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Detection of trends in moderate and heavy rainfall events in Chhattisgarh state

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Abstract

The observed trends in moderate (25-50 mm per day) and heavy rainfall (50-75 mm, 75-100 mm and > 100 mm per day) events during southwest monsoon season and on annual basis in 26 districts of Chhattisgarh state was worked out and Mann- Kendall test has been applied to understand the significance the events. Results indicated that there is generally no significant trend of changes in the events under moderate and heavy rainfall events in most of the districts during southwest monsoon period as well on annual basis. However, significant increasing trend in 25-50 mm category has been noted in Bemetara, Korba and Kondagaon districts. On annual basis, significant increasing trend is found in Kawardha district while Balodabazar, Janjgir Champa, Koriya, Surajpur showed significant decreasing tendency under 50-75 mm category. The trend in number of days with 75-100 mm rainfall showed significant increasing trend in Bemetara and Mahasamund districts and significant declining trend is observed in Janjgir Champa, Kondagaon and Surajpur districts. Significant increasing trend was observed in Bemetara district under moderate and heavy rainfall events during southwest monsoon and on annual basis and it is suggested that creating new drainage canals and community tanks / check dams may assist the farming community to drain and to save the surplus rainwater during the heavy rainfall events.

Keywords: moderate rainfall, heavy rainfall, mann-kendall test, southwest monsoon, Chhattisgarh state

Introduction

Analysis of observed precipitation data and simulation output from climate models revealed that global warming is main cause for heavy / extreme precipitation events occurred over the globe (Ghosh *et al.*, 2012; Mishra *et al.*, 2012) ^[13, 7] which in turn augment the atmospheric moisture content (Willett *et al.*, 2007) ^[13]. Indian sub continent is highly vulnerable to heavy / extreme rainfall and flash floods as it wreck havoc the properties, lives, agricultural / horticultural crops and livestock which may lead to crisis in rural economy, livelihood and environment also (Kripalani *et al.*, 2003; De *et al.*, 2005) ^[6, 2]. The challengeable issue in this regard is the episode of heavy rainfall events and its intensities are highly uneven.

Many studies were found in literature related to frequencies and trend in heavy or extreme rainfall over India. Sinha Ray *et al.*, (2000) ^[11] studied the changes in heavy rainfall (≥ 7 cm) days using 151 stations data all over India for a period of 1901 to 1990 and they found that, during monsoon season number of stations in Kutch and Gujarat and most of the stations over west coast of India showed an increasing trend in heavy rainfall events. Under the global warming scenario, a strong relationship between the Indian Ocean Sea Surface Temperature and extreme rainfall events was indicating that the frequency of extreme rainfall events and risk of floods may increase over the central India (Rajeevan *et al.*, 2008) ^[8]. According to Goswami *et al.*, (2007) it is expected that hazards due to occurrence of heavy rainfall over central India would increase in the years to come. It is also vital utilizing actual observed station data for analyzing heavy / extreme rainfall events give better results than grid data as heavy / extreme rainfall events might have missed owing to interpolation technique (Guhathakurta *et al.*, 2010) ^[5]. Moreover, most of the studies are carried out at macro level. Hence, it is important to understand the climate variability and the frequency of extreme weather at district level. Rao *et al.*, (2011a) ^[9] opined that rainfall analysis at micro level is crucial and needful for better planning than at macro level. In this context, the present study was carried out to find trend in moderate and heavy rainfall events over 26 districts of Chhattisgarh State.

Materials and methods

Daily rainfall data of 26 stations to represent 26 districts of Chhattisgarh state (except Balrampur district for which data was not available) was collected from the department of Agro-meteorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur. Daily rainfall data

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available period for study of different stations along with their latitude and longitude are presented in Table 1.

