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Modeling, Probability Analysis and Forecasting of Rainfall in Betwa River Basin in Bundelkhand Region, India

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***Abstract* – Daily rainfall data of 41 years (1975-2015) of MP and UP districts covered under the boundary of Betwa river basin of Bundelkhand region have been considered to analyse the long term average and its temporal variability on seasonal and annual basis by using MK test and Sen's estimator, and annual rainfall forecasted by using ARIMA model for five year period from 2016 to 2020. The average annual rainfall in the Betwa river basin was 958.6 mm with 25.1 percent coefficient of variation indicating thereby that the annual rainfall was not much stable over the years. Upper to middle region of basin received more average annual rainfall than middle to lower region of the basin. Hamirpur, Tikamgarh, Raisen, Bhopal, Shivpuri, Chhatarpur, Jalaun, Mahoba, Ashoknagar, Lalitpur, Sagar and Vidisha annual rainfall time series shows negative trend while Jhansi annual rainfall shows positive trends. These trends are tested for seasonal rainfall for districts seasonal rainfall at 5%level of significance. All station shows insignificant positive and negative trend in winter season rainfall followed by pre monsoon, SW monsoon and post monsoon season rainfall. The rate of decrease in the annual rainfall for districts covered under Betwa river basin except Jhansi varied 1.57 to 13.12 mm/yr and for Jhansi rate of increase in annual rainfall was estimated to be 0.4387 mm/yr. Using Weibull's (extreme value type III) method weekly rainfall for monsoon season was predicted at 50, 75, and 90 percent probability levels. The average annual rainfall time series is forecasted for the period 2016 to 2020 at 80% and 95% prediction intervals. Results of this study can be helpful in the planning, development and management of present and future plan in the Betwa river basin.**

***Keyword* – Mann Kendall Test, Sen's Slope, ARIMA Model, Betwa River Basin, Rainfall, Forecasting, Probability Analysis and Trend Analysis.**

I. Introduction

Rainwater is the main source of surface and groundwater. It is a major renewable resource has become very important for overall development and management of ecology and environment surrounding the human being. Climate and living organisms is adversely affected due to the overexploitation of natural resources at regional and national level. Intergovernmental Panel on Climate Change (2013) reported that the global average surface warming is occurring at a rate of 0.74 ± 0.18 °C during the period 1983-2012. It also reported that global sea level rose by 0.19 m over the period 1901 to 2010. Due to global surface warming there is changes in the global water cycle cause contrast in rainfall between wet and dry regions and also increasing contrast between wet and dry seasons (Nikhil Raj and Azeez, 2012; IPCC, 2013). Climate change over India by southwest monsoon causes drastic change in hydrological parameters such as rainfall, evaporation and streamflow, would have a significant impact of agricultural and livestock production, water resources management and overall economy of the country (Abeysingha et al., 2014; IPCC, 2013; Palizdan et al., 2015). The monsoon irregularity has severely affected the water availability in river systems. The resulting diminishing surface water availability as well as groundwater availability has not only decreased the availability of drinking water for people and domestic animals, but also impacted the natural vegetation of the region and increase the problem of famine and droughts (Kumar et al., 2010). So, therefore trend analysis of long-term rainfall time series data using statistical tools has been extensively useful in study and proper assessment of impacts of climatic change along with its variability in the river basin (Kothyari and Singh, 1996; Longobardi and Villani, 2010;Chakraborty et al., 2013;Bera, 2017; Murumkar and Arya, 2014; Gajbhiye et al., 2016).Nonparametric method of Sen's slope estimator has been frequently used to estimate the trend's magnitude, whose statistical significance was assessed by the Mann–Kendall test (Mann, 1945; Kendall, 1975; Pohlert, 2016). In general, studies of trend analysis for different climatic variables is determined either using parametric test or nonparametric test (Sen, 1968). Suryavanshi et al., (2013) observed that there is no trend in seasonal and annual rainfall except summer rainfall. It also observed that a decreasing trend during the summer rainfall, and a similar seasonal rainfall pattern over entire Betwa river basin of Bundelkhand region in the state of Madhya Pradesh and Utter Pradesh (Sutcliffe et al., 1981).

Probability analysis of rainfall data series enables us to determine the expected rainfall at various levels of chances. Rainfall at 80 per cent chance can be safely taken as assured rainfall, while 50 per cent chance can be considered as the maximum limit for taking any risk (Bhakar et al., 2008; Sharma and Singh, 2010). Daily, weekly, monthly and seasonal probability analysis of rainfall data series is mainly for amount of rainfall, crop planning and so on (Sharda and Das, 2005).

A time series data must exhibit smooth behavior by avoiding inconsistent result. The autoregressive integrated moving average (ARIMA) model is a most common time series model and widely used in forecasting hydrologic and climatic time series modeling. The model forecasted variable by a linear combination of the previous state of

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variable (pure AR component), and previous forecast error (pure MA component) (Gautam and Sinha, 2016). This model was developed for a climatic time-series forecasting model to forecast climatic variations (Soltani et al., 2007) and ARIMA model have been applied, and improved by many hydrologists for forecasting long term as well as short term climate time series data (Hipel et al., 1977; Burlando et al., 1993) and also applied in forecasting of crop and livestock production (Kumar and Anand, 2014).

