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EVALUATION OF DROUGHT SCENARIO IN SAGAR AND CHHATARPUR DISTRICTS IN BUNDELKHAND REGION OF MADHYA PRADESH

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Abstract

The Bundelkhand region reeling under the severe recurrent droughts and famine conditions for the last few years, resulting in loss of agricultural livelihood, decreased grain production, depletion of surface and groundwater resources, and drinking water crisis making life miserable for the local population. This paper is an attempt towards a critical assessment of drought scenario in Sagar and Chhatarpur, two important districts of the Bundelkhand region of Madhya Pradesh, so as to plan for mitigation measures. Analysis of annual and seasonal long-term rainfall records revealed that the drought conditions in Sagar district occurred with an average frequency of 1 in 3 years at Kesli, Deori, Garhakota, Rehli and Shahgarh to 1 in 5 years at Sagar, Rahatgarh and Malthone whereas the average drought frequency in Chhatarpur district varies between 1 in 3 years at Chhatarpur to 1 in 5 years at Nowgong, Rajnagar, Laundi and Badamalhera blocks. Relative departure index, a weighting scheme developed to assess the drought proneness of individual blocks in a district based on drought severity has been used to prioritize the development blocks for drought mitigation. Kesli, Shahgarh and Banda in Sagar district and Buxwaha, Bijawar and Nowgong in Chhatarpur district are the priority blocks for initiating the drought mitigation activities.

The probability analysis of the annual and seasonal rainfall revealed that 6 out of 12 blocks in Sagar district, namely Banda, Shahgarh, Garhakota, Rehli, Deori and Kesli and 3 out of 7 blocks in Chhatarpur district namely, Chhatarpur, Bijawar and Buxwaha have been identified as drought prone blocks. Dry spell analysis has been performed for planning life saving supplementary irrigation for rainfed crops to reduce the water stress during critical dry spell periods. The first critical dry spell for Sagar district commences from third week July for duration of 16 days, whereas the second critical dry spell commences from third week of August for duration of 17 days. The non-parametric Mann-Kendall test have been employed to identify the possibility of any increasing trend in the duration of dry spell lengths and an increasing trend,

even though not significant has been observed in all the drought prone blocks. The crop water requirement have also been assessed for the various drought prone blocks using the Penman-Monteith method and irrigation water requirement estimated considering the effective rainfall based on USDA Soil Conservation Service method. This would enable the administrators to plan for various water resources development programmes and activities directed towards drought mitigation.

Key words: *departure, probability, dry spell, crop water requirement, crop water requirement*

1.0 INTRODUCTION

Drought is one of the most serious hazards due to its complexities, which arises from climatic variability, and its impact appears after the event is already over. Drought is an insidious hazard of nature which is the most complex but the least understood of all natural hazards (Obasi, 1994; Wilhite, 2000). Nearly 50% of the world's agricultural areas are susceptible to droughts. Although the definition of drought is very complex, it is usually related to a long and sustained period in which water availability becomes scarce (Havens, 1954;, Dracup et. al., 1980; Redmond, 2002). Droughts can be considered to be essentially a climatic phenomenon (Beran and Rodier, 1985) related to an abnormal decrease in precipitation and occurs whenever the links in the hydrologic cycle is broken or destabilized.

Drought is a complex process with varying vulnerabilities for various sectors and regional variation in vulnerability within each sector. It is not possible to avoid droughts but drought preparedness can be developed and drought impacts can be managed and the success of drought management depends on how well the droughts are defined and drought characteristics quantified (Smakhtin, et. al., 2004). Meteorological drought refers to the precipitation deficit from the normal; agricultural drought refers to the inadequate soil moisture during crop growing period whereas the hydrological drought refers to marked depletion of surface water storage in lakes, reservoirs, rivers and streams. The meteorological drought precedes the agricultural and hydrological drought.

