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METEOROLOGICAL DROUGHT ASSESSMENT USING STANDARDIZED PRECIPITATION INDEX – A CASE STUDY OF MAN RIVER BASIN

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Abstract:

Drought is a slow arrival, creeping natural hazard and a regular feature of climate which occurs in virtually all regions of the world; it results in severe environmental and socio-economic effects. The objective of this study is to assess Meteorological drought severity and monitoring using Standardized Precipitation Index (SPI) for different time scales in the Man river basin. The monthly Precipitation data's from 1979 to 2013 were collected for three stations in the Man river basin from Indian Meteorological Department (IMD), Pune and used in the analysis. SPI_SL_6 program is used for calculating SPI.The Man region faces more extreme drought in the year 2003 and 1992 for 12 months, 2011 for rainy season and 1990, 2008 for winter season.

Keywords: *Precipitation, Drought Severity, Standardized Precipitation Index (SPI), Meteorological Drought*

Introduction:

Drought is the most serious physical hazard to agriculture in nearly every part of the world. Drought is a climatic anomaly characterized by deficient supply of moisture resulting either from sub-normal rainfall, erratic rainfall distribution, higher water need or a combination of all the three factors. [1] Drought is the cumulative effect of shortage of water, which effects agriculture, natural circumference and related activities in the form of a natural disaster. According to Indian Meteorological Department (IMD), drought is a condition when actual rainfall is seventy five per cent less than average normal in that geographical area. [2]

Droughts are commonly classified by type as meteorological, agricultural, hydrological and socio-economic. Meteorological drought is generally defined by a precipitation deficiency threshold over a predetermined period of time. [3]Meteorological and climatological drought is defined in terms of the magnitude of a precipitation shortfall and the duration of this shortfall event.[4]

Drought indices are one of the significant tools to assess and to monitor drought, because they simplify complex inter-relationships between many climate factors. There is extensive literature on the quantification of drought by using various indices, models and water balance simulations. Precipitation has been used to develop a variety of indices, because it is a significant variable to study meteorological drought. [5]

Meteorological drought indices have been developed by meteorologists and climatologists around the world such as Normalized Deviation (ND), Dryness Index (DI), De Martun's Quotient (IA), Aridity Index (AI), Pluvothermic Quotient (PQ), Relative Precipitation Index (RPI), Effective Drought Index (EDI), Drought Severity Index (DSI), Standardized Precipitation Index (SPI), Accumulated Negative Moisture Index (NMI), Palmer Drought Severity Index (PDSI), Reclamation Drought Index (RDI) and Climatic Water Balance (CWB). [6]

Among the Meteorological drought indices, the Palmer Drought Severity Index (PDSI) and Standardized Precipitation Index (SPI) are more commonly used. [5] Those indices such as percentage of normal precipitation and precipitation percentiles to more complicated indices such as the Palmer Drought Severity Index. However, an index desired to be simple, easy to calculate and statistically appropriate and meaningful. [7]Moreover, the understanding that a deficit of precipitation has different impacts on groundwater, reservoir storage, soil moisture, snowpack and streamflow led American scientists McKee, Doesken and Kleist to develop the Standardized Precipitation Index (SPI) in 1993. [8]

Various studies used SPI for real time monitoring and analysis of drought. Christos A. Karavitis& et al. (2011) used SPI for application of the Standardized Precipitation Index (SPI) in Greece. [9] The SPI used by Palchaudhuri, M., & et al., (2013) to analysis of meteorological drought using SPI for Purulia district of West Bengal. [5] Solanki, J., et al. (2014) examines the SPI drought index in application for the Vallabha Vidyanagar Station.[7]Leszek Łabędzki & et al.,(2014) contains an inventory of drought measures (indicators) that are applied to evaluate meteorological and agricultural drought in Poland.[10]SPI was applied to monitor Meteorological drought using standardized precipitation index (SPI), China-Z index (CZI), modified CZI (MCZI) and Z-Score (Z) drought indices for Salt Lake Basin in Iran by Asefjah, B., et al, (2014).[11] Mamatha, K., et al. (2015) carried out a study on meteorological condition for Bijapur region in the lower Bhima basin using relative precipitationindex (RPI), effective drought index (EDI), standardized precipitation index (SPI) and climatic water balance (CWB).[12] Naresh Kumara, M., et al. used Standardized Precipitation Index (SPI) for drought intensity assessment for Ananthpur and Khammam district of Andhra Pradesh. [13]

Many drought planners appreciate the SPI's usefulness. It is also used by a various research institutions, universities, and National Meteorological and Hydrological Services across the world as part of drought assessment and early warning efforts. [8]

Objective: To assess meteorological drought severity and monitoring using Standardized Precipitation Index (SPI) in the Man river basin

Data Source and Methodology: Monthly Precipitation data for the period of 1979 to 2013 at the three stations (Station I: 74. 68 E & 17.64 N, Station II: 75.00 E & 17.32 N, Station III: 75.30 E & 17.64 N) in the Man river basin were collected from IMD, Pune. The monthly precipitation data were used as input for calculation of SPI. In this study, the Standardized Precipitation Index (SPI) hasbeen selected to assess the meteorological drought situation.