Table 1: Geographical locations of 26 districts under study and rainfall availability period

Sl. No	Districts	Stations	Latitude	Longitude	Database Period
1	Bastar	Jagdapur	19°05' N	82°02' E	1960-2013
2	Bijapur	Bijapur	18°50' N	80°50' E	1960-2013
3	Bilaspur	Bilaspur	22°05' N	82°08' E	1960-2013
4	Dantewada	Dantewada	18°53' N	81°21' E	1973-2013
5	Dhamtari	Dhamtari	20°42' N	81°34' E	1960-2013
6	Durg	Bhilai	21°13' N	81°17' E	1960-1998
7	Janjgir Champa	Janjgir Champa	22°01' N	82°35' E	1960-2013
8	Kanker	Kanker	20°16' N	81°30' E	1981-2013
9	Korba	Kanki	22°00' N	82°42' E	1960-2013
10	Koriya	Manendragarh	23°15' N	82°34' E	1974-2013
11	Kawardha	Kawardha	22°01' N	81°15' E	1963-2013
12	Mahasamund	Mahasamund	21°06' N	82°06' E	1960-2013
13	Narayanpur	Narayanpur	20°17' N	81°07' E	1972-2013
14	Raigarh	Dharamjaigarh	21°55' N	83°24' E	1960-2013
15	Raipur	Raipur	21°14' N	81°39' E	1960-2013
16	Rajnandgaon	Rajnandgaon	21°05' N	81°02' E	1960-2013
17	Surguja	Surguja	23°07' N	83°12' E	1981-2013
18	Bemetara	Bemetara	21°70' N	81°53' E	1962-2013
19	Baloda bazar	Baloda bazaar	21°23' N	81°67' E	1960-2013
20	Kondagaon	Kondagaon	23°21' N	82°21' E	1999-2013
21	Jashpur	Jashpur	22°83' N	84°14' E	1960-2013
22	Gariyaband	Gariyaband	20°63' N	82°06' E	1960-2013
23	Mungeli	Mungeli	22°05' N	81°68' E	1960-2013
24	Sukma	Sukma	18°40' N	81°67' E	1972-2013
25	Balod	Balod	20°73' N	81°20' E	1964-2013
26	Surajpur	Pratappur	23°22' N	82°85' E	1999-2013

Rainfall Analysis

Moderate (25-50 mm) and heavy rainfall (50-75 mm, 75-100 mm and > 100 mm in 24 hour period) events have been computed on seasonal (Southwest monsoon season June – Sept) and on annual basis using weather cock software (Rao *et al.*, 2011b) [10].

Mann-Kendall's test

Mann-Kendall's test is a non-parametric method, this method tests whether there is a trend in the time series data. It is a non-parametric test. The n time series values ($X_1, X_2, X_3, \dots, X_n$) are replaced by their relative ranks ($R_1, R_2, R_3, \dots, R_n$) (starting at 1 for the lowest up to n).

The test statistic S is:

$$s = \sum_{i=1}^{N-1} \sum_{j=i+1}^N \text{sgn}(R_j - R_i)$$

$$\text{sgn}(X) = \begin{cases} +1 & \text{for } (X) > 0 \\ 0 & \text{for } (X) = 0 \\ -1 & \text{for } (X) < 0 \end{cases}$$

If the null hypothesis H_0 is true, then S is approximately normally distributed with:

$$\mu = 0$$

$$\sigma = n(n-1)(2n+5)/18$$

The z -statistic is therefore (critical test statistic values for various significance levels can be obtained from normal probability tables):

$$Z = |S|/\sigma^{0.5}$$

A positive value of S indicates that there is an increasing trend and vice versa.

In the present study, trends of high rainfall events, high and low temperature events was done by using trend detecting software to know whether the trend is significant or not (Chiew *et al.*, 2005) [1].