The Betwa river basin of Bundelkhand region is to be highly underdeveloped due to lack of irrigation facilities, because around 60% of main workers are engaged in agriculture as cultivators or laborers (Gupta et al., 2014). The area is prone to famines and droughts, particularly the upper and middle regions. So, there is a need to study of long term rainfall time series for overall physical, biological and social development and management of Betwa river basin of Bundelkhand region. In this study, a much detailed view has been taken to assess the presence of linear monotonic upward or downward trends in the temporal structure of rainfall and to quantify the trend statistics on seasonal and annual scales for Betwa river basin of Bundelkhand region in the state of Madhya Pradesh and Utter Pradesh.

II. Materials and Methods

2.1. Study Area

The Betwa river basin lies between 22°54' and 26° 05' N latitude and 77°10' and 80°20'E longitude, which having total catchment area is approx.. 43469 km^2 is shown in (Fig. 1). The total length from its origin in the Raisen district of Madhya Pradesh at an elevation of about 576 m above mean sea level to its confluence in Yamuna river near Hamirpur in Uttar Pradesh at an elevation of about 106 m is approximately 590 km. The basin is saucer shaped with sandstone hills around its perimeter. It covers the areas of Bundelkhand uplands, the Vindhyan scrap and the Malwa plateau lands in the districts of Tikamgarh, Sagar, Vidisha, Raisen, Bhopal, Ashoknagar, Shivpuri and Chhatarpur of Madhya Pradesh and Hamirpur, Jalaun, Jhansi, Mahoba, Lalitpur and Banda districts of Uttar Pradesh. The average annual rainfall varies from 700 to 1,200 mm, out of which nearly 80 % occurs during the SW monsoon season (Suryavanshi et al., (2013).The climate of the basin is characterized by mild winter with minimum temperature is 8.1 ^{0}C and hot summer with maximum temperature reaches upto42 °C. The mean monthly relative humidity in the basin is 90% (August) and 18 % (April and May) respectively. The wind velocities in the upper reaches of the basin are generally higher than that of the lower reaches in the basin.

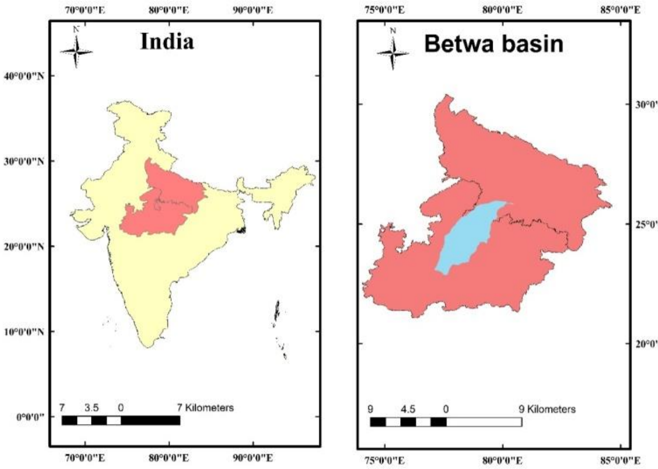


Fig. 1. Location map of Betwa basin

2.2. Collection of Data

To study the temporal distribution of rainfall in Betwa basin, a trend analysis of the annual (mm) and seasonal (mm) were considered. The daily rainfall over 41 years (1975 – 2015) for 13 stations was obtained from India Meteorological Department (IMD), Pune to examine the temporal variability of the rainfall data. Trend analysis of rainfall was performed for Betwa basin in Bundelkhand region on annual and seasonal (pre-monsoon from March to May, monsoon from June to September, post-monsoon from October to November, and winter from December to February), which is also reported by Rainfall statistics of India (2016), IMD. The location (longitude and latitude) and altitude of weather stations are shown in Table 1. The altitude of the weather stations varied from 137 to 473 m. The seasonal and annual mean rainfall statistics is represented in table 1.