The Standardized Precipitation Index (SPI) was developed by McKee and others (1993) to quantify the precipitation deficit for multiple timescales. These timescales reflect the impact of drought on the availability of the different water resources. [12]Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow and reservoir storage reflect the longer-term precipitation anomalies. For these reasons, McKee and others originally calculated the SPI for 3, 6, 12, 24 and 48 month timescales.[8]

The SPI calculation for any place 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. [12]Positive SPI values indicate larger than median precipitation and negative values indicate less than median precipitation. [5]Because the SPI is normalized, wetter and drier climates can be represented in the same way; thus, wet periods can also be monitored using the SPI.[8] Drought intensity class has been carried out in reference of table number 1 which was developed by Mckee et al in 1993.

Drought Classification based on SPI (Mckee et al 1993)

Table No : 1

SPI Value	Class	**SPI Value**	Class
> 2.00	Extremely Wet	-1.00 to -1.49	Moderate Dry
1.50 to 1.99	Very Wet	-1.50 to -1.99	Severe Dry
1.00 to 1.49	Moderate Wet	<-2.00	Extremely Dry
-0.99to0.99	Near Normal		

Source: World Meteorological Organization, 2012

In this study, SPI_SL_6 program developed by the National Drought Mitigation Centre, University of Nebraska-Lincoln is used to calculate time series of drought indices (SPI) for three stations in the Man river basin and for each month of the year at different time scales (SPI Rainy, SPI Winter and SPI 12months).

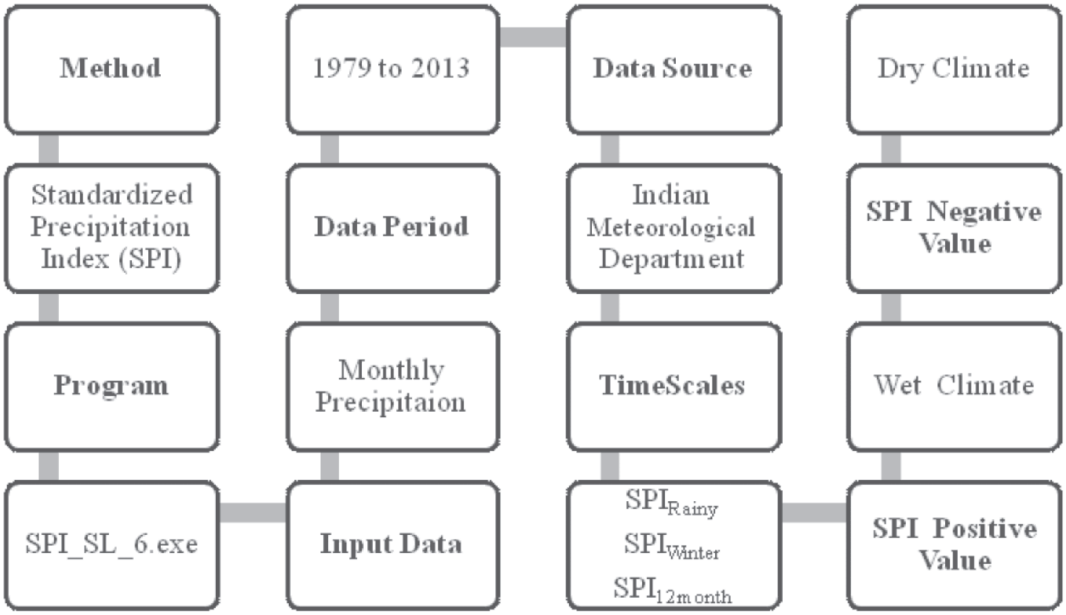

Figure Methodology

Study Region:

The present study considers the precipitation station located near Man River for to study the Meteorological drought and subsequently this station comes under Man river basin. The study region selected for present study is Man River Basin. The Man is a tributary of the Bhima River. It rises in the Tital hill in Man tahsil. It covers total area of 4757.47 km2 and lies between in 170 51'to 170 00'Northand 740 22' to 750 30'East Longitude in Satara, Sangli and Solapur districts in Maharashtra state. Total 346 villages are identified in Man basin. Its bed is sandy and its banks are highly eroded. [14]

Results and Discussion:

The study produced meteorological drought severity at rainy, winter and 12 month timescales in the Man River Basin. Month of September was chosen for calculating SPI for four month time step as June to September is normally rainy season. January was chosen for calculation SPI for four month time step as October to January is normally winter season. Month of December was chosen for the calculating SPI for 12 month time step as January to December will indicate drought throughout the year.