Results and Discussion

Trend in heavy rainfall days during southwest monsoon season

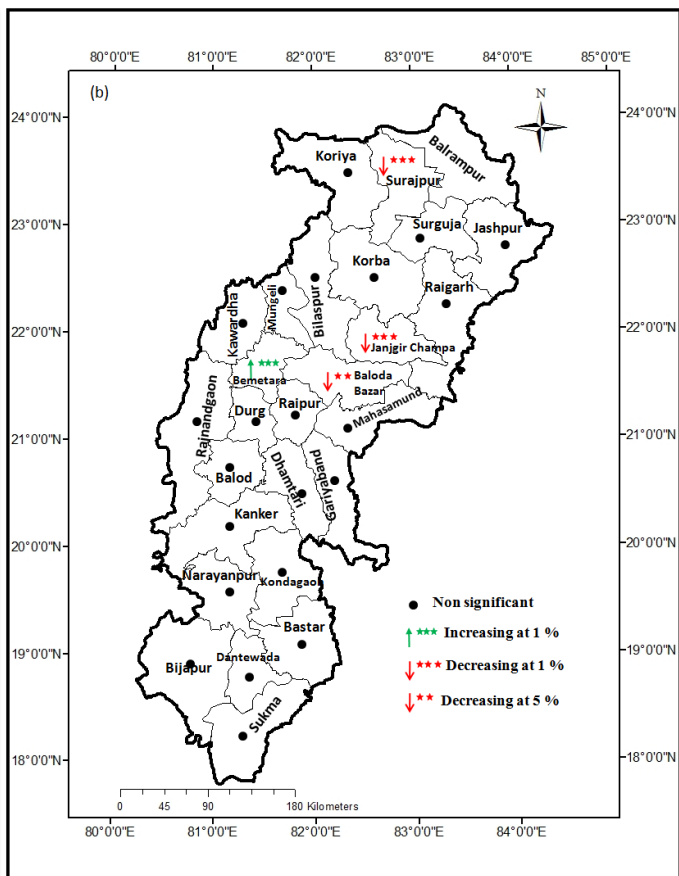
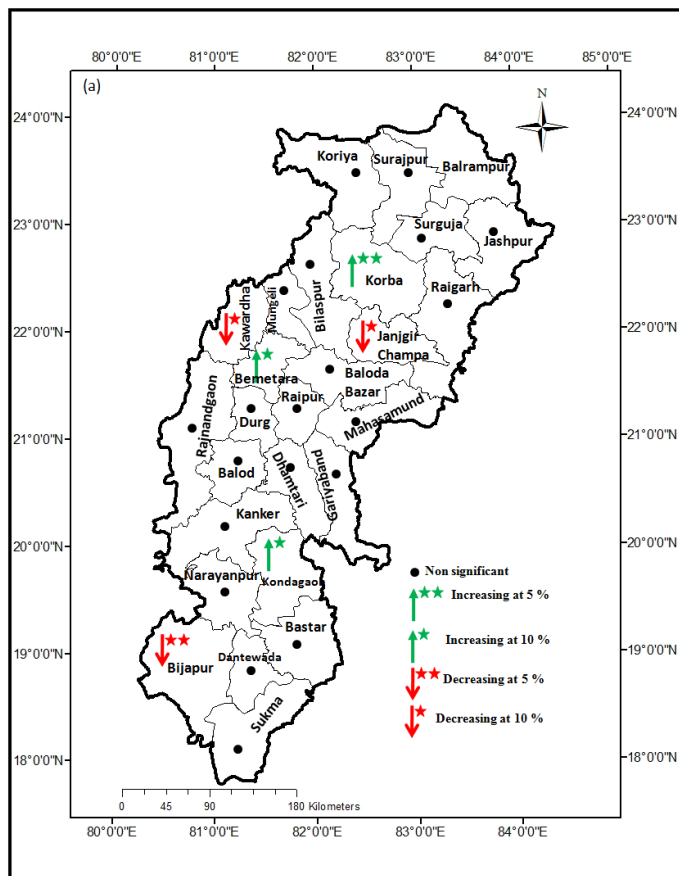
Mann Kendall test results indicated that, no significant trend was observed in majority of districts of Chhattisgarh under moderate and heavy rainfall categories. 20 districts under 25-50 mm category, 22 districts under 50-75 mm category, 21 districts under 75-100 mm category and 22 districts under more than 100 mm category did not show any significant change during the southwest monsoon season (Fig 1a-d). Goswami *et al.*, (2007) also reported significant declining trend in the occurrence of moderate rainfall events over central India during monsoon season during the study period 1951-2000. Our study showed that, significant increasing pattern found in Bemetara, Korba and Kondagaon districts and significant decreasing trend is seen in Bijapur, Janjgir Champa and Kawardha districts under 25-50 mm category. Number of days during southwest monsoon period under 50-75 mm category showed that significant increasing trend was observed in Bemetara and a significant declining trend was showed in Surajpur, Baloda bazaar and Janjgir Champa districts. A significant decreasing trend was found in Surajpur, Kondagaon, Mungeli and Janjgir Champa and increasing trend was observed in Bemetara under 75-100 mm category. For > 100 mm per day category, a significant increasing trend was noticed in Bemetara, Gariyaband and Raipur districts. At the same time, significant declining trend has been observed in Janjgir Champa district (Fig 1d). It is