2.0 STUDY AREA

Despite its rich resources like forests and minerals, Bundelkhand is a region of distress and crisis. Neglect of traditional water management systems and the push towards cultivation of water-

intensive commercial crops has resulted in the present situation and the Bundelkhand region is now considered as a water deficit drought prone area. The Sagar district is located in the north central region of Madhya Pradesh and lies between north latitude 23°10' to 24°27' and east longitude 78°4' to 79°21' with an area of 10,252 sq. km. and comprises of 12 development blocks (Jaisinagar, Rahatgarh, Bina, Khurai, Banda, Shahgarh, Garhakota, Rehli, Deori, Kesli, Malthone & Sagar). Betwa, Bebas, Bina, Dhasan and Sonar are major rivers traversing the district. Wheat and soyabean are main agricultural crops grown in rabi and kharrif season respectively.

Chhatarpur district located in the central portion of the Bundelkhand plateau lies between north latitudes 24°06' and 25°20' and east longitude 79°59' and 80°26' covering an area of 8616.82 sq. km. is located at the northern boundary of the M.P. The district is divided in to 8 development blocks (Gourihar, Laundi, Nowgong, Chhatarpur, Rajnagar, Bijawar, Badamalhera & Buxwaha). The major soils encountered in the district include alluvial, red & yellow, mixed red & black and medium black soils. Jowar, arhar, til, wheat and gram are the main crops grown in Chhatarpur district. The average annual rainfall is 1123.4 mm for Sagar district and 1022.9 mm for Chhatarpur district. The map showing the various districts in Bundelkhand is given as Fig. 1. The increasing pressures on water resources coupled with the variability of the hydrological cycle and climate and the inability to predict and manage the quantity and quality of water and the impacts of droughts has led to a hopeless situation of distress and crisis in Bundelkhand region. This grave situation calls for effective and integrated management of the available water resources in a sustainable manner. It is obvious that well-conceived policies, preparedness plans, and mitigation programmes can greatly reduce societal vulnerability and, therefore, the risks associated with drought.

3.0 IDENTIFICATION OF DROUGHT PRONE AREAS

The probability of occurrence of 75% of average annual rainfall has been computed to delineate the drought proneness in various districts of Bundelkhand region. An area can be considered as drought prone if the probability of occurrence of 75% of normal rainfall is less than 80%. The probability of occurrence of rainfall equivalent to the 75% of normal rainfall for Sagar and Chhatarpur districts is presented in Table 1. Banda, Shahgarh, Garhakota, Rehli, Deori and Kesli are the drought prone blocks of Sagar district whereas Chhatarpur, Bijawar and

Buxwaha are identified as drought prone blocks in Chhatarpur district. All subsequent analysis have been limited to these drought prone blocks of both districts.

Table 1: Probability analysis of annual rainfall in Sagar and Chhatarpur districts

S. No.	Name of block	Mean annual rainfall (mm)	Rainfall at 75% probability level (mm)	Probability of the 75% mean rainfall (%)	Drought condition
SAGAR DISTRICT					
1.	Banda	1001.09	758.0	77.23	*Drought Prone*
2.	Shahgarh	1013.58	781.5	78.30	*Drought Prone*
3.	Garhakota	1057.91	802.1	77.39	*Drought Prone*
4.	Rehli	1179.75	884.2	74.87	*Drought Prone*
5.	Deori	1242.62	964.2	78.26	*Drought Prone*
6.	Kesli	1145.86	859.7	75.13	*Drought Prone*
CHHATARPUR DISTRICT					
1.	Chhatarpur	1005.6	773.95	77.42	*Drought Prone*
2.	Bijawar	1129.1	867.95	78.22	*Drought Prone*
3.	Buxwaha	1047.9	719.00	71.19	*Drought Prone*

4.0 IDENTIFICATION OF DROUGHT YEARS

Meteorological drought is characterized by the water shortage induced by the imbalance between precipitation and evaporation, in particular, water shortage based solely on precipitation. The departure analysis of annual and seasonal rainfall have been carried out to identify the drought years, drought frequency and drought severity based on the rainfall deficit from normal rainfall values. Meteorological drought over an area is defined as a situation when seasonal rainfall over the area is less than 75% of its long term normal. It is further classified as 'severe drought' when rainfall deficit exceeds 50%, 'moderate drought' when rainfall deficit is between 26 and 50% and 'mild drought' when rainfall deficit is between 20 and 26%. The rainfall data of all the 12 blocks of Sagar district and 8 blocks of Chhatarpur district were analyzed to study rainfall distribution, drought magnitude and its frequency in terms of rainfall deficiency.

