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Assessment of Drought Characteristics over Vindhyan Region through Different Drought Indices

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Abstract: The activities performed over a period of time by human induces circumstances that results in increasing the extreme events that causes severe impact to environment, agriculture, and livelihood relying on. One of the most devastating impacts can be seen as drought. Increased drought frequency with higher magnitude and intensity has severe implication to the water resources availability in the region. The aim of the present study was to evaluate the drought and its characteristics over Vindhyan region in Mirzapur and Sonbhadra district. The average annual rainfall over Vindhyan region is 934.75 mm with a coefficient of variation of 25.83. The rainfall in the region varies from 863.34 mm in Mirzapur district to 1003.26 mm in Sonbhadra district. The variation over Sonbhadra region is less in comparison with Mirzapur district. Identification of drought prone block indicates that in Mirzapur district 10 out of 12 blocks are drought prone whilein Sonbhadra district 3 out of 8 blocks are drought prone. In Vindhyan region there was widespread drought during 1982, 1988, 1992, 1997, 2002, 2004, 2009, 2015, and 2017. Relative departure index (RDI) indicates Chhanvey, Narainpur and Pahari blocks at highest priority with RDI=0.70 in Mirzapur district followed by Ghorawal blocks with RDI = 0.60 in Sonbhadra district. Standardized Precipitation Index (SPI) was adapted to evaluated meteorological drought characteristics. 1 month SPI and 3 month SPI was evaluated for assessing severity, duration, intensity, magnitude and extent of drought over the region. Based on the findings, drought preparedness and mitigation plan may be implemented, which will aid in reducing the influence of drought and its potentially dangerous consequences.

Keywords: Drought, Standard Precipitation Index (SPI), Vindhyan region, Relative Departure Index (RDI)

Droughts have drawn the attention of environmentalists, ecologists, hydrologists, meteorologists, geologists, and agricultural scientists as an environmental disaster which occurs in virtually all climatic zones (Belal et al 2014). It is mostly related to the reduction in the amount of precipitation received over an extended period. The reason for droughts occurrence includes strong temperatures, high winds, low relative humidity, and the timing and characteristics of rainfall, such as the distribution of rainy days during crop growing seasons, rain strength and length, and onset and termination. Due to the slow progress of its effects, it is still unclear and sometimes referred to as a creeping disaster. The frequency of drought unexpectedly increases worldwide as an outcome of global warming, which is induced due to anthropogenic activities coupled with climate change scenarios (Dai 2012, Frich et al 2002). Meteorological drought is simply the departure of meteorological variables from normal that induces drying of the surface. It is usually region-specific because the atmospheric conditions in different areas are highly variable in space and time. When meteorological drought is prolonged it subsequently leads to agricultural drought wherein the water quantity in the soil is unable to meet the demand of plants at various growth stages. The meteorological drought could also result in hydrological drought, which is indicated by the decline in streamflow, river discharge, and groundwater level. Insignificant rainfall marks the onset of meteorological drought, which is followed by hydrological drought as a decrease in the surface water and groundwater levels and thus has a direct effect on the crops resulting in agricultural drought (Mishra and Singh 2010, Thomas et al 2015, Aswathi et al 2018).

Most of the indexes used in drought assessment, by and large, involve a lot of datasets. But the most relevant and most comprehensive one which can serve the purpose of drought monitoring and detecting and which has also been recommended by WMO (2009) and WCRP (2010) is the Standardized Precipitation Index (SPI) and has been used in the present study. Soil moisture status can also be estimated using SPI and it is considered as a better indicator for estimating soil wetness. Keyantash and Dracup (2002) established the strength of SPI in drought analysis based on six weighted evaluation performance criteria viz, robustness, tractability, transparency, sophistication, extendibility, and dimensionality in comparison with other drought indexes (Thomas et al 2016).