understood from the analysis that significant increasing and declining trend in moderate and heavy rainfall events was observed in Bemetara and Janjgir Champa respectively, during southwest monsoon period. In order to tide over the ill effect of flood / inundation of crop fields due to heavy rainfall, creation of new drainage canals and community tanks may help farming community. For instance, the renovation of Kharbar canal, a 12 km long drainage channel in Puri district of Odisha as adaptation measure to heavy rainfall induced flood during monsoon period enhanced the resilient capacity the farmers of that locality to cultivate paddy and or other allied activities (UNDP, 2014) [12].

Trend in heavy rainfall days on annual basis

Almost same pattern as that of southwest monsoon season was noted in the trend in frequency of moderate and heavy rainfall on annual basis across Chhattisgarh. It may be attributed that most of the rain events occur during southwest monsoon period and it is evident that around 90 percent of annual rainfall is being received during southwest monsoon period (Shiv Kumar Bhurya *et al.*, 2015). The study of Guhathakurta *et al.*, (2010) [5] also supporting our results as they found significant declining trend in extreme rainfall

frequency in Chhattisgarh, Jharkhand and parts of north India. In Kanker, Korba, Sukma and Kondagaon districts, number of days with rainfall 25-50 mm were showing significant increasing trend while a significant decreasing trend is found in Baloda bazar district. A significant increasing trend is observed in Kawardha district while Baloda bazaar, Janjgir Champa, Koriya and Surajpur showed significant decreasing tendency under 50-75 mm category (Fig 2b). The trend of number of rainfall day under 75-100 mm on annual basis showed significant increasing trend in Bemetara and Mahasamund districts and a significant declining trend is observed in Janjgir Champa, Kondagaon and Surajpur districts (Fig 2c). For rainfall > 100 mm per day category, only Bemetara and Gariyaband districts in the state showed an increasing tendency. In the remaining districts for number of days with >100 mm, trend was found non-significant. It is evident from the results that districts like Baloda bazaar and Janjgir Champa may not get affected due to heavy rainfall as they showed significant declining trend in frequency of rainy days with 25-50 mm, 50-75 mm and 75-100 mm categories. At the same time, significant increasing trend was noticed in frequency of rainy days with 75-100 mm and more than 100 mm in Bemetara district.