The analysis reveals that widespread drought was experienced in the year 2007-08 in Sagar district with seven blocks having departures more than 40% while the remaining blocks also faced deficit in varying amounts. Only Banda block was subjected to a severe drought condition in 2007-08 with deficit more than 50% whereas the moderate drought scenario was experienced in the remaining blocks of Sagar district. Similarly 2002-03 also was a drought year

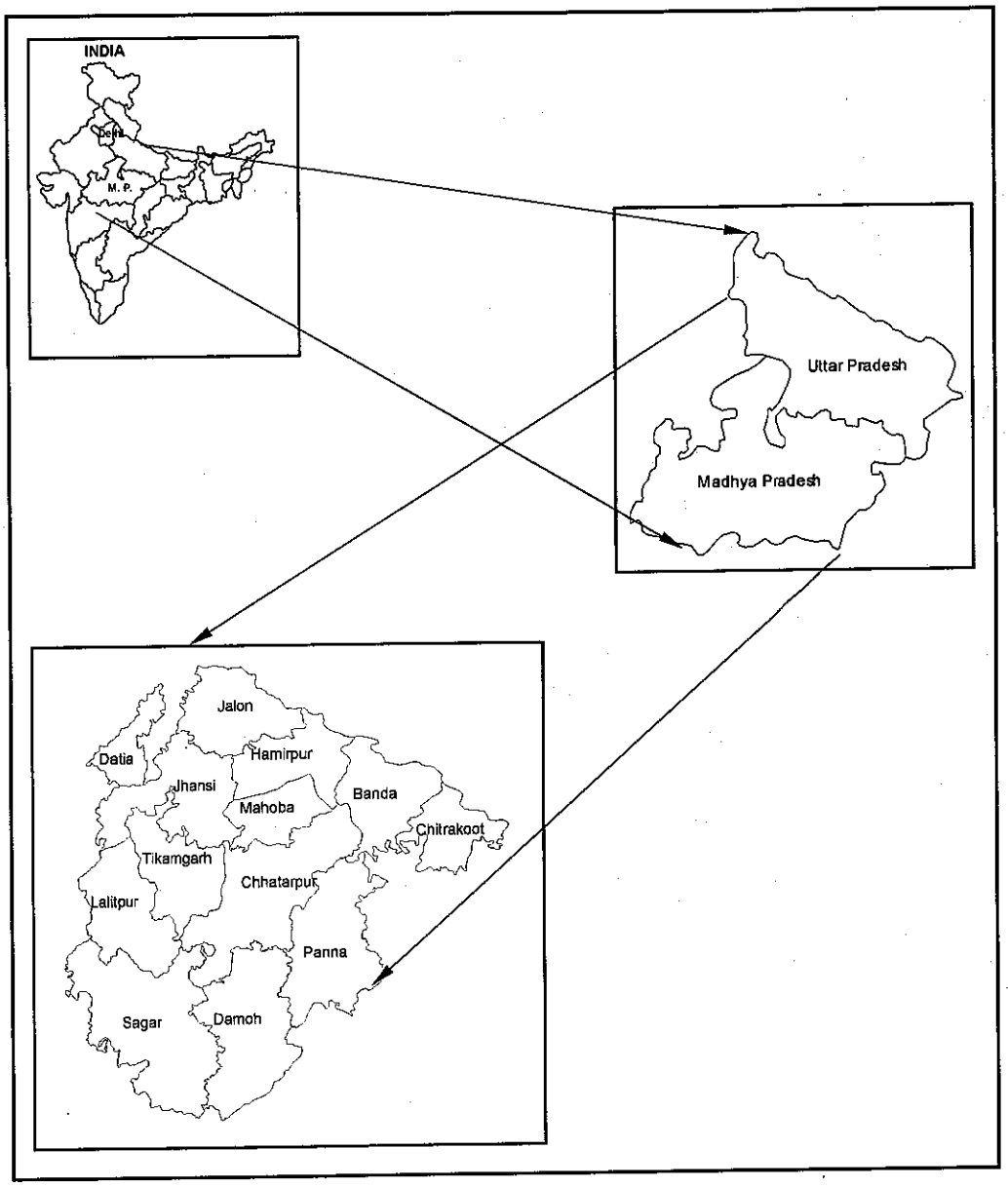


Fig. 1: Index map of showing the Bundelkhand region in MP and UP

with eight blocks experiencing mild to moderate drought conditions in the district whereas 5 blocks experienced drought conditions in 2006-07. The drought years, drought severity and drought frequency for Sagar and Chhatarpur districts is given in Table 2.