The suitability and adaptability of SPI with other indicators through the development of meaningful relationships help in a more comprehensive evaluation of drought characteristics. Most of the studies performed by Gocic et al (2013), Basamma et al (2017), Rahman et al (2018) highlighted the suitability of SPI based on computation at different time scales in comparison with other drought indicators for meteorological, agricultural and hydrological drought evaluation. The present study mainly encompasses to evaluate the meteorological drought characteristics using SPI and other suitable drought indicators for a more comprehensive and more exhaustive assessment which help in revealing salient features of drought behaviors in the Vindhyan region comprising of Mirzapur and Sonbhadra district.

MATERIAL AND METHODS

Study area: The Vindhyan region of Uttar Pradesh lies between 82° 4' to 83°33' East longitude and 23° 52' to 25° 17' North latitude which includes the districts i.e., Mirzapur and Sonbhadra (Fig. 1). The region has a relatively subtropical climate with high variation between summer and winter temperatures. The average temperature is 32°C-42°C in the summer and 2°C-15°C in the winter. The study area has an area of 11,310 sq km. Most of the region has alluvial soil and the average elevation in the study area is 298.3m.

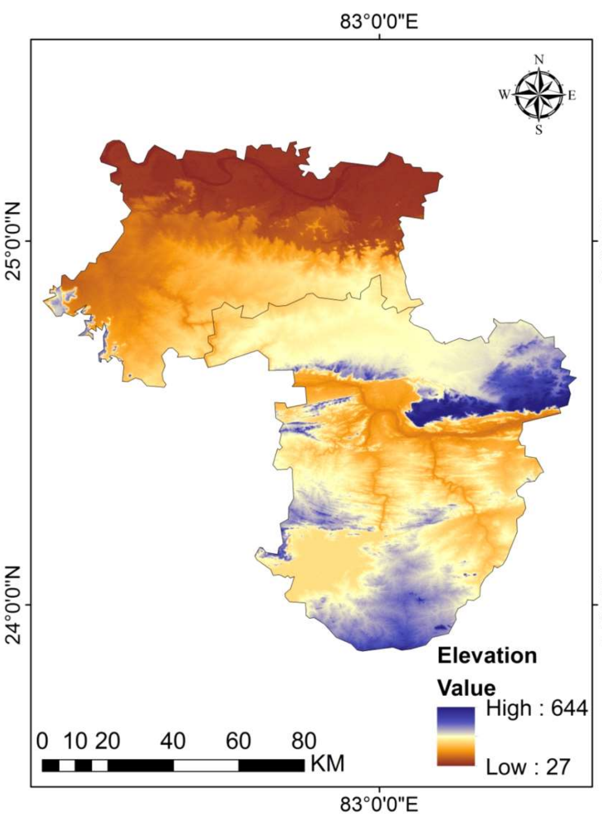

Fig. 1. Location and elevation map of Vindhyan region, U.P.

Data used: For assessment of drought characteristics in Vindhyan region, gridded daily rainfall data has been used and which was downloaded from Indian Meteorological Department (IMD), Pune. (https://www.imdpune.gov.in)

Identification of drought prone block: The drought-prone blocks in the study area have been identified based on the probability analysis of annual and seasonal rainfall (Thomas et al 2015, Sharma et al 2021). For computation the annual rainfall series sorted in the descending order and ranks has been assigned from 1, 2, 3, to N, up to the last record and thereafter Weibull's distribution fitted to the ranked data. An area will be considered to be drought prone if the probability of occurrence of 75 % of mean annual rainfall is less than 80 %. Kar et al (2016) adopted the similar technique for computing drought prone blocks in Bundelkhand region.

Identification of drought year and drought severity: The drought year has been identified based on the departure analysis of annual and seasonal rainfall. In the Indian context, since more than 90 % of the annual rainfall is received during the monsoon season, the seasonal rainfall departure has been adopted for computation as it better represents the drought conditions during the critical crop growth periods. The seasonal rainfall departure (Di) for the study area has been computed by subtracting the mean seasonal rainfall (Xm) from the seasonal rainfall series (Xi) as given below.

$Di = Xi - Xm$

Subsequently, the percentage departure (D %) is computed as:

$D\% = Di/Xm * 100$

IMD considers a season as drought affected, if the total seasonal rainfall is less than 75 % of the normal. Based on the seasonal rainfall departures and the prevailing climatic condition in the region, four drought classes have been defined for the study area viz., (a) mild drought (b) moderate drought (c) severe drought (d) extreme drought (Table 1.)