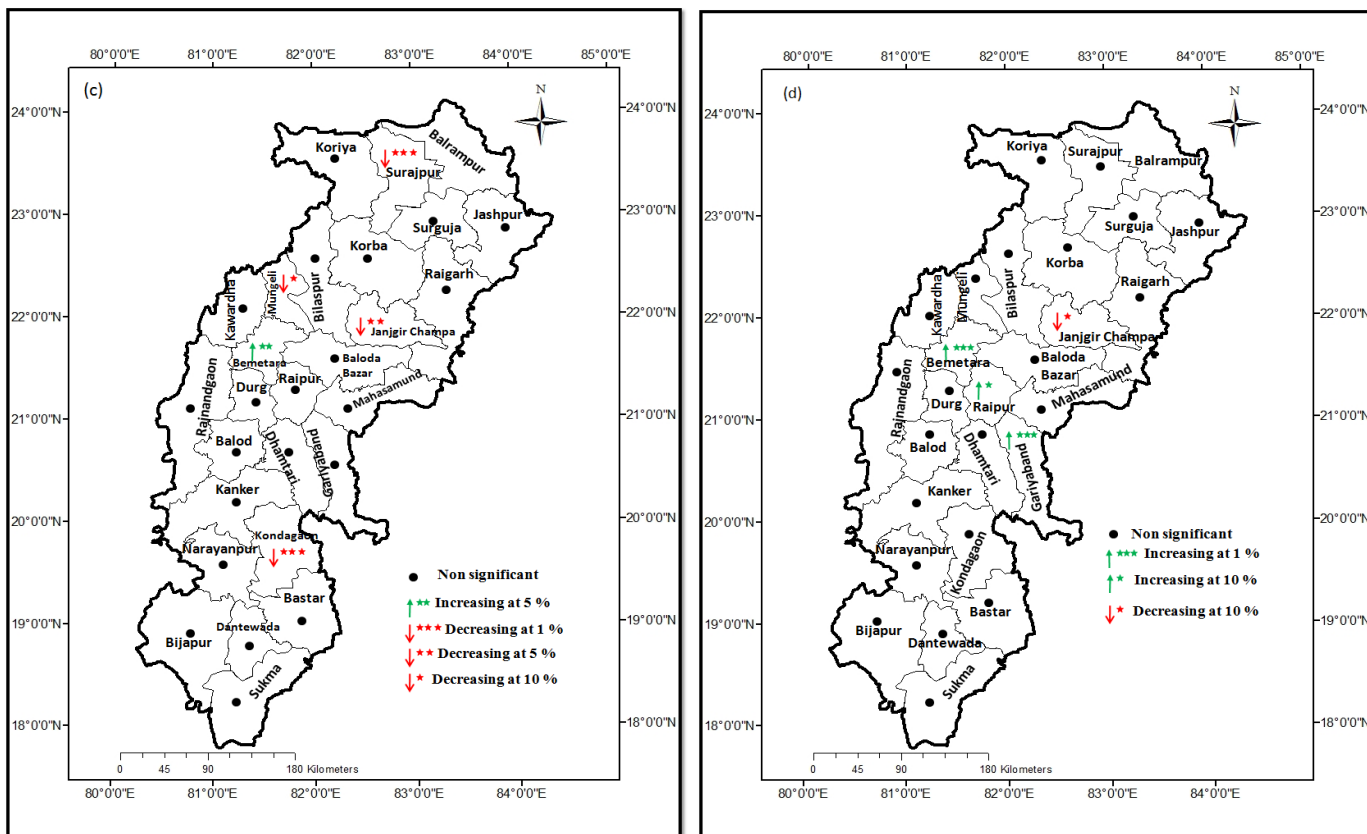