The average drought frequency in Sagar district varies between 1 in 3 years at Kesli, Deori, Garhakota, Rehli and Shahgarh to 1 in 5 years at Sagar, Rahatgarh and Malthone and 1 in 6 years at Khurai block. The severe drought conditions are seldom experienced in Sagar district but the many of the blocks in the district experienced moderate drought situation for a considerable number of years. The average drought frequency in Chhatarpur district varies

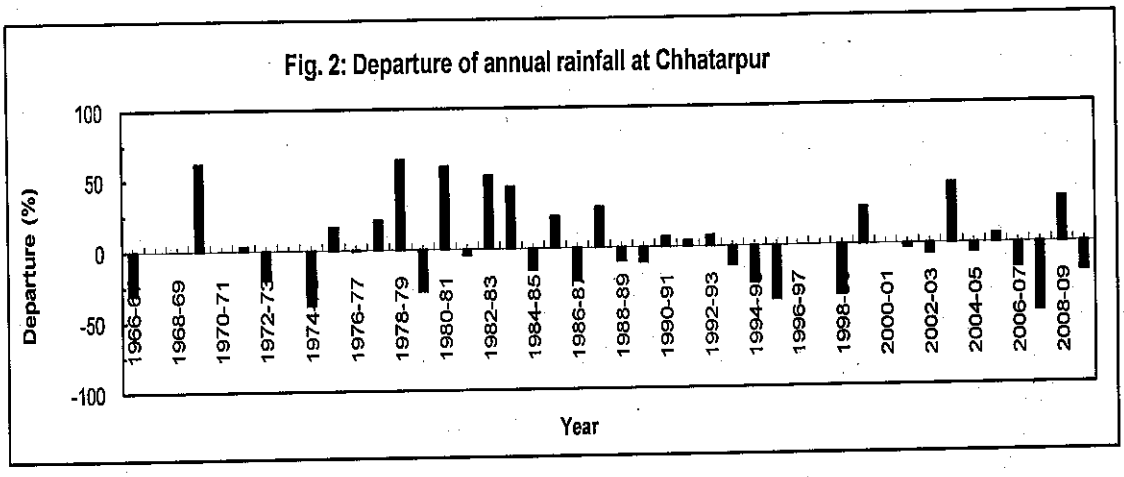
Table 2: Drought years, drought frequency and drought severity in Sagar and Chhatarpur districts

S. N.	Station	Drought years	Drought Severity	Drought frequency
SAGAR DISTRICT				
1.	Banda	1981-82, 1986-87, 1988-89, 1989-90, 1998-99, 2000-01, 2002-03, 2006-07, 2007-08	mild to severe	1 in 4 years
2.	Shahgarh	1995-96, 1998-99, 2000-01, 2002-03, 2006-07, 2007-08	mild to moderate	1 in 3 years
3.	Garhakota	1995-96, 2000-01, 2001-02, 2006-07, 2007-08	mild to moderate	1 in 3 years
4.	Rehli	1982-83, 1984-85, 1986-87, 1988-89, 1991-92, 2000-01, 2004-05, 2006-07, 2007-08	mild to moderate	1 in 3 years
5.	Deori	1984-85, 1986-87, 1988-89, 1989-90, 1991-92, 1992-93, 1995-96, 2008-09, 2009-10	mild to moderate	1 in 3 years
6.	Kesli	1992-93, 1996-97, 2000-01, 2002-03, 2007-08, 2008-09	mild to moderate	1 in 3 years
CHHATARPUR DISTRICT				
1.	Chattarpur	1979-80, 1986-87, 1994-95, 1995-96, 1996-97, 1998-99, 2000-01, 2007-08, 2009-10	mild to severe	1 in 3 years
2.	Bijawar	1966-67, 1970-71, 1971-72, 1974-75, 1979-80, 1988-89, 1989-90, 1991-92, 1995-96, 2000-01, 2006-07, 2007-08	mild to severe	1 in 3 years
3.	Buxwaha	1976-77, 1979-80, 1981-82, 1986-87, 1989-90, 1995-96, 2002-03, 2006-07, 2007-08, 2009-10	moderate to severe	1 in 4 years