Relative departure index based prioritization of drought prone blocks: Relative departure index (RDI) is a ranking system, used to prioritize block based on departure analysis. This analysis helps for developing an initial drought mitigation plan for these affected blocks. For this purpose, weights have been assigned to various drought years as

Table 1. Seasonal rainfall departure based drought classification

Drought classes	Range (%)
Mild drought	-20 < D < -25
Moderate drought	-25 < D < -35
Severe drought	-35 < D < -50
Extreme drought	D > -50

follows, mild drought (1), moderate drought (2), severe drought (3) and extreme drought (4).

The relative departure index for the rain gauge stations will be divided by the total cumulative weights obtained for the study period during drought years with total number of years under consideration as given in equation below. Sharma et al (2021) had also used RDI based prioritization of drought prone blocks in Chambal basin falling in Madhya Pradesh and Rajasthan region.

$RDI = \frac{\sum_{i=1}^{n} W_i}{N}$ Where, N= Total number of year under consideration, W_i= Weight for the i^{th} drought years.

SPI- based meteorological drought evaluation: The Standardized Precipitation Index is based on an equi-probability transformation of aggregated monthly precipitation into a standard normal variable. Assumed the aggregated precipitation to be gamma distributed and used a maximum likelihood method to estimate the parameters of the distribution. The computation of the SPI involves, (a) calculation of mean of the normalized precipitation of the lognormal (ln) rainfall series; (b) fitting a two-parameter gamma probability density function to a given frequency distribution of the precipitation and computation of shape and scale parameters β and α, for each time scale of interest (1, 3, 6 and 12 months), respectively, as given by the following equations (3)

$$Log\ mean\ (\overline{X}_{\ln}) = \frac{\Sigma \ln X}{N}$$

$$\text{Shape parameter } (\beta) = \frac{1}{4U}\left[1 + \sqrt{\frac{4U}{3}}\right]$$

$$\text{Scale parameter } (\alpha) = \frac{\overline{X}}{\beta}$$

Where U is the constant given by

$$U = \ln(\overline{X}) - \overline{X}_{\ln}$$

The resulting distribution parameters which have been estimated by the maximum likelihood approach are then used to find the cumulative probability of an observed precipitation event for the given month and time scale, for a particular station. The cumulative probability as given by gamma distribution (Kar et al 2018) is

$$G(x) = \frac{1}{\alpha^{\beta}\Gamma\beta}\int_0^x x^{\beta-1} e \frac{-x}{a} dx$$

Letting $t = \frac{-x}{a}$, this equation becomes the incomplete gamma function

$$G(x) = \frac{1}{\Gamma\beta}\int_0^{t\alpha} t^{\beta-1} e^{-t} dt$$

Since the gamma function is undefined for x = 0 and a precipitation distribution may contain zero, the cumulative probability becomes

H(x) = q + (1 – q) G(x)

Where 'q' is the probability of a zero.

However, the three parameter gamma distribution is considered to produce more robust values of SPI. If m is the number of zeros in a precipitation time series, then q can be estimated by m/N and using the tables of incomplete gamma function to determine cumulative probability H(x) (Thomas et al 2015). The cumulative probability is then transformed to the standard normal random variable Z with mean zero and variance one, which is the value of the SPI. The Z or SPI values are more easily obtained computationally using an approximation that converts cumulative probability to the standard normal random variable Z (Abramowitz and Stegun, 1965).

$$SPI = -\left[t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right] For\ 0 < H(x) \le 0.5$$

$$SPI = +\left[t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right] For\ 0.5 < H(x) \le 1.0$$

Where,

$$t = \sqrt{\ln\left\{\frac{1}{(H(x))^2}\right\}} For\ 0 < H(x) \le 0.5$$

$$t = \sqrt{\ln\left\{\frac{1}{(1\text{-}H(x))^2}\right\}} For\ 0.5 < H(x) \le 1.0$$

c_0 = 2.515517, c_1 = 0.802853 and c_2 = 0.010328,
d_1 = 1.432788, d_2 = 0.189269 and d_3 = 0.001308