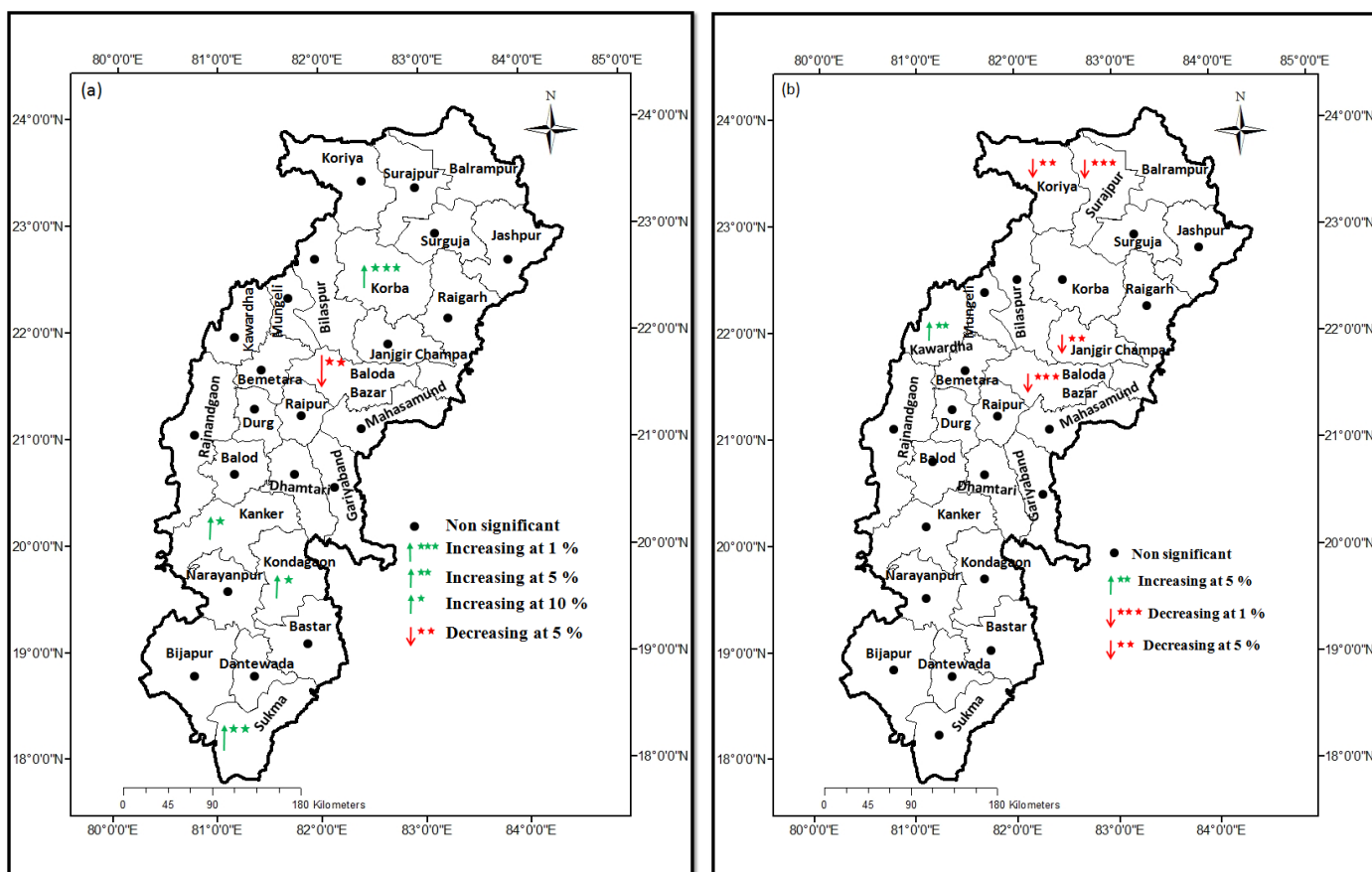