between 1 in 3 years at Chhatarpur to 1 in 5 years at Nowgong, Rajnagar, Laundi and Badamalhera blocks. Severe drought conditions were experienced in most of the blocks of Chhatarpur district in 2007-08 with Nowgong having a deficit of more than 60% followed by Rajnagar with a deficit of 55.79%. The annual departure at Sagar is given in Fig. 2.

5.0 RELATIVE DEPARTURE INDEX

In order to assess the relative drought proneness of various blocks in a district, a weighting scheme was designed based on the drought severity. The weighing scheme allowed a weight of 1, 2 and 3 for mild, moderate and severe drought respectively. The relative departure index (RDI) for each block was computed by dividing the total weights of a block by the number of years of analysis. Based on the ranking provided by RDI index, block can be prioritized



for initiation of drought mitigation strategies. The RDI for the various blocks of Sagar and Chhatarpur districts along with the priority ranks is given in Table 3.

Table 3: Relative Departure Index for Sagar and Chhatarpur district

S.No	Block name	Relative Departure Index	Ranking	Block name	Relative Departure Index	Ranking
	SAGAR DISTRICT			CHHATARPUR DISTRICT		
1	Kesli	0.778	1	Buxwaha	0.611	1
2	Shahgarh	0.556	2	Bijawar	0.537	2
3	Banda	0.552	3	Nowgong	0.500	3
4	Rehli	0.545	4	Badamalhera	0.462	4
5	Deori	0.515	5	Rajnagar	0.429	5
6	Garhakota	0.471	6	Chhatarpur	0.415	6
7	Khurai	0.424	7	Gaurihar	0.360	7
8	Sagar	0.394	8	Laundi	0.293	8
9	Rahatgarh	0.391	9			
10	Malthone	0.385	10			
11	Bina	0.360	11			
12	Jaisinagar	0.350	12			

The analysis reveals that five blocks in Sagar district namely Kesli, Shahgarh, Banda, Rehli and Deori and Buxwaha, Bijawar and Nowgong in Chhatarpur district can be considered as priority blocks for drought mitigation. The Kesli block in Sagar district and Buxwaha in Chhatarpur district has the highest rank which is indicative of the fact that it has more frequent droughts of higher severities as compared to other blocks of the district.

6.0 ONSET AND WITHDRAWAL OF EFFECTIVE MONSOON

The success or failure of crops particularly under rainfed conditions is closely linked with the rainfall patterns like date of onset of effective monsoon, duration of wet spells, duration of

intervening dry spells and number of rainy days. Presently, rainfed agriculture is the only alternative for majority of the farmers in Bundelkhand. The selection of crop varieties and time for seedbed preparation are governed by onset, termination, rainfall and length of monsoon, which plays very significant role in the success of agricultural crops. The rainfall data have been analyzed critically to identify the onset and withdrawal of effective monsoon and number. The date of onset of effective monsoon can be defined as the date of commencement of a wet spell satisfying the following criteria.

- The first day's rain in 7- days spell is not less than average daily evapotranspiration (ET).
- At least four out of seven days are rainy days with not less than 2.5 mm of rain each day.
- The total rain during the 7 – day spell is not less than (5ET+10) mm.

The mean and standard deviation of the date of onset of effective monsoon is has been computed for all the blocks and given in Table 4. The onset of the monsoon occurs by the first to mid-second week of July and the monsoon withdrawal takes place by the third week of September and the significant seasonal rainfall mostly lasts only for the three months of July, August and September.