2.3. Mann-Kendall Test

The Mann-Kendall (MK) non parametric test is generally used to tested monotonic upward or downward trends in climatologic and in hydrologic time series (Mann, 1945 and Kendall, 1975). It is an excellent tool for trend detection by many researchers (Pohlert, 2016). The Mann-Kendall test statistic is represented in equation (1)

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sgn}(X_J - X_K) = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sgn}(x) \qquad (1)$$

Where

$$\text{sgn}(x) = \begin{Bmatrix} 1 & if & x > 0 \\ 0 & if & x = 0 \\ -1 & if & x < 0 \end{Bmatrix} \qquad (2)$$

It has been documented that when n ≥ 10, the mean of Sis E(s) = 0 and the variance (σ^2) of S is

$$\sigma^2 = \left\{ n(n-1)(2n+5) - \sum_{j=1}^{p} t_j (t_j - 1)(2t_j + 5) \right\} / 18 \qquad (3)$$

Where, n is the number of time series data points, p is the number of the tied groups in the time series data set and t_j is the number of data points in the jth tied group. The test statistic S is closely related to Kendall's rank correlation coefficient, tau (τ) is represented by the equation (4)

$$\tau = \frac{S}{D} \qquad (4)$$

Where, S is the Kendall score and D is the maximum possible value of S. and

$$D = \left[\frac{1}{2}n(n-1) - \frac{1}{2}\sum_{j=1}^{p} t_j(t_j-1)\right]^{1/2}\left[\frac{1}{2}n(n-1)\right]^{1/2} \qquad (5)$$

The Z-statistics is represented by the equation (6)

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} & if \quad S>0 \\ 0 & if \quad S=0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & if \quad S<0 \end{cases} \qquad (6)$$

The null hypothesis, H0, is that the data are independent and are normally distributed. The alternative hypothesis, HA, data follows a monotonic decreasing or increasing trend. The trends were tested at 5% level of significance. A positive value of S indicates an increasing trend, and negative value indicates a decreasing trend of time series data set.

2.4. Sen's Estimator Method

This method is generally used to detect the magnitudes of trend of time series data. Non parametric Sen's slope estimator (Sen, 1968) was used to calculate the change per unit time. The trend slope gave the rate of increase or decrease in the annual and seasonal trend and the direction of change.

2.5. Weibull's Distribution

The weekly rainfall data for monsoon season (i.e. approx. 85 percent average annual rainfall takes place during monsoon season in India) were analyzed for computation of weekly probable rainfall amount at 50, 75 and 90 percent probability level by using Weibull's equation is represented in equation (7)

$$P = \frac{m}{n+1} \qquad (7)$$

where, P is the probability of occurrence of rainfall, m is the rank of the observed rainfall value after arranging them in ascending or descending order of magnitude and n is the total number of years in time series.

2.6. ARIMA Model

Autoregressive integrated moving average (ARIMA) model is used to predict future values of a time series. This model is a generalization of ARMA models which incorporates a non-stationary time-series is obtained by involving the differencing into the model. Forecasting by using ARIMA models is commonly known as the Box-Jenkins approach (Zucchini and Nenadic, 2011). A time series $\{x_t\}$ is said to follow an ARIMA model, denoted by elements of ARIMA model of order (p, d, q), if $\nabla^d x_t = (1-B)^d x_t$ is ARMA (p, q). The model is represented in the equation (8)

$$\phi(B)(1-B)^d x_t = \theta(B)\omega_{t,} \ \{\omega_t\} \sim WN(0,\sigma^2) \qquad (8)$$

Where, WN is indicating White Noise. The integration parameter d is a nonnegative integer. When d = 0, ARIMA (p, d, q) ≡ ARMA (p, q).The model is used for forecasting next five year time series by using forecast package in R language.

III. Results and Discussions

3.1. Rainfall Statistics in the Basin

The seasonal and annual mean rainfall statistics is presented in table 1. The mean seasonal rainfall is uniformly distributed in whole Betwa basin, although average annual rainfall for the district under this river basin varies from 770 to 1155 mm during the period 1975 to 2015. Table 1. Also shows the variability of average annual rainfall as given by the coefficient of variability (CV), which is standard deviation is divided by mean of annual rainfall. The CV values show the little changes over the Betwa basin, suggesting that the standard deviation is proportional to the mean of annual rainfall. Tikamgarh shown highest CV (38.1%) while Vidisha shown lowest CV (20.4%), marked high rainfall in upper to middle region of the basin and medium to low rainfall in the middle to low region of the basin. The average annual rainfall in the Betwa river basin is 958.6 mm with approx. 25% coefficient of variation, which is lower than the average annual rainfall (1190 mm) of the country (Rainfall statistics of India, 2016).

Table 1. Rainfall statistics in Betwa River Basin

Station	Lat.	Long.	Elev. (m)	Seasonal Mean Rainfall (mm)				Average annual rainfall (mm)	CV
				Winter	Pre monsoon	Monsoon	Post monsoon		
Shivpuri	25.27	78.24	364	24.44	22.19	780.3	43.02	870.0	0.214
Chhatarpur	25.03	79.51	171	32.83	24.89	930.5	44.47	1032.7	0.257
Hamirpur	25.69	79.89	137	30.62	25.72	798.8	43.72	898.9	0.239
Jalaun	25.94	79.64	141	23.56	24.92	687.5	35.58	771.6	0.254
Jhansi	25.43	78.57	274	27.38	25.72	818.1	42.34	913.9	0.216
Mahoba	25.17	79.51	181	25.90	23.35	812.7	36.90	898.8	0.254
Tikamgarh	24.72	78.81	392	25.86	21.54	756.1	42.32	845.8	0.381