Fig 1: Trend in moderate [a] and heavy [b, c & d] rainfall events during southwest monsoon period in different districts of Chhattisgarh state



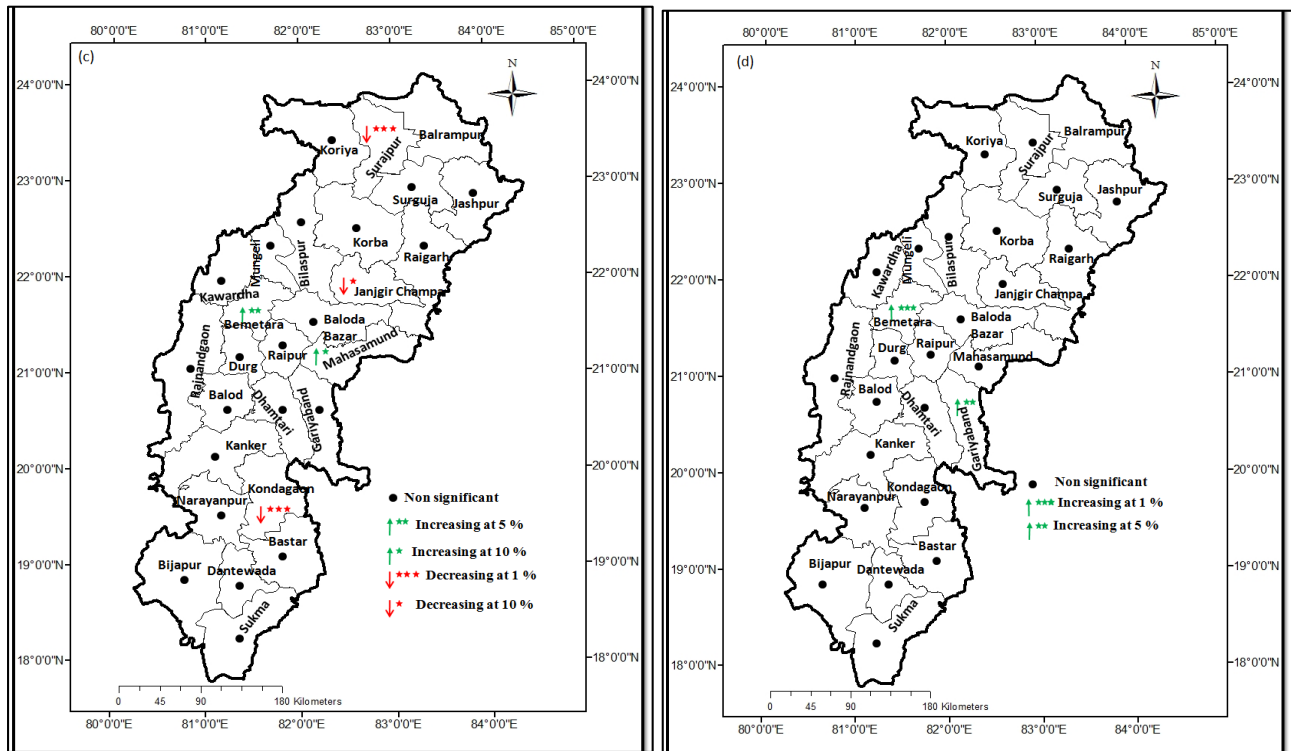


Fig 2: Trend in moderate [a] and heavy [b, c & d] rainfall events on annual basis in different districts of Chhattisgarh state

Conclusion

The present study did not show signs of either significant increasing or decreasing trend in occurrence of moderate and heavy rainfall days in majority of districts under study over Chhattisgarh state during southwest monsoon season and also on annual basis. However, in some districts significant increasing or declining trend in frequency of moderate and heavy rainfall days was observed. It is important to mention that mitigation and adaptation plans may be prepared for Bemetara district as significant increasing trend was found in moderate and heavy rainfall categories during southwest monsoon period and on annual period also. On the other hand, it is expected that the occurrence of moderate and heavy rainfall events would decline as significant declining trend was seen for Janjgir Champa district. Creation of new drainage canals / renovation of old and natural drainage systems and community tanks / check dams would help to drain and to conserve the excess rainwater during heavy rainfall events.

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