Classification of SPI-A drought event occurs during the period when SPI is continuously negative and reaches an intensity of -1.0 or less and ends when the SPI become positive. The frequency, duration and intensity of drought can be calculated with SPI. The positive sum of the SPI for all the months within a drought event is termed as drought magnitude. The division of the drought magnitude by its duration results in drought intensity. The drought severity has been evaluated using the classification used by Hayes et al. (1999) (Table 2).

A 1-month SPI (1m-SPI) and 3-month SPI (3m-SPI) has been adopted in the present study for assessing short-term or seasonal or meteorological drought. But it can also be used for assessing surface water drought and hydrological drought if investigated at 6 month and 12 month time scale.

RESULTS AND DISCUSSION

Statistical approaches based assessment of rainfall:

Evaluation based on statistical approach reveals that the area receives the average annual rainfall of 934.75 mm with an average coefficient of variation of 25.83. The region lying in the Mirzapur district receives minimal rainfalls in Jamalpur block (863.34 mm) whereas minimal rainfall amount occurs in Myorpur block (901.63 mm) in Sonbhadra district of Vindhyan region (Fig. 2). Higher variability in the rainfall amount signifies the irregularity in the rainfall pattern both spatially and temporally. This can be ascertained based on the variability in the annual rainfall amount in the region (Fig. 3). The highest coefficient of variation was observed at Kon blocks (33.14) followed by Chhanvey block in Mirzapur district of the study area whereas in Sonbhadra district highest coefficient of variation was obtained in Ghorawal block (26.70) followed by Dudhi blocks.

When comparing Vindhyan region in Mirzapur and Sonbhadra district it has been observed that the variation in average annual rainfall is low in Sonbhadra district and also the contribution of rainfall by the district to Vindhyan region is more. Trend analysis of annual rainfall indicated that blocks viz.Narainpur, Jamalpur and Hallia in Mirzapur district showed decreasing rainfall trend whereas in Sonbhadra district decrease in rainfall was observed in Chatra, Nagwa and Babhani blocks.

Drought prone blocks identification: In the present time prospect the frequency of drought occurrence increased certainly due to climate change scenario. The frequent drought resulted in inadequate water availability and water stress conditions in the region. Hence the drought prone (DP) blocks have been identified from non drought prone (NDP) blocks based on probability analysis using Weibull's formula so that region specific drought mitigation strategies can be implemented by the government agency to minimize the impact of drought (Table 3).

In Mirzapur district of the study area, 10 out of 12 blocks are drought prone except Majhawa and Sikhar blocks whereas in Sonbhadra district, 3 out of 8 blocks are drought prone. The distribution of rainfall was erratic and irregular coupled with the consequences of the climate change scenario there exists a situation where there was a drought in one region while in the close vicinity, the region remained unaffected. The study area is rain fed, therefore irregularity caused due to different climatic phenomenon viz. El-Nino, La Nina and ICZC affected the area to a large extent. Based on departure analysis of seasonal rainfall it was observed that most of the parts in Vindhyan region were under the grip of widespread drought during 1982, 1988, 1992, 1997, 2002, 2004, 2009, 2015, and 2017 (Table 4). Maximum drought years occurred in Narainpur block followed by Rajgarh in Mirzapur district and Robertsganj block in Sonbhadra district. The frequency of drought occurrence in Mirzapur district was more prominent in comparison with Sonbhabha district. The drought severity classes were also identified to examine the critical deficit rainfall region (Table 5).

