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L E T T E R S

551.509.33 : 551.577.3 (540.29)

STATISTICAL ANALYSIS OF SEASONAL AND ANNUAL RAINFALL TRENDS OVER DHANBAD, JHARKHAND INDIA

1. Rainfall is a key climatic parameter which is also an important event of hydrological cycle dynamics and long term changes in rainfall can be an indicator of climate change. Intergovernmental Panel on Climate Change (IPCC, 2014) reported that in terrestrial regions the frequency of events of heavy downpours have increased as compared to the regions where it has decreased. To cope up with these consequences of climate change, it's now being obligatory to prepare suitable and cost-effective sustainable adaptation measures (Tadross *et al*., 2005). In recent years, the study of rainfall characteristics has attracted attention, especially because of increased frequency of extreme climatic events. Therefore in this study an attempt has been made to understand rainfall characteristics with the help of statistical analysis of rainfall. Mann Kendall test is the most commonly used statistical non parametric test for the analysis of rainfall trends in many regions of world. In the present study rainfall spatio-temporal variability over Dhanbad district has been studied. It is located at the North east border of Jharkhand state, covering an area of 2509.5 sq. km and lies within 23°37'3" N -24°4' N latitude and 86°6'30" E - 86°50' E longitude (Fig. 1). Agriculture in the district is mostly rain fed and comprises mono-crop area. There are three crop seasons namely Kharif, Rabi and summer while Kharif is the main crop in the district. The climate of Dhanbad is transitional between humid subtropical and tropical & wet and dry climate.

2. The monthly rainfall (mm) data at 0.5º × 0.5º grid (1901-2013) over Dhanbad from 1901-2013 has been downloaded from Centre of Environmental Data Archival (http://badc.nerc.ac.uk) CRU TS 3.23. A total of 3 grid points have covered the whole region. From the basic monthly rainfall data, Mean rainfall, Standard Deviation (SD) and Coefficient of Variation (CV) were computed annually and season-wise and presented in Table 1**.** The non-parametric Mann-Kendall rank (Mann, 1945; Kendall, 1975) statistics and Sen's method (Sen, 1968) were applied to analyze the significant temporal changes annually and on seasonal basis. The Parametric *t* test was also applied to confirm the results obtained by Man-Kendall test. Further Pettitt's test (Pettitt, 1979) and Buishand test (Buishand, 1982) test were applied to detect change points.

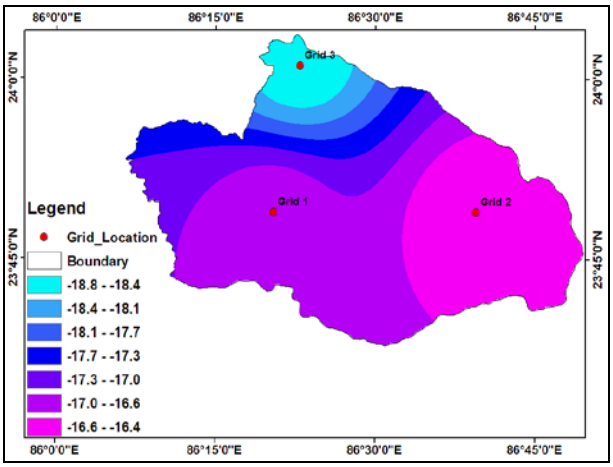

Fig. 1. Spatial variation of change value as percentage of mean in annual rainfall

Annual rainfall Change percentage has been also calculated by the given formula (Yue and Hashino, 2003)

$$\text{Percentage change}(\%) = \frac{\beta \times \text{length of year}}{\text{Mean}} \times 10 \quad (1)$$

where, β is the median slope and in this case the Sen's slope value (β) is used.

3. The annual rainfall of Dhanbad varies from 1343 mm (Grid 2) to 1227 mm (Grid 3) with annual average rainfall over whole area of 1294 mm. The results of basic statistics for annual as well as season wise are shown in Table 1.The coefficient of variation of annual rainfall is 17.4%, 17.3% and 20.6% respectively for Grid 1, 2 and 3.