Station	Lat.	Long.	Elev. (m)	Seasonal Mean Rainfall (mm)				Average annual rainfall (mm)	CV
				Winter	Pre monsoon	Monsoon	Post monsoon		
Ashoknagar	24.65	77.78	467	-	-	-	-	971.9	0.288
Lalitpur	24.68	78.41	428	24.75	22.21	768.0	43.02	857.9	0.269
Sagar	23.83	78.81	451	28.46	22.00	965.2	44.40	1060.0	0.211
Vidisha	23.52	77.81	463	26.13	22.80	976.9	51.43	1077.2	0.204
Raisen	23.34	77.77	443	26.9	20.72	1010.1	50.36	1108.1	0.236
Bhopal	23.28	77.35	473	29.45	26.08	1041.0	58.33	1155.0	0.239
Average								958.6	0.251

3.2. Trends in Annual and Seasonal Mean Rainfall

To study the temporal variation in annual and seasonal mean rainfall of the Betwa river basin in Bundelkhand region of MP and UP state trend analysis of annual and seasonal mean rainfall for a period 1975 to 2015 was done by using Mann Kendall (MK) test and results of selected weather station in district boundary coverage are represented in Table 2 and Table 3.

Table 2. Mann Kendall test for annual rainfall for a period 1975–2015

Station	S	Tau	Var(S)	p-value
Shivpuri	-152	-0.185	7926.67	0.090
Chhatarpur	-160	-0.195	7926.67	0.074
Hamirpur	-176	-0.215	7926.67	0.049*
Jalaun	-72	-0.088	7926.67	0.425
Jhansi	8	0.010	7926.67	0.937
Mahoba	-166	-0.202	7926.67	0.064
Tikamgarh	-254	-0.310	7926.67	0.004*
Ashoknagar	-36	-0.044	7926.67	0.694
Lalitpur	-90	-0.110	7926.67	0.317
Sagar	-120	-0.146	7926.67	0.181
Vidisha	-166	-0.202	7926.67	0.064
Raisen	-248	-0.302	7926.67	0.006*
Bhopal	-196	-0.239	7926.67	0.029*

*Note: Significant at 5% level of significance based on MK test

Table 3. Mann Kendall test for Seasonal rainfall for a period 1975-2015

Station	Winter			pre monsoon			SW Monsoon			Post monsoon		
	S	Tau	p value	S	Tau	p value	S	Tau	p value	S	Tau	p value
Shivpuri	67	0.08	0.46	53	0.06	0.56	-151	-0.18	0.09	-47	-0.06	0.61
Chhatarpur	-25	-0.03	0.79	162	0.20	0.07	-206	-0.25	0.02*	-16	-0.02	0.87
Hamirpur	3	0.01	0.98	215	0.26	0.02*	-258	-0.32	0.02*	-25	-0.03	0.79
Jalaun	63	0.08	0.49	161	0.20	0.07	-116	-0.14	0.20	-29	-0.04	0.75
Jhansi	49	0.06	0.59	215	0.26	0.02*	-47	-0.06	0.61	-21	-0.03	0.82
Mahoba	18	0.02	0.85	203	0.25	0.02*	-206	-0.25	0.02*	-41	-0.05	0.65
Tikamgarh	-23	-0.03	0.80	-19	-0.02	0.84	-310	-0.38	0.01*	-96	-0.12	0.29
Lalitpur	34	0.04	0.71	227	0.28	0.01*	-148	-0.18	0.10	-14	-0.02	0.88
Sagar	-2	0.01	0.99	221	0.27	0.01*	-150	-0.18	0.09	-112	-0.14	0.21
Vidisha	-52	-0.06	0.57	132	0.16	0.14	-167	-0.20	0.06	-133	-0.16	0.14
Raisen	-89	-0.11	0.32	104	0.13	0.25	-266	-0.32	0.01*	-117	-0.14	0.19
Bhopal	-32	-0.04	0.73	130	0.16	0.15	-228	-0.28	0.01*	-205	-0.25	0.02*

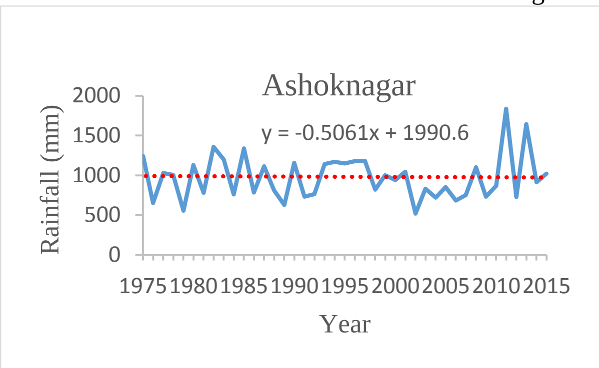
* Note: Significant at 5% level of significance based on MK test