Figure No. 2a, 2b, 2c shows SPI values for three different timescales namely rainy, winter season and 12 months for the three stations. Result shows that for station I, the maximum SPI value (-2.57) is for 12 month time scale in the year 2003. For rainy and winter season time scales the SPI value

is maximum in the year 2011 (-2.24) and 1990 (-1.81) respectively. For the station II, the maximum SPI value (-2.76) found in 2011 for rainy season time scales. For 12 months and winter season time scales the SPI value is maximum in the year 2003 (-2.58) and 2008 (-2.09) respectively. For the station III, the maximum SPI value (-2.43) is for winter season time scales in the year 2008. For 12 months and winter season time scales the SPI value is maximum in the year 1992 (-1.93) and 2011 (-1.88) respectively

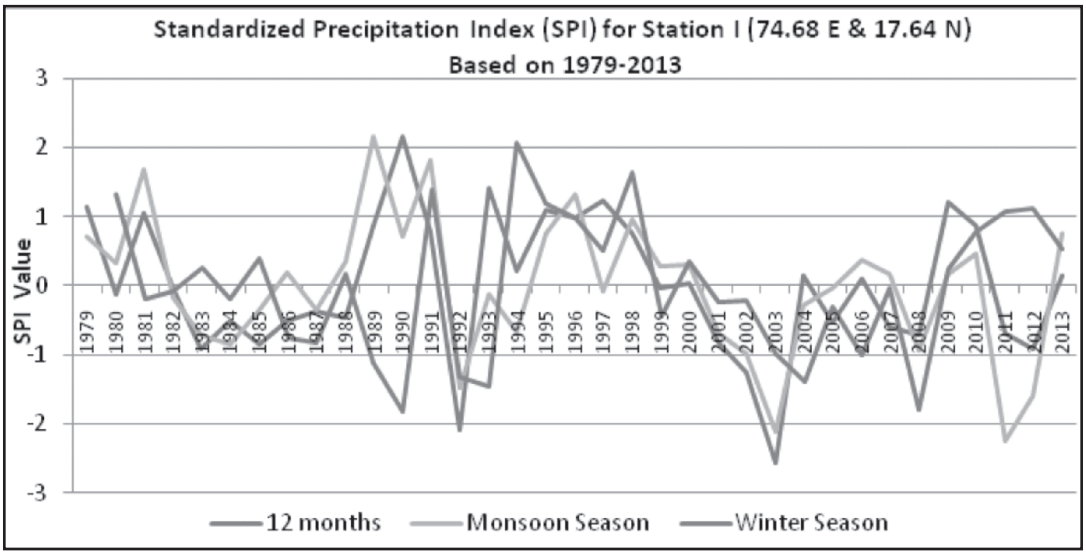

Figure a

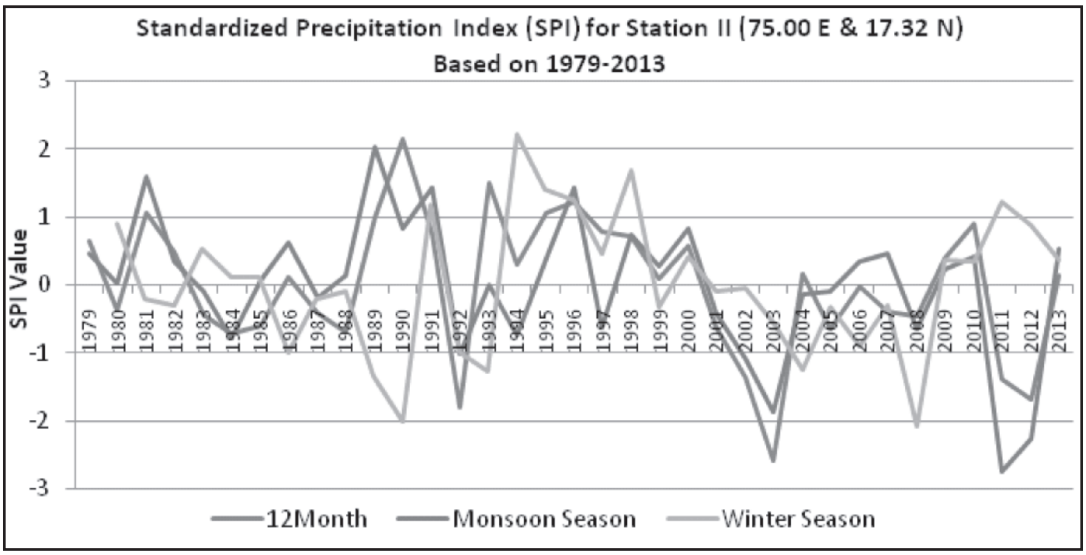

Figure b

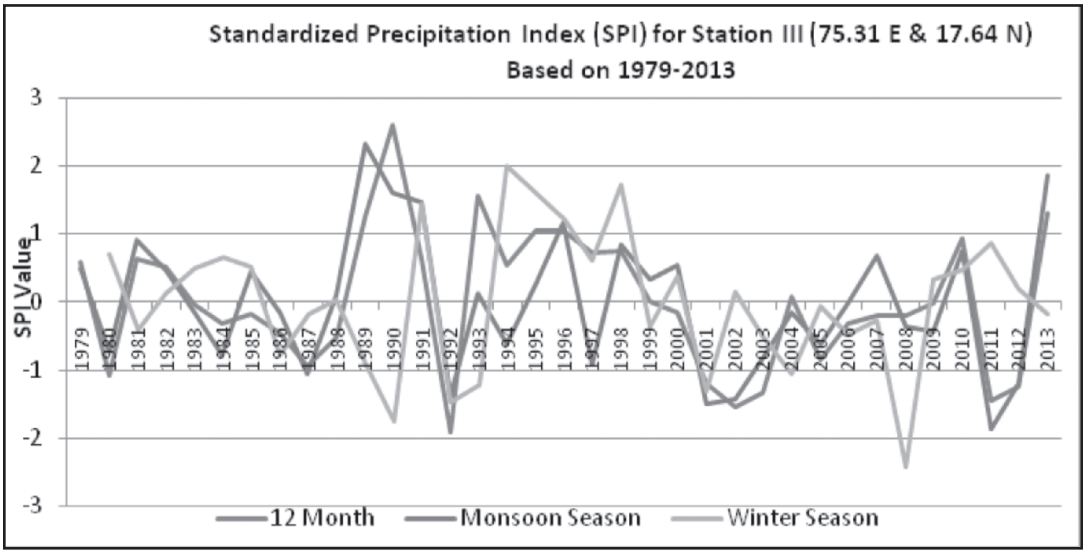

Figure c

Table No. 2

Drought Severity for the 12 Months, Monsoon and Winter Season of 1979-2013

Station	Moderate Dry			Sever Dry			Extremely Dry		
	12 Months	Monsoon Season	Winter Season		Monsoon Season	Winter Season	12 Months	Monsoon Season	Winter Season
I	2002	1992	1989 1992 2004 1993	-	2012	2008 1990	1992 2003	2003 2011	-