The differences in the severity classes indicating the facts that there is high variability in the rainfall amount which resulting different drought severity classes in the region. Maximum extreme drought events occurred in Chhanvey block (4 events) followed by City, Kon, and Lalganj block (3 events) in Mirzapur district. The occurrence of extreme drought was less in Sonbhadra district as compared to Mirzapur district. Maximum severe drought events occurred

Table 2. SPI based drought severity classification

SPI range	Classification
≥2.0	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
0.0 to 0.99	Mild wet
0.0 to -0.99	Mild drought
-1.0 to -1.49	Moderate drought
-1.5 to -1.99	Severe drought
≤-2.0	Extreme drought

Table 3. Drought prone blocks in Mirzapur and Sonbhadra district of Vindhyan region

District	Block	Inferences
Mirzapur	Chhanvey	DP
	City	DP
	Hallia	DP
	Jamalpur	DP
	Kon	DP
	Lalganj	DP
	Marihan	DP
	Majhawa	NDP
	Narainpur	DP
	Pahari	DP
	Rajgarh	DP
	Sikhar	NDP
Sonbhadra	Robertsganj	DP
	Ghorawal	DP
	Chatra	NDP
	Nagwa	NDP
	Chopan	NDP
	Babhani	NDP
	Myorpur	DP
	Dudhi	NDP

Table 4. Drought year in Vindhyan region

Block name	Drought years														Drought frequency (In 40Yrs)
Chhanvey	1997	1998	2004	2005	2006	2007	2009	2014	2015	2017					10
Kon	1997	1998	2002	2004	2006	2007	2009	2014	2015	2017					10
Majhawa	1992	2004	2006	2007	2009	2010	2012	2014							8
Sikhar	1992	2004	2006	2007	2009	2010	2013	2014	2015						9
Narainpur	1982	1992	1997	1998	2002	2004	2006	2007	2009	2010	2013	2014	2015	2017	14
Jmalpur	1982	1992	1997	1998	2002	2004	2006	2009	2010	2014	2015				11
Lalganj	1997	1998	2004	2005	2006	2007	2009	2014	2015	2017					10
City	1992	1997	1998	2004	2006	2007	2009	2014	2015	2017					10
Pahari	1982	1988	1992	1997	1998	2004	2006	2009	2010	2013	2015				11
Rajgarh	1982	1988	1992	1997	1998	2004	2005	2009	2010	2013	2014	2015			12
Hallia	1982	1983	1998	2004	2007	2009	2010	2014	2015	2017					10
Marihan	1997	1998	2004	2005	2006	2007	2009	2014	2015	2017					10
Ghorawal	1982	1983	1997	1998	2004	2005	2007	2009	2010	2014	2015				11
Robertsganj	1982	1983	1992	1995	1997	2004	2005	2007	2009	2010	2014	2015			12
Chatra	1988	1992	2004	2009	2010	2014	2015								7
Nagwa	1988	1992	2002	2004	2005	2009	2010	2014	2017	2018					10
Chopan	1992	1998	2004	2005	2007	2009	2010	2014	2015						9
Myorpur	1992	1997	1998	2004	2007	2008	2009	2010	2015						9
Dudhi	1989	1992	2004	2009	2010	2015	2017								7
Babhani	1998	2004	2009	2010	2014	2015									6

Table 5. Block-wise drought severity classes and relative departure index

District	Block	Mild	Moderate	Severe	Extreme	RDI
Mirzapur	Chhanvey	1	4	1	4	0.7
	City	2	2	3	3	0.68
	Hallia	3	3	5	0	0.6
	Jamalpur	2	7	3	0	0.63
	Kon	2	2	3	3	0.68
	Lalganj	1	4	2	3	0.68
	Marihan	2	4	2	2	0.6
	Majhawa	2	4	1	1	0.43
	Narainpur	3	8	3	0	0.7
	Pahari	0	9	2	1	0.7
	Rajgarh	2	7	2	1	0.65
	Sikhar	3	4	1	1	0.45
Sonbhadra	Robertsganj	4	7	1	0	0.53
	Ghorawal	0	9	2	0	0.6
	Chatra	2	5	0	0	0.3
	Nagwa	4	5	1	0	0.43
	Chopan	2	4	3	0	0.48
	Babhani	1	3	1	1	0.35
	Myorpur	1	3	4	1	0.58
	Dudhi	1	2	3	1	0.45