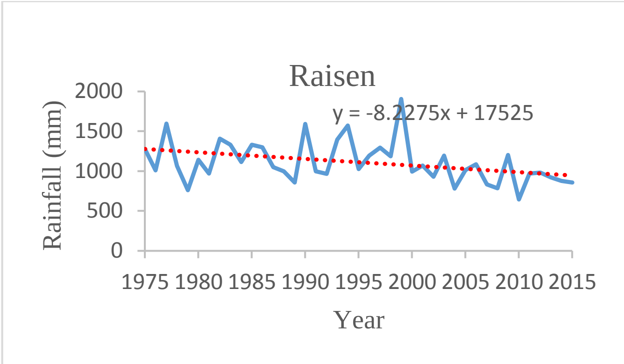
Table 2. Shows both negative and positive trends in the annual mean rainfall time series of the selected weather stations in the district boundary coverage under the Betwa river basin of the Bundelkhand region. Annual mean rainfall for Hamirpur (S=176 and p= 0.049), Tikamgarh (S=254 and p=0.004), Raisen (S=248 and p=0.006) and Bhopal (S=196 and p=0.029) weather station shows a significant ($p<0.05$) negative trend. Otherwise, annual mean rainfall for Shivpuri, Chhatarpur, Jalaun, Mahoba, Ashoknagar, Lalitpur, Sagar and Vidisha weather station shows insignificant ($p<0.05$) negative trend while Jhansi (S=8 and p=0.937) weather station shows insignificant

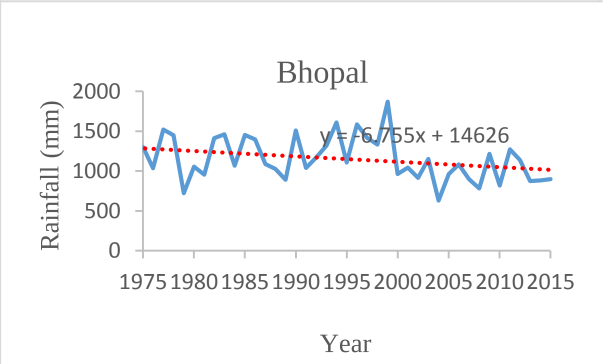
(p<0.05) positive trend. The variance of score for all weather stations coverage in the Betwa river basin is 7926.67.

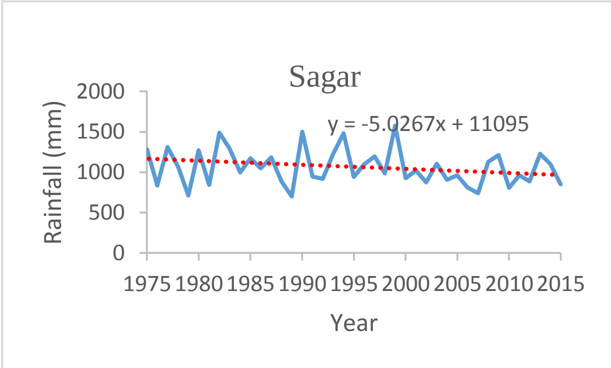
All weather station shows insignificant (p<0.05) positive and negative trend in winter season rainfall. Chhatarpur, Tikamgarh, Sagar, Vidisha, Raisen and Bhopal weather station shows negative trend, other than these weather station shows positive trend for winter season rainfall. For pre monsoon season weather station in Hamirpur, Jhansi, Mahoba, Lalitpur and Sagar shows significant (p<0.05) positive trend while other weather station shows insignificant (p<0.05) positive trend except, Tikamgarh weather station shows insignificant negative trend in pre monsoon season. Chhatarpur, Hamirpur, Mahoba, Tikamgarh, Raisen and Bhopal weather station shows significant (p<0.05) negative trend in SW monsoon season. All other weather station shows insignificant (p<0.05) negative trend in SW monsoon season. In post monsoon season only weather station in Bhopal shows significant (p<0.05) negative trend and all other weather station shows insignificant negative trends.

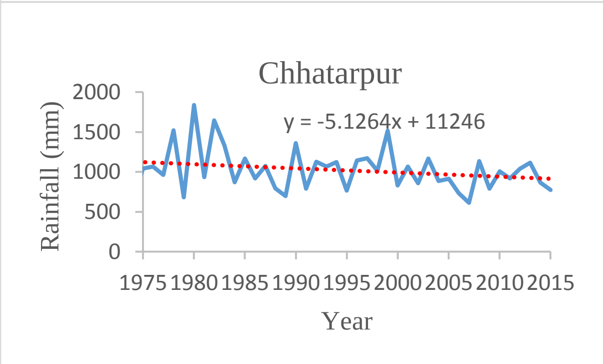
From the Sen's slope estimator revealed that the rate (or slope) of decrease in the annual rainfall for the all district covered under Betwa river basin except Jhansi, slope varied 1.57 to 13.12 mm/yr and Jhansi district slope or rate of increase in annual rainfall was estimated to be 0.4387 mm/yr over the period 1975 to 2015 (Fig. 2). From this it may be concluded that the average annual rainfall has decrease from 1975 to 2015 for twelve district and only increase for Jhansi district and is expected to follow same trend in the future. Sen's slope was indicated in red dotted line in Fig. 2.