II	2002 2011	1992 2002	1992 2004 1993 1989	2012 1992	2003	-	2003	2011 2012	1990 2008
III	1980 2001 2012 2003	1980 2001 2012 2003	2004 1993 2001 1992	2002 1992	2002 1992	1990	-	-	2008

Station I:74.68 E & 17.64 E, **Station II:**75.00 E & 17.32 N, **Station III:**75.30 E & 17.64 N

Source: Computed by Author

Table number 3 indicates that, Based on an analysis of 3 stations across Man River Basin, the SPI indicates mild drought 42.85 % of the time, moderate drought 2.85 % of the time, severe drought 0.00 % of the time and extreme drought 5.71 % of the time of station-I in the Man River Basin.

Table No: 3

Occurrence and Frequency of Drought Severity Class in Man River Basin (Station I)			
SPI Value	Category	Occurrence and Frequency	Severity event
0.00 to - 0.99	Mild Drought	15 (42.85 %)	1 in 2.5 years
-1.00 to -1.49	Moderate Drought	01 (02.85 %)	1 in 35 years
-1.5 0to -1.99	Severe Drought	00 (00.00 %)	0in 35 years
<-2.00	Extremely Drought	02 (05.71 %)	1 in 17.5 years

Source: Computed by author

Table number 4 indicate that, Based on an analysis of 3 stations across Man River Basin, the SPI indicates mild drought 31.42 % of the time, moderate drought 5.71 % of the time, severe drought 5.71 % of the time and extreme drought 2.85 % of the time of station-II in the Man River Basin.

