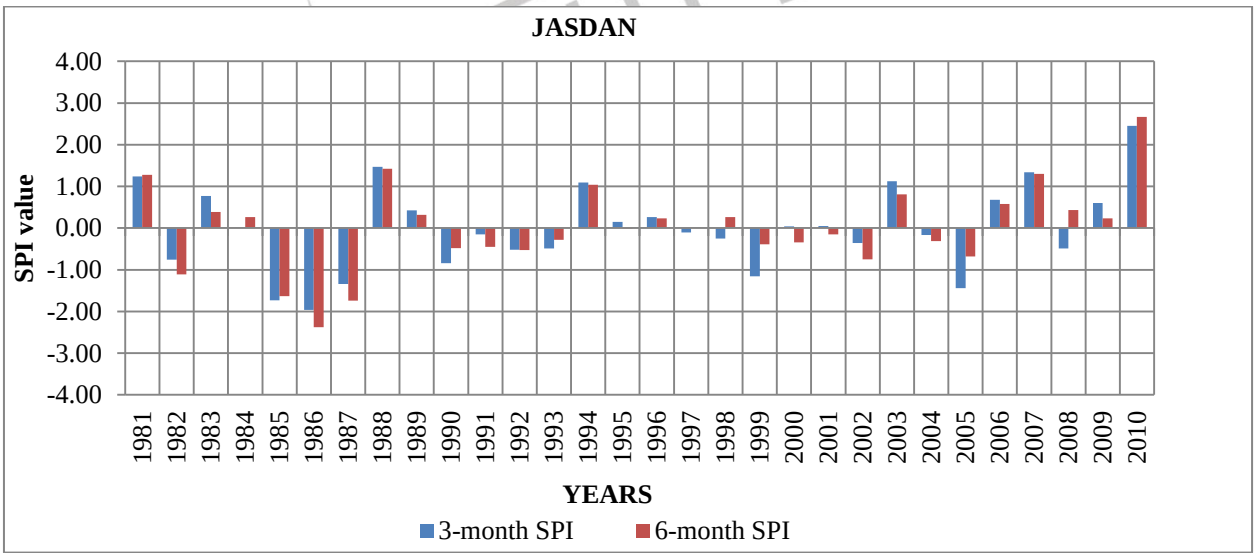

Fig. 3 SPI values for Jasdan station for period 1981-2010.

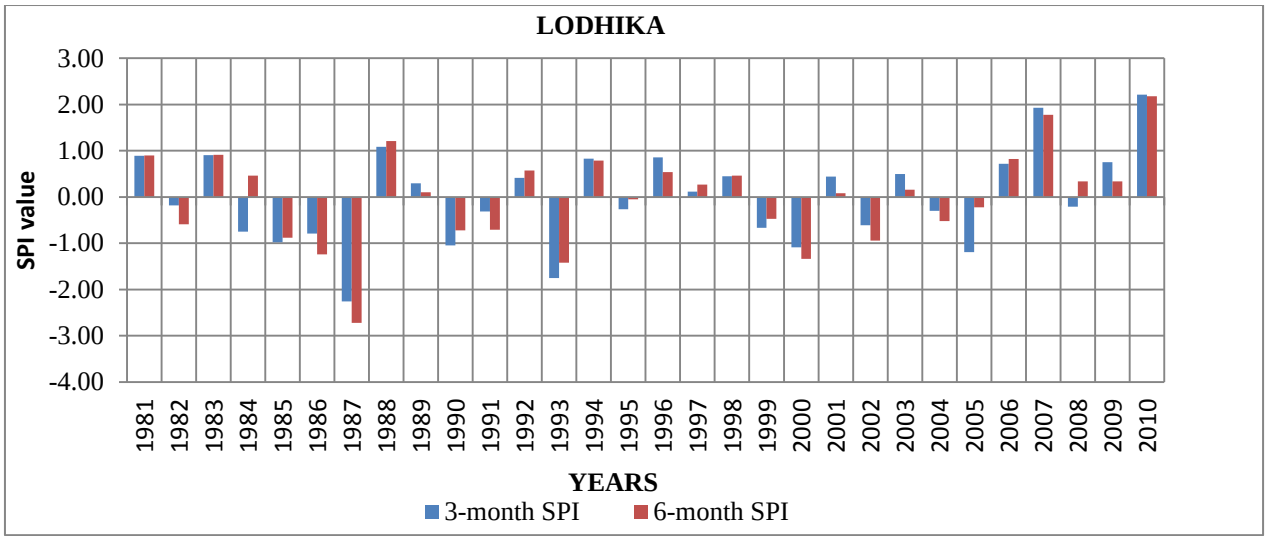

Fig.4 SPI values for Lodhika station for period 1981-2010.