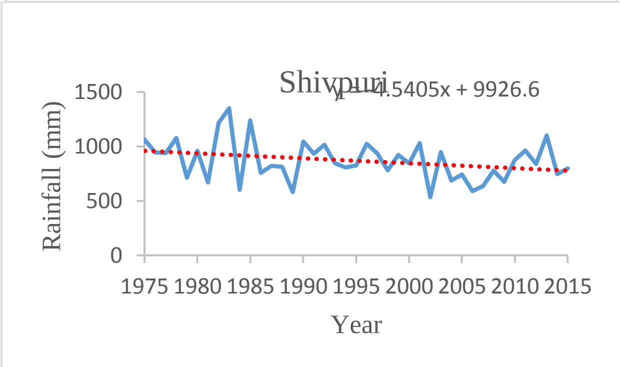












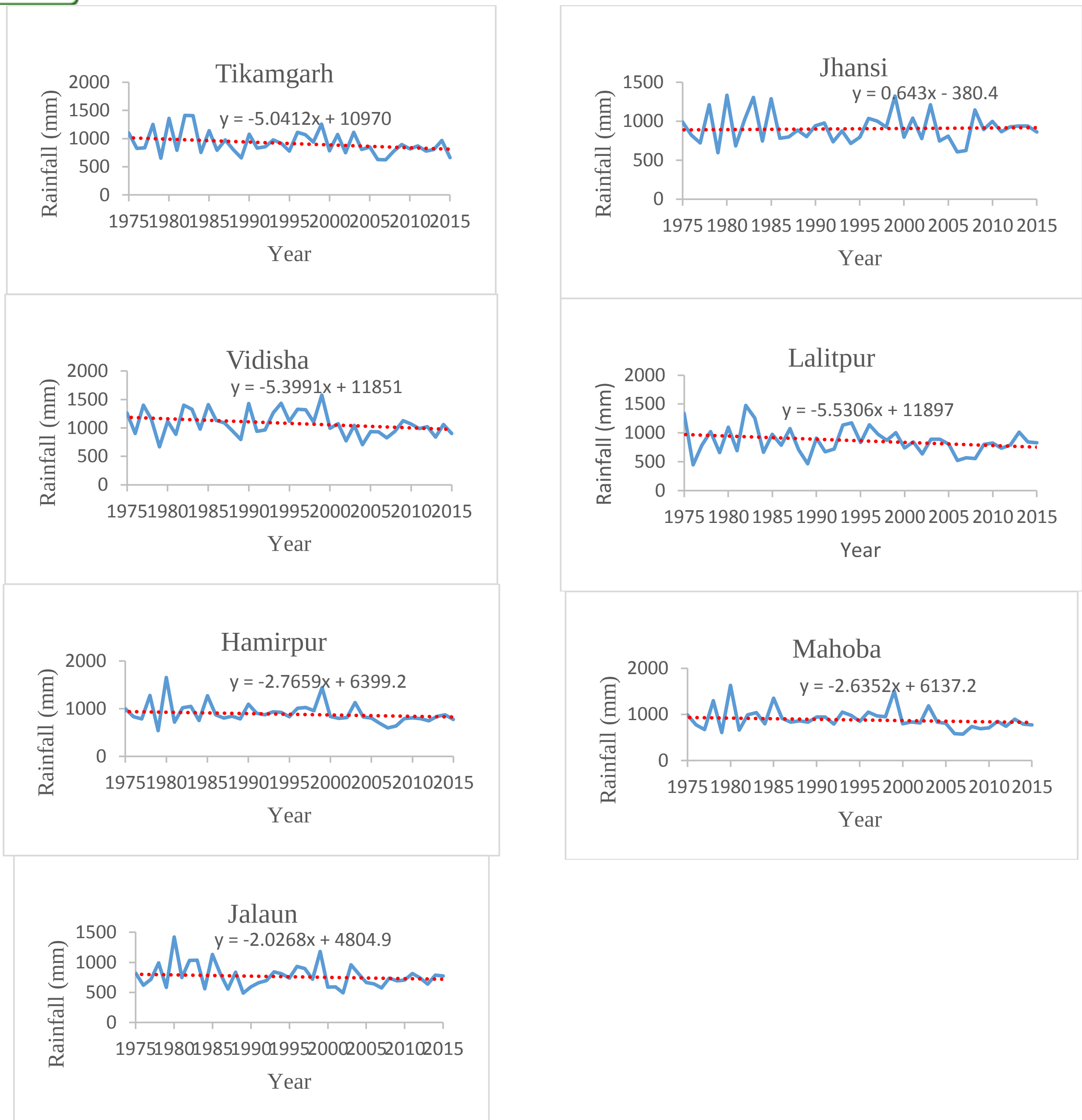
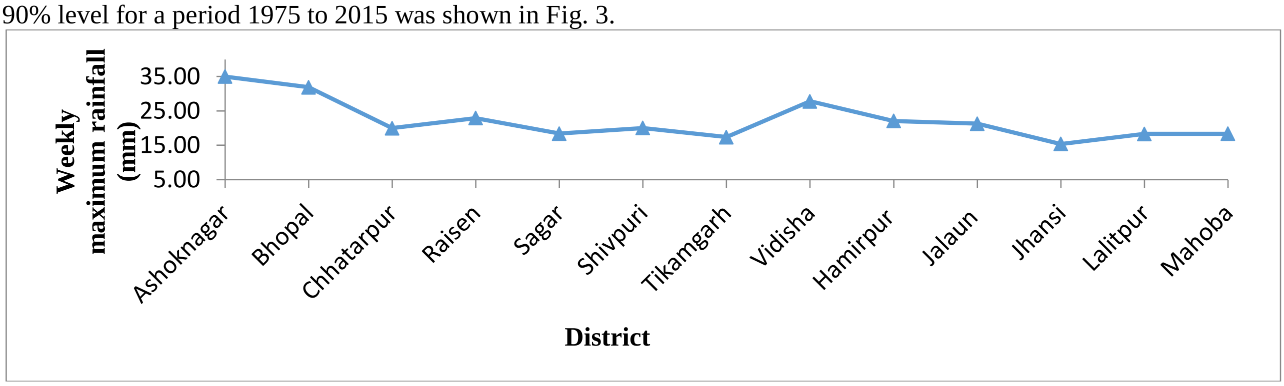