Table 4: Onset and withdrawal of effective monsoon in Sagar and Chhatarpur districts

S. No.	Name of block	Mean date of onset	Standard deviation (days)	Median date of onset	Mean date of withdrawal
SAGAR DISTRICT					
1.	Banda	02 July	12	30 June	18 Sept
2.	Shahgarh	04 July	16	06 July	23 Sept
3.	Garhakota	22 June	11	23 June	30 Sept
4.	Rehli	22 June	11	21 June	24 Sept
5.	Deori	26 June	12	25 June	26 Sept
6.	Kesli	28 June	18	26 June	26 Sept
CHHATARPUR DISTRICT					
1.	Chhatarpur	02 July	15	03 July	22 Sept
2.	Bijawar	03 July	13	03 July	26 Sept
3.	Buxwaha	29 June	16	28 June	24Sept

7.0 REFERENCE EVAPOTRANSPIRATION

The evapotranspiration rate from a reference surface, not short of water, is called the reference evapotranspiration denoted as ET_o. As water is abundantly available at the reference evapotranspiring surface, soil factors do not affect evapotranspiration (ET). FAO Penman Monteith method is now recommended as the sole standard method for definition and

computation of reference evapotranspiration using weather data such as radiation, air temperature, air humidity and wind speed (Allen et al. 1998) and is given by

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad \ldots\ldots (1)$$

where, ET_o = reference evapotranspiration [mm/day], R_n = net radiation at the crop surface [MJ/m^2/day], G = soil heat flux density [MJ/m^2/day], T = mean daily air temperature at 2 m height [°C], u_2 = wind speed at 2 m height [m/s], e_s= saturation vapor pressure [kPa], e_a = actual vapor pressure [kPa], e_s - e_a = saturation vapor pressure deficit [kPa], Δ = slope vapor pressure curve [kPa/°C], γ = psychometric constant [kPa/°C]. The monthly reference evapotranspiration at Sagar is given as Table 5.

Table 5: Reference evapotranspiration (ET_o) at Sagar

S. No.	Month	ET_o (mm/day)	S. No.	Month	ET_o (mm/day)
1.	January	2.90	7.	July	4.45
2.	February	3.77	8.	August	3.73
3.	March	4.87	9.	September	3.98
4.	April	5.91	10.	October	3.92
5.	May	6.87	11.	November	3.17
6.	June	6.26	12.	December	2.69

8.0 CRITICAL DRY SPELL ANALYSIS

Knowledge of the distribution of dry spells during the monsoon period is therefore essential for successful rainfed farming in this region facing recurrent droughts for deciding the sowing date, cropping pattern and planning for protective irrigation and intercultural operations. After the onset of the monsoon, a dry spell is determined as the interval of dry days between two consecutive wet spells. Dry days are considered as days having rainfall less than 2.5 mm. A wet spell can be defined as:

- A rainy day with rainfall equal to or more than 5ET or
- A spell of two consecutive rainy days with rainfall totaling at least 5ET or
- A 7-day period having at least 3 or 4 rainy days with a total rainfall not less than 5ET

On the basis of crop-soil combination the minimum length of a dry spell is considered as ten days that become critical to the crops grown in the Bundelkhand region. The probable period

of commencement of critical dry spells and their duration for the drought prone blocks in Sagar and Chhatarpur districts are presented in Table 6.

Table 6: Occurrence of Critical Dry Spells (CDS) in Sagar and Chhatarpur district

S. No.	Name of Block	First CDS		Second CDS	
		Probable period of commencement	Average length in days	Probable period of commencement	Average length in days
SAGAR DISTRICT					
1.	Banda	July-III Week	15	Aug- IV Week	15
2.	Shahgarh	July-IV Week	17	Aug- III Week	14
3.	Garhakota	July-I Week	14	Aug- II Week	17
4.	Rehli	July-IV Week	17	Aug- IV Week	18
5.	Deori	July-III Week	14	Aug- III Week	17
6.	Kesli	July-II Week	17	Aug- IV Week	23
CHHATARPUR DISTRICT					
1.	Chhatarpur	July-III Week	19	Aug- II Week	18
2.	Bijawar	July-IV Week	18	Aug- IV Week	19
3.	Buxwaha	Aug- I Week	14	Aug- IV Week	16