in Hallia block (5 events) in Mirzapur district and Myorpur block (4 events) in Sonbhadra district. In the region severe drought events varies between 1 to 5 events. The Maximum number of moderate drought events (9 events) occurred in Pahari block in Mirzapur district and Ghorawal block in Sonbhadra district. The Maximum mild drought events occurred in Robertsganj and Nagwa block of Sonbhadra district (4 events) followed by Hallia, Narianpur, and Sikhar block (3 events) in Mirzapur district. Prioritization based on Relative departure index (RDI) indicates Chhanvey, Narainpur and Pahari blocks at highest priority with RDI=0.70 in Mirzapur district followed by Ghorawal blocks with RDI = 0.60 in Sonbhadra district.

Meteorological drought evaluation based on SPI: Meteorological drought characteristics have been evaluated at 1m-SPI and 3m-SPI time scales. The response of drought is depicted using rainfall data for the period spanning 40 years (1980-2019). 1m-SPI and 3m-SPI help to reveal drought characteristics with respect to available soil moisture. It depicts short term drought characteristics prevailing. Drought events evaluated using 1m-SPI and 3m-SPI are depicted in Table 6 and 7.

The number of drought events of different severity classes is different at different timescales. In 1m-SPI

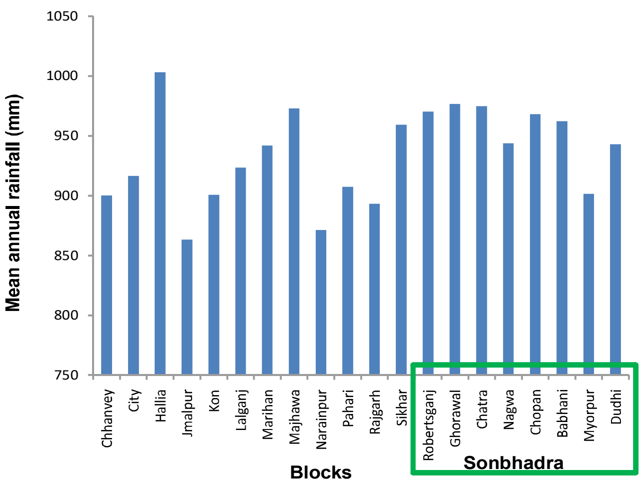

Fig. 2. Mean annual rainfall for different block in Vindhyan Region

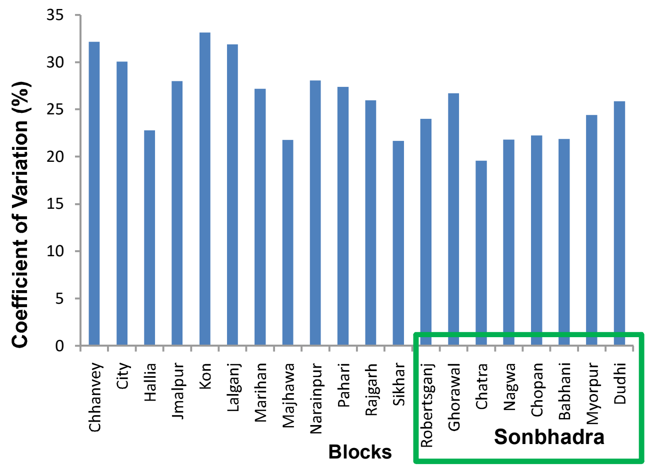

Fig. 3. Coefficient of variation for different block in Vindhyan Region

Table 6. 1m-SPI for the different blocks of Vindhyan region falling in Mirzapur and Sonbhadra district