Table No: 4 Occurrence and Frequency of Drought Severity Class in Man River Basin (Station II)			
SPI Value	Category	Occurrence and Frequency	Severity event
0 to - 0.99	Mild Drought	11 (31.42 %)	1 in 3 years
-1.00 to -1.49	Moderate Drought	02 (05.71 %)	1 in 17.5 years
-1.5 0to -1.99	Severe Drought	02 (05.71 %)	1 in 17.5 years
<-2.0	Extremely Drought	01 (02.85 %)	1 in 35 years
			Source: Computed by author

Table number 5 indicates that, Based on an analysis of 3 stations across Man River Basin, the SPI indicates mild drought 37.14 % of the time, moderate drought 14.28 % of the time, severe drought 5.71 % of the time and extreme drought 0.00 % of the time of station-III in the Man River Basin.

Table No: 5
Occurrence and Frequency of Drought Severity Class in Man River Basin (Station III)

SPI Value	Category	Occurrence and Frequency	Severity event
0 to - 0.99	Mild Drought	13 (37.14 %)	1 in 3 years
-1.00 to -1.49	Moderate Drought	05 (14.28 %)	1 in 7 years
-1.5 0to -1.99	Severe Drought	02 (05.71 %)	1 in 17.5 years
<-2.0	Extremely Drought	00 (00.00 %)	0 in 35 years

Source: Computed by author

Conclusion:

The main conclusions based on this research are:

1. The Man region faces more extremedrought in the year 2003 and 1992 for 12 months, 2011 for rainy season and 1990, 2008 for winter season.Hence, the irrigation requirement can be evaluated on the rainfall deficits & its severity for the givenyears.
2. Extreme drought occure in the west and central part of study region. The central and north east part of the study region is prone for severe drought and mild and moderate drought occure in west, central and north east of the study region. Hence, the whole study region can be labled as drought prone area.
3. A high fequency of drought occurrence can be observed in Man river basin. This research provideuseful information to regional water resource management and support to the future water distribution.

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References:

1. Murthy C.S. & et al.: 'Agricultural drought monitoring and assessment', Remote Sensing Applications, NRSC, Hyderabad.
2. Gurjar R. K, 2008: Drought and Dry Farming, Geography of Water Resources, Rawat Publications, Jaipur, pp.259-260
3. World Meteorological Organization, 2006: Drought monitoring andearly warning:concepts, progress and future challenges, WMO-No.1006, ISBN 92-63-11006-9
4. https://www.ametsoc.org/ams/index.cfm/about-ams/ams-statements/archive-statements-of-the-ams/meteorological-drought/
5. Palchaudhuri, M., & et al., 2013: Analysis of Meteorological Drought Using Standardized Precipitation Index – A Case Study of Puruliya District, West Bengal, India, International Journal of Environmental, Geological and Geophysical Engineering, Vol.: 7, No: 3,pp. 167
6. Nagarajan, R., 2009: Drought Assessment, Springer, pp. 160-199
7. Solanki, J. & et al., 2014: Drought Assessment Using Standardized Precipitation Index, International Journal of Science and Research (IJSR), Volume 3, Issue 7, pp. 1073-1076

8. World Meteorological Organization, 2012: Standardized Precipitation Index User Guide (M. Svoboda, M. Hayes and D. Wood). (WMO-No. 1090), Geneva.
9. Christos A. Karavitis, 2011: Application of the Standardized Precipitation Index (SPI) in Greece, Water, 3, 787-805; doi: 10.3390/w3030787, ISSN 2073-444 www.mdpi.com/journal/water
10. Leszek Łabędzki & et al., 2014: Meteorological and agricultural drought indices used in drought monitoring in Poland: a review, Meteorology, Hydrology and Water Management, Vol. 2 Issue 2
11. Asefjah, B.,& et al, 2014, Meteorological drought monitoring using several drought indices (case study: Salt Lake Basin in Iran), Desert Online at http://desert.ut.ac.ir, 19-2, pp. 155-165
12. Mamatha, K. et al., 2015: Analysis of Meteorological drought condition for Bijapur region in the lower Bhima basin, India, International Journal of Combined Research & Development (IJCRD), Vol.: 4, Issue: 9, pp. 502
13. Naresh Kumar,& et al.: 'On the use of Standardized Precipitation Index (SPI) for drought intensity assessment'
14. Shikalgar, R., 2015: Study on Population Growth of Man River Basin in Maharashtra, Golden Research Thought, Volume-4, Issue-8,ISSN 2231-5063

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