Fig. 2. Sen's linear estimates of annual rainfall time series of districts covered by Betwa river basin

3.3. *Probability Analysis of Monsoon Rainfall*

Probability analysis at weekly basis of monsoonal rainfall of thirteen districts of Betwa river basin at 50%, 75% and 90% level for a period 1975 to 2015 was shown in Fig. 3.



(a)

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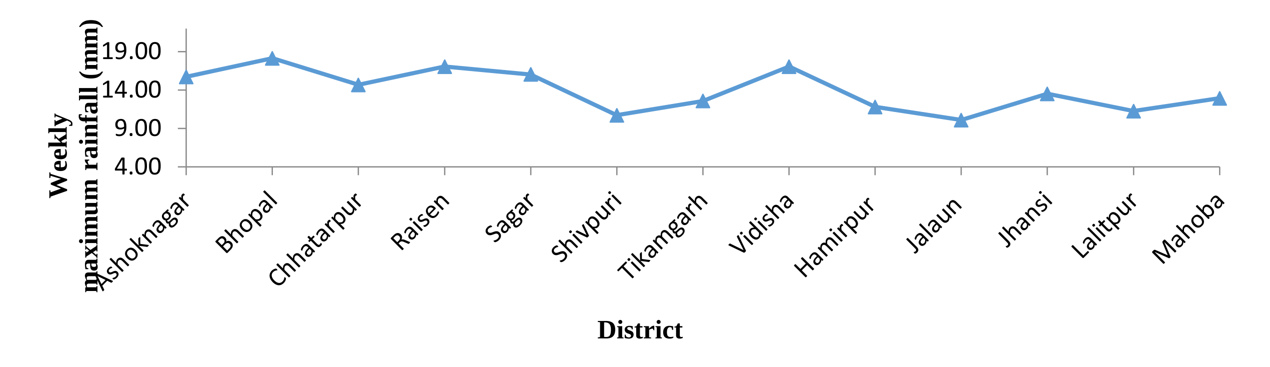

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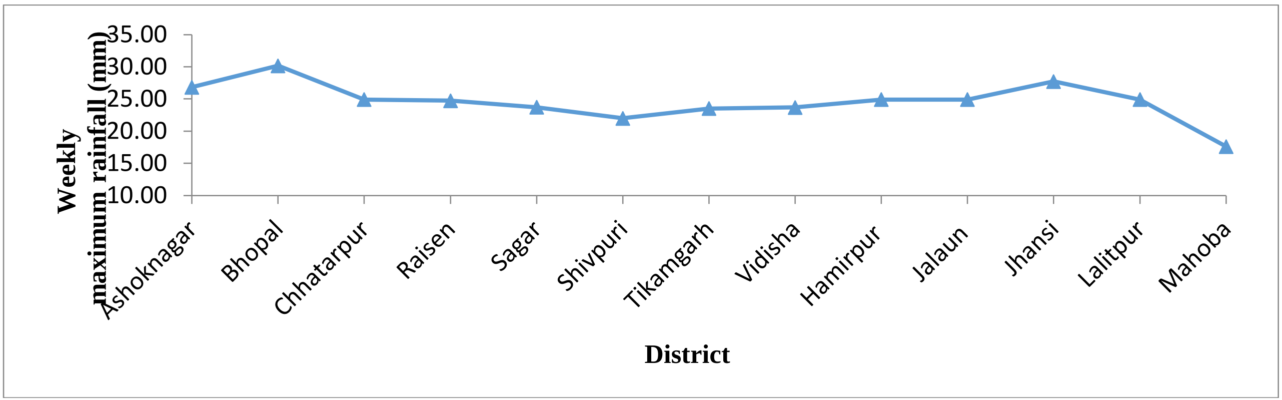