Lag 1 autocorrelation at 0.1%, 1% and 5% significance level were applied to the dataset and absence of autocorrelation in all the Grid's data was found. So the Mann-Kendall (MK) test is directly applied to the data along with Sen's slope method and the results of MK test are presented in Table 1. The results indicated significant decreasing trend in annual, monsoon and winter rainfall at all the Grids (at 1%, 5% and 10% significance level). The winter rainfall had showed significant decreasing trend. During winter season a decrease of 24.21 mm, 18.08 mm and 22.04 mm had been noticed against their respective average of Grid 1, 2 and 3. A very low insignificant increasing trend in pre-monsoon rainfall has been noticed as suggested by MK test over all the grids. An increase

TABLE 1

Statistical analysis of rainfall (mm) along with Mann Kendall Z statistics and Sen's slope (β) over Dhanbad district from 1901-2013

Season	Grid 1					Grid 2					Grid 3				
	Mean (mm)	SD (mm)	CV (%)	Z	B (mm/yr)	Mean (mm)	SD (mm)	CV (%)	Z	β (mm/yr)	Mean (mm)	SD (mm)	CV (%)	Z	B (mm/yr)
Winter (Jan-Feb)	42	28	65	**-2.74**	-0.21	37	26	106	*-2.42*	-0.16	37	25	105	**-2.73**	-0.20
Pre-monsoon (Mar-May)	82	43	52	0.06	0.01	101	51	71	0.13	0.03	75	42	79	0.00	0.00
Monsoon (Jun-Sep)	1098	204	19	**-3.25**	-1.96	1105	211	19	**-3.08**	-1.89	1030	208	22	**-3.46**	-2.06
Post monsoon (Oct-Dec)	89	61	68	0.81	0.12	99	68	45	0.83	0.13	84	62	45	0.59	0.08
Annual	1312	228	17	**-3.33**	-2.15	1343	237	17	**-3.02**	-2.01	1227	235	21	**-3.49**	-2.27

Bold ones are significant at 0.1% level, Bold & italic ones are significant at 1% level and only italic ones are significant at 5% level

of 1.13 mm, 3.39 mm in pre-monsoon season for Grid 1 and 2 was observed over the whole study period. The monsoon rainfall also showed a significant declining trend with a decrease of 221.48 mm, 213.57 mm and 232.78 mm for Grid 1, Grid 2 & Grid 3 was noticed. This season contributes above 80% to the annual rainfall, hence it is the main season contributing to rainfall and a decline in this season is an indicator of overall a decline in rainfall.

The post-monsoon rainfall showed an insignificant increasing trend with increase of 13.28 mm, 14.55 mm and 8.61 mm against the average post-monsoon rainfall of Grid 1, 2 and 3. The Annual rainfall showed a decrease of -2.15mm/year, 2.01mm/year and 2.27 mm/year for Grid 1, Grid 2 and Grid 3 respectively over the period of 113 years as indicated by Sen's slope value (β). The overall decline (1901-2013) in annual rainfall, *i.e.*, 242.95 mm (Grid 1), 227.13 mm (Grid 2) and 256.51 mm (Grid 3) has been computed as change percentage over mean annual rainfall (given in Table 1) using eq. (1) and it shows a decline in rainfall with maximum fall at Grid 3 (-18.8%) followed by Grid 1(-16.7%) and Grid 2 (-16.4%) over the period of 113 years. IDW method of Interpolation was used to study the spatial variation in change percentage of mean in annual rainfall over the district (Fig. 1). For detecting change point in data series the Cumulative deviation test and SNHT single series shift test were applied. The results of these tests indicated year 1979 as change point.

4. The important finding of the present study was the presence of significant decreasing trend in monsoon, winter and annual rainfall. This decrease in rainfall may be attributed to a declining trend in the frequency of depressions, cyclonic storms and systems during the months June to September (Joseph *et al*., 2004; Rao *et al*., 2004; Sathiyamoorthy, 2005)**.** The knowledge of temporal distribution and changing pattern of rainfall will be helpful for the planning and management of water resources in the region and agricultural planners.

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