Blocks	Extreme	Severe	Moderate	Drought duration (Months)	Drought magnitude	Drought intensity
Babhani	4	10	21	34	-50.85	-1.5
Chatra	5	13	26	44	-63.72	-1.45
Chopan	5	11	33	48	-68.48	-1.43
Chhanvey	8	5	29	41	-62.37	-1.52
City	7	4	35	46	-67.97	-1.48
Dudhi	4	12	22	38	-55.49	-1.46
Ghorawal	6	8	31	43	-62.4	-1.45
Hallia	4	8	33	44	-61.99	-1.41
Jmalpur	4	6	16	26	-42.69	-1.64
Kon	7	9	31	42	-62.96	-1.5
Lalganj	7	5	32	44	-64.07	-1.46
Marihan	5	11	24	39	-60.55	-1.55
Majhawa	5	9	32	45	-64.54	-1.43
Myorpur	5	8	32	45	-64.16	-1.43
Nagwa	3	14	25	42	-62.19	-1.48
Narainpur	5	4	33	42	-59.43	-1.42
Pahari	5	4	38	47	-66.02	-1.4
Rajgarh	5	7	27	38	-57.02	-1.5
Robertsganj	4	12	36	50	-68.84	-1.38
Sikhar	4	10	36	48	-68.17	-1.42

maximum extreme events occurred in Chhanvey blocks (8 events) followed by City, Kon and Lalganj block (7 events) in Mirzapur district and Sonbhadra district maximum of 6 extreme events occurred in Ghorawal blocks. The occurrence of severe events was maximum in Nagwa block (14 events) followed by Chatra block (13 events) in Sonabhadra district. In Pahari block maximum moderate drought events occurred (38 events) followed by Robertsganj and Sikhar blocks of the study area (36 events). Similar conclusions can be drawn for 3m-SPI using Table 7. Temporal variation of 1m-SPI and 3m- SPI of selected blocks are shown in Figure 4 to 7.

Temporal variation of 1m-SPI for Pahari block in Mirzapur district and Robertsganj block in Sonbhadra district. In case of Pahari block it can be observed that in 1986, 1997, 1998, 2009, and 2015 there is extreme soil moisture deficit condition wherein1m-SPI<-2.0. Drought of varying severities occurred in Robertsganj blocks of Sonbhadra district. In 1981, 1997, 2008, 2009 and 2016 extreme drought conditions existed in the region. This dissimilarity is due to the undulating topography of the region which resulting in maximum disposal of rainwater as runoff and thus causing water scarcity in the region along with prolonged dry spells and subsequent drought.

The temporal variation using 3m-SPI at Pahari blocks in Mirzapur district is given in Figure 6. The soil moisture deficit results due to prolonged dry spells for longer periods. The

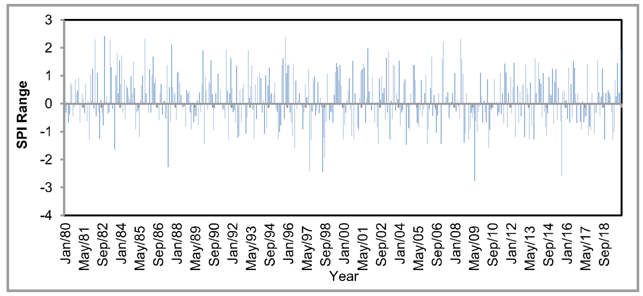

Fig. 4. 1m-SPI for Pahari block in Mirzapur district

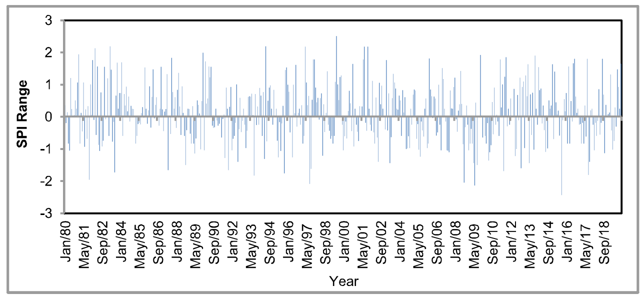

Fig. 5. 1m-SPI for Robertsganj block in Sonbhadra district

Table 7. 3m-SPI for different block in Mirzapur and Sonbhadra district of Vindhyan region