(c)

Fig. 3.Weekly analysis of monsoonal rainfall at (a) 50% (b) 75% and (c) 90% probability level

Result shows that at 50% probability level the chance of occurrence of maximum weekly rainfall is more as compared to 75% probability level while at 90% probability level the occurrence of maximum weekly rainfall was similar to 50% probability level and more than at 75% level. Variation in weekly rainfall was due to occurrence of maximum rainfall in thirteen districts of Betwa river basin was in different weeks of monsoon season (i.e., month June to September). At 75% probability level the occurrence of weekly rainfall was due to climate change, change, change in rainfall pattern, change in cropping pattern, and mismanagement of natural resources of areas. Probability analysis at 50% and 90% level shows good results of occurrence of weekly maximum rainfall during monsoon season. So, probability analysis of monsoonal rainfall at weekly basis would help in designing water harvesting structure, groundwater recharge modeling, cropping pattern, irrigation water management, and overall economical and social development of areas.

3.4. Forecasting of Rainfall

ARIMA model was used for five year (2016 to 2020) future forecasting of average annual rainfall time series data by using average annual rainfall time series data for a period 1975-2015 in the Betwa river basin of Bundelkhand region. The climatic variable rainfall time series is forecasted for 80% and 95% prediction intervals and results of average annual rainfall forecasting of district weather station under boundary of Betwa river basin is presented in table 4.

Table 4. Five year forecasting of average annual rainfall for fitted model

Forecast	Bhopal	Chhatarpur	Hamirpur	Jhansi	Mahoba	Raisen	Shivpuri	Tikamgarh
2016	884.98	884.98	856.68	911.84	829.51	938.73	831.75	739.43
2017	889.61	889.61	810.31	889.82	779.04	938.73	831.75	757.32
2018	891.25	891.25	822.31	928.47	806.60	938.73	831.75	718.51
2019	888.43	888.43	829.71	912.27	799.18	938.73	831.75	747.69
2020	889.85	889.85	816.97	907.87	795.71	938.73	831.75	733.08

Result shows that average annual rainfall time series for station Ashoknagar, Jalaun, Lalitpur, Sagar and Vidisha are fitted with ARIMA(0,0,0) model, these model are able to forecast future forecast of average annual rainfall based on previous average annual rainfall time series. The average annual rainfall for station Ashoknagar, Jalaun, Lalitpur, Sagar and Vidisha are 971.85 mm, 771.59 mm, 857.94 mm, 1060.04 mm and 1077.25 mm respectively for forecasting period 2016 to 2020. The station Bhopal, Chhatarpur, Hamirpur, Mahoba and Tikamgarh average annual rainfall time series are fitted with ARIMA(2,1,0) model, Raisen and Shivpuri stations average annual rainfall are fitted with ARIMA(0,1,1) model, and Jhansi station average annual rainfall are fitted with ARIMA(2,0,2). These models are able to forecast future time series of average annual rainfall based on previous annual rainfall time series. The forecasted five year average annual rainfall for Raisen and Shivpuri station were 938.73 mm and 831.75 mm respectively while station Bhopal and Chhatarpur has similar average annual rainfall forecasting for period 2016 to 2020.

IV. Conclusions

Long term seasonal as well as annual rainfall time series of the Betwa river basin in India were analysed to detect annual as well seasonal rainfall regime. In this study trend analysis and forecasting of seasonal as well as annual rainfall was carried out by using non parametric MK test, Sen's slope estimator and parametric linear model ARIMA. The results indicated a positive and negative trend in winter, pre monsoon, SW monsoon and post monsoon rainfall, and annual rainfall. The trends identified were significant at the 5% level of significance. 50% and 90% probability level shows good results of chance of occurrence of weekly rainfall than 75% probability level due to sufficient weekly rainfall magnitude in the monsoon season. Station Ashoknagar, Jalaun, Lalitpur, Sagar and Vidisha are fitted with ARIMA(0,0,0) model and Bhopal, Chhatarpur, Hamirpur, Mahoba, Tikamgarh, Raisen, Shivpuri and Jhansi annual rainfall time series are fitted with ARIMA(2,1,0), ARIMA(0,1,1) and ARIMA(2,0,2) model respectively. Forecasting of annual rainfall helped in the future plan of the areas which faced by mainly water scarcity problem and also will help in development of water storage structure. Seasonal and annual rainfall trend analysis can be helpful in planning and management water resources, cropping pattern, ensure food security, overcome water scarcity problem, mitigate drought and floods problem and economic growth in the basin areas.

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