9.0 DETECTION OF TREND IN CRTICAL DRY SPELL PATTERN

The evaluation of the critical dry spells in the Bundelkhand district helps to give an idea of the dates of onset and durations of critical dry spells in various blocks of the district. Due to the recurrent crop failures and droughts in the region in the last decade, an attempt was made to analyze the existence of trend in the critical dry spells and whether these trends are significant enough to arrive at some conclusions. To identify trend the possibility of climate change, the Mann-Kendall test has been employed by a number of researchers with temperature, precipitation and stream flow data series (Taylor & Loftis, 1989; Burn, 1994; Burn *et al.*, 2004). Before applying the Mann-Kendall test, the data series were tested for serial correlation. The Mann-Kendall statistic (S) is defined as (Salas, 1993):

$$S = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \operatorname{sgn}(x_j - x_i) \qquad \text{where, } \operatorname{sgn}(x_j - x_i) = \begin{bmatrix} 1 if (x_j - x_i) > 1 \\ 0 if (x_j - x_i) = 1 \\ -1 if (x_j - x_i) < 1 \end{bmatrix} \quad \ldots\ldots (2)$$

and N is the number of data points. This statistic represents the number of positive differences minus the number of negative differences for all the differences considered. For large samples (N > 10), the test is conducted using a normal distribution (Helsel & Hirsch, 1992) with the mean and the variance as follows:

$$E(S)=0; \qquad \mathrm{var}(S)=\frac{N(N-1)(2N+5)-\sum_{k=1}^{n} t_k(t_k-1)(2t_k+5)}{18} \qquad \ldots\ldots (3)$$

where, n is the number of tied (zero difference between compared values) groups, and t_k is the number of data points in the k_{th} tied group. The standard normal deviate (Z statistic) is then computed as (Hirsch *et al.*, 1993):

$$Z=\begin{cases}\dfrac{S-1}{\sqrt{\mathrm{var}(S)}} \; if S>0 \\ 0 \; if S=0 \\ \dfrac{S+1}{\sqrt{\mathrm{var}(S)}} \; if S<0\end{cases} \qquad \ldots\ldots (4)$$

If $Z > +1.96$ or $Z < -1.96$, the null hypothesis (Ho) is rejected at 95% significance level.

The series consisting of the maximum length of critical dry spells in each year was used for the trend analysis using Mann-Kendal test. The results of the analysis for the drought prone blocks of Sagar and Chhatarpur district are given in Table 7.

Table 7: Trend of Critical Dry Spells in Sagar and Chhatarpur districts

S.No	Station	Test Statistic (Z)	Remarks
SAGAR DISTRICT			
1	Banda	+ 1.58	Rising trend but not significant at 95% significance level
2	Shahgarh	+ 0.69	
3	Garhakota	+ 1.92	
4	Rehli	+ 0.39	
5	Deori	+ 1.65	
6	Kesli	+ 1.58	
CHHATARPUR DISTRICT			
1	Chhatarpur	+ 0.17	Rising trend but not significant at 95% significance level
2	Bijawar	+ 0.84	
3	Buxwaha	+ 1.45	

As can be observed from the analysis, there is definite increasing trend in the duration of maximum dry spells encountered in both the districts. However the rising trend is not significant at 95% significance levels as the test statistic value is less than 1.96. The maximum rising trend is observed at Kesli and Banda in Sagar district which are drought prone blocks and also facing frequent droughts of higher intensities as identified by the relative departure index.

10.0 CROP WATER REQUIREMENT

Crop evapotranspiration represents crop water demand which is governed by weather and crop conditions. The crop evapotranspiration has been estimated from ET_o as,

$$ET_{crop} = ET_o \times K_c \quad \ldots\ldots (5)$$

where, ET_{crop}= crop evapotranspiration (mm/day), ET_o= reference evapotranspiration (mm/day); K_c= crop coefficient

The crop evapotranspiration have been computed on a ten-daily basis considering the four crop growth stages namely, initial stage, development stage, growth stage and the final stage. The effective rainfall has been computed using the USDA Soil Conservation Service Method. The supplemental irrigation requirement during the first and second critical dry spells for the drought prone blocks in Sagar and Chhatarpur districts is given in Table 8.