Blocks	Extreme	Severe	Moderate	Drought duration (Months)	Drought magnitude	Drought intensity
Babhani	7	19	50	75	-112.82	-1.5
Chatra	7	27	47	80	-117.49	-1.47
Chopan	9	26	46	81	-123.18	-1.52
Chhanvey	17	24	34	74	-124.44	-1.68
City	17	27	34	77	-127.39	-1.65
Dudhi	6	26	49	79	-118.62	-1.5
Ghorawal	10	21	53	81	-121.2	-1.5
Hallia	7	32	47	84	-125.73	-1.5
Jmalpur	5	21	51	76	-112.34	-1.48
Kon	16	27	33	75	-124.66	-1.66
Lalganj	13	24	36	73	-121.11	-1.66
Marihan	12	26	41	78	-125.61	-1.61
Majhawa	12	25	44	79	-121.78	-1.54
Myorpur	12	24	50	85	-129.61	-1.52
Nagwa	8	19	58	77	-112.5	-1.46
Narainpur	8	25	42	73	-113.97	-1.56
Pahari	13	18	48	79	-121.83	-1.54
Rajgarh	8	26	43	76	-118.6	-1.56
Robertsganj	10	21	49	77	-116.07	-1.51
Sikhar	12	24	44	77	-119.32	-1.55

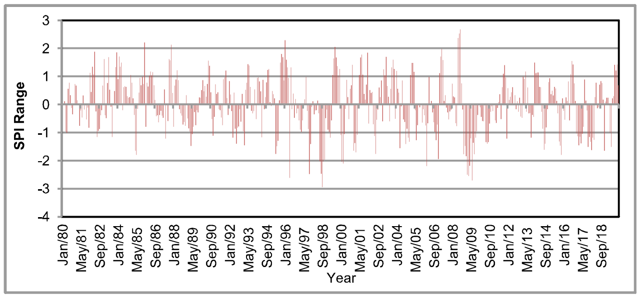

Fig. 6. 3m-SPI for Pahari block in Mirzapur district

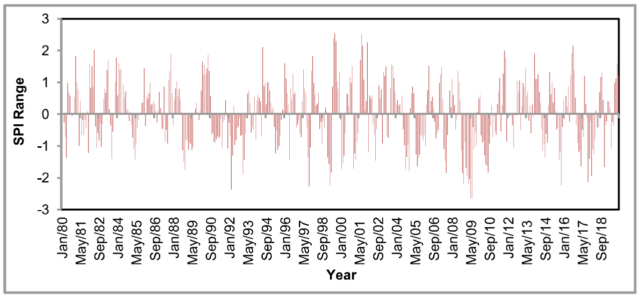

Fig. 7. 3m-SPI for Robertsganj block in Sonbhadra district

duration of the drought increase with the increase in the time scale of the SPI. 1996, 1997, 1998, 2005 and 2009 have been the predominant drought years. Extreme droughts which are observed in Pahari blocks are less as compared to the Robertsganj blocks in Sonbhadra district during 2008 and 2009.All the extreme soil moisture droughts were not translated into surface water drought probably due to favourable conditions in the intermittent years. Similarly, the severe soil moisture droughts are also fewer in both the blocks of Mirzapur and Sonbhadra district and the remaining years experienced moderate and mild soil moisture droughts.

CONCLUSION

The present study analysed the in-depth drought characteristics using indices and techniques which are suitable to analyse the drought scenario in Vindhyan region of Uttar Pradesh in Mirzapur and Sonbhadra district. The region due to water scarcity and undulating topography resulting in maximum disposal of rainwater as runoff causing water scarcity in the region. The region also experiences dry spells during the monsoon period, which, when prolonged, results in drought. The abnormal deficiencies in rainfall resulted in unfavourable conditions for agricultural production as well during the peak crop periods. Identification of drought prone block using Weibull's formula indicates that in Mirzapur district 10 out of 12 blocks are drought prone while in Sonbhadra district 3 out of 8 blocks are drought prone. In Vindhyan region there was widespread drought during 1982, 1988, 1992, 1997, 2002, 2004, 2009, 2015, and 2017. The assessment done helps to suggest suitable measures adopted to reduce drought impact and to cope under such devastating conditions. The focus of the mitigation strategy should be mainly diverted to accept the challenges that were put forward due to water stress conditions and which are having a negative impact on both crops and livestock.

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