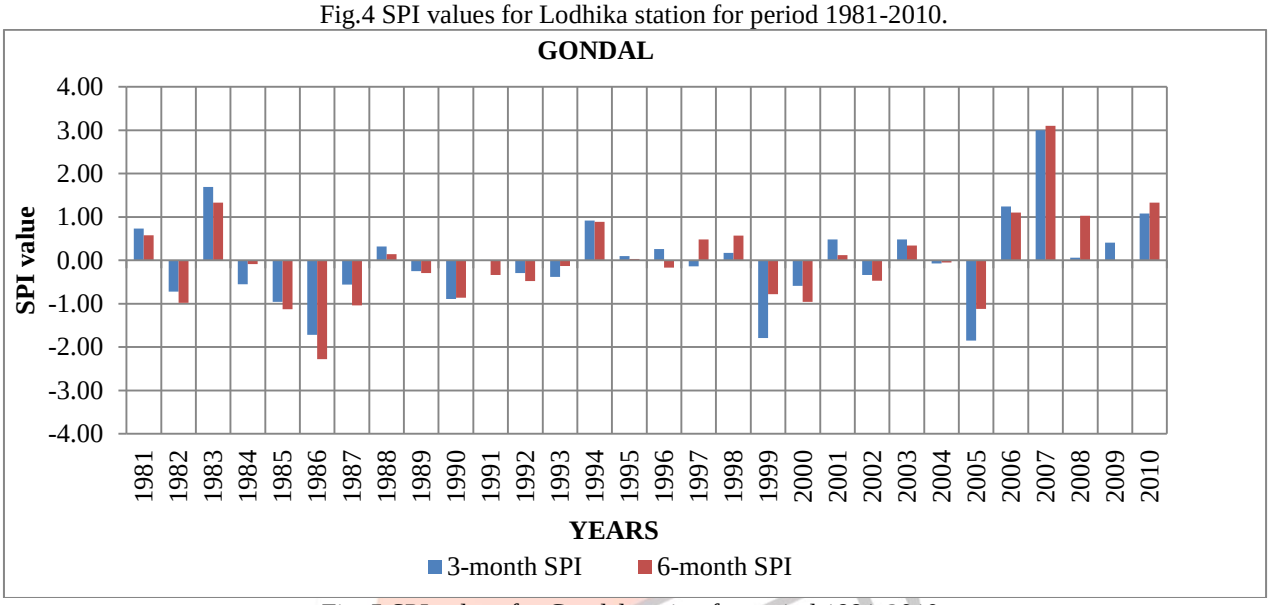

Fig. 5 SPI values for Gondal station for period 1981-2010.

VII. VII. CONCLUSION

From the graphs of SPI it can be concluded that,

1. Rajkot station had felt drought condition for four consecutive years from 1984 to 1987 and from 1999 to 2002, where 1987 and 1999 had been the driest years for Rajkot station for period 1981-2010.
2. Morbi station had felt severe drought in years 1987 and 1999.
3. Jasdan, Lodhika and Gondal stations had felt drought condition for three consecutive years from 1985 to 1987, where 1986 had been the driest year for all three stations for period 1981-2010.
4. The other drought years were being 1982, 1984, 1985, 1986, 1990, 1991, 1992, 1999, 2000, 2002 and 2005 for Rajkot district.
5. There has been not any major drought for all stations since 2005.
6. On an average there is a condition of drought in Rajkot district once in two years.

REFERENCES

[1] Anil K. Gupta et al., "Drought disaster challenge and mitigation in India: strategic appraisal", Current Science, Vol. 100, No.12, 25 June 2011, pp 1795-1806.
[2] Zarna J. Chovatiya, "Mapping of drought using geographic information system", Proceedings of 1st National Conference on: Technical Research Advances in Civil Engineering @ Ldpr-Itr, Gandhinagar, 2011.
[3] Samra. J. S, "Review and analysis of drought monitoring, declaration and management in India, Working Paper 84, Colombo, Sri Lanka: International Water Management Institute", 2004.
[4] Manual for drought management, Department of Agricultural And Cooperation, Ministry Of Agricultural, Government of India, New Delhi, November 2009.
[5] R. P. Pandey & K. S. Ramasastri, "Incidence of droughts in different climatic regions", Hydrological Sciences, 47(S), August 2002.

[6] M. Svoboda et al., "Standardized precipitation index user guide", World Meteorological Organization, 2012
[7] N. R. Patel, P. Chopra and V. K. Dadhwal, "Analyzing spatial patterns of meteorological drought using standard precipitation index", Meteorological Application, 2007, 14, pp 329-336.
[8] National disaster management guidelines, Management of Drought, National Disaster Management Authority, Government of India.
[9] Website: http://rajkotdp.gujarat.gov.in/Rajkot retrieved on 02-03-2014.
[10] Website: http://www.drought.unl.edu/monitor/spi/program/spiprogram.htm retrieved on 05-03-2014.