The crops grown in the Bundelkhand region can be protected from the stresses during the critical dry spells which is a regular feature in the region and generally the region experience two critical dry spells during most of the years. The provision of scope for supplemental irrigation will help in promoting the farmers of the region to take cultivation during kharif season also, which is not the practice presently as this will reduce the probabilities of crop failures during the critical dry spells in monsoon season.

11.0 CONCLUSIONS

The Bundelkhand region is facing recurrent droughts in recent years and last decade has witnessed few drought years varying from severe to moderate severity, causing severe hardships to local populace. On an average, the frequency of occurrence of drought in study area varies between 1 in 3 years to 1 in 6 years. The trend analysis of rainfall data suggests that even though there is a falling trend in annual and monsoon season rainfall amounts, but overall no block depicts a significant falling trend at 95% significance level. The mean date of onset of monsoon varies between last week of June to first week of July and the monsoon withdraws generally by

Table 8: Irrigation requirement during critical dry spells in Sagar and Chhatarpur district

S. No.	Name of Block	Critical Dry Spell	Irrigation requirement (mm)			
			Rice	Soyabean	Vegetables	Jowar
SAGAR DISTRICT						
1.	Banda	I CDS	22.84	05.89	16.07	03.52
		II CDS	43.03	48.19	43.32	34.51
		Total	*65.87*	*54.08*	*59.39*	*38.03*
2.	Garhakota	I CDS	34.02	09.83	21.05	06.77
		II CDS	64.36	65.79	65.14	37.87
		Total	*98.38*	*75.63*	*86.19*	*44.64*
3.	Deori	I CDS	14.17	03.38	4.83	02.54
		II CDS	59.72	63.58	10.77	40.61
		Total	*73.89*	*66.93*	*15.60*	*43.15*
4.	Rehli	I CDS	32.29	12.47	28.94	03.80
		II CDS	57.33	62.16	55.99	50.43
		Total	*89.62*	*74.63*	*84.93*	*54.24*
5.	Kesli	I CDS	28.61	09.28	20.19	06.37
		II CDS	15.15	17.19	13.29	12.82
		Total	*26.47*	*26.47*	*33.49*	*19.19*
6.	Shahgarh	I CDS	48.30	24.03	23.05	14.02
		II CDS	50.67	54.10	35.49	36.18
		Total	*98.91*	*78.13*	*58.54*	*50.18*

CHHATARPUR DISTRICT								
S. No	Name of Block	Critical Dry Spell	Irrigation requirement (mm)					
			Rice	Soyabean	Vegetables	Jowar	Arhar	Til
1.	Chhatarpur	I CDS	29.28	13.20	25.02	8.01	10.14	09.27
		II CDS	17.30	19.17	17.41	12.78	6.11	6.55
		Total	*46.58*	*32.37*	*42.43*	*20.79*	*16.25*	*15.82*
2.	Bijawar	I CDS	06.30	00.00	05.10	00.00	00.00	00.00
		II CDS	28.75	31.14	27.68	26.39	06.14	17.69
		Total	*35.05*	*31.14*	*32.78*	*26.39*	*06.14*	*17.69*
3.	Buxwaha	I CDS	11.99	08.23	12.08	05.52	03.59	03.85
		II CDS	32.14	35.14	28.84	28.18	15.86	13.06
		Total	*44.13*	*43.37*	*40.92*	*33.7*	*19.45*	*16.91*

the last week of September. Two critical dry spells of duration of 10 days and more are frequently occurring in most of the years, for which planning is required for provision of supplemental irrigation. A rising trend in the length of critical dry spells, even though not significant at 95% significance level, have been observed in most of the blocks in Bundelkhand region and hence planning for drought should cater to this very important aspect too. The results

of the analysis show that rain-fed agriculture in the region is virtually impossible without the provision for adequate supplementary irrigation during periods of distress in critical dry spells. A proactive approach is necessary and systematic planning is required to meet the water requirements for domestic, livestock and agriculture to tide over the crisis during periods of droughts which has now become more of a regular feature in this region.

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