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L E T T E R S

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RAINFALL AND TEMPERATURE EXTREME OVER DIFFERENT SUB ZONES OF JHARKHAND

1. Developing countries are vulnerable to extreme weather events in present day climatic variability and facing substantial economic damage. Heavy rains and flooding are becoming more frequent. Increases in mean temperature and precipitation, rise in sea level and extreme weather events due to climate change would make developing countries more exposed to disasters. Vulnerability to extreme weather events, disaster management and adaptation must be part of long term sustainable development planning in developing countries. Higher maximum temperatures, more hot days and higher minimum temperatures, fewer cold days and frost days over nearly all land areas are projected for 21st century. More intense precipitation events over mid-to-high latitude land areas in northern hemispheres, are also likely to occur (IPCC, 2001). According to the estimates by IPCC (2007) earth's linearly averaged surface temperature has increased by 0.74 °C during the period 1901-2005. Rupa Kumar *et al.* (1994) showed that there was an irregularity in the temperature trends in terms of daytime and night time temperature over India. The observed warming was predominantly due to an increase in maximum temperature, while the minimum temperature remained practically constant during the past century. Srivastava *et al*. (1992) reported an increasing temperature trends in India on decadal basis. A study by Pai *et al*. (2004) revealed that during the decade 1991-2000, a significant increase in the frequency, persistency and spatial coverage of heat wave / severe heat wave has been observed in comparison to that during the earlier decades. Increasing trends of rainfall and minimum temperature in Gangetic plains of Bihar was observed by Haris *et al.* (2010). During 2002, twelve out of 36 subdivisions of the country came under the grip of moderate to severe drought when about 29% of the total area of the country was affected by drought. Landslides associated with heavy rains in Mumbai during July 2000 and water logging due to intense floods of Hyderabad in August killed many persons (De *et al*., 2005). In view of impression that climate change would bring about increase in occurrence of extreme heat and intense rainfall, it is worthwhile to investigate whether identifiable fluctuation in annual and monsoonal rainfall as well as temperature over Jharkhand exist? The purpose of this paper is to analyze the frequency and intensity of extreme temperature and rainfall events and their trends over the State.

TABLE 1

Districts under agroclimatic sub zones of Jharkhand

Agroclimatic sub-zone	Districts
Zone IV	Bokaro, Chatra, Deoghar, Dumka, Dhanbad, Godda, Giridih, Hazaribagh Jamtara, Koderma, Khunti, Pakur, Ramgarh, Ranchi, Sahebganj
Zone V	Garhwa, Palamu, Latehar, Lohardaga, Gumla, Simdega
Zone VI	E. Singhbhum, W. Singhbhum, Saraikela

TABLE 2

Temperature and rainfall indices with their definition

Indices	Description
Severe cold wave	T Min ≤2 °C
Cold wave	T Min ≤4 °C
Heat wave	T Max ≥40 °C
Severe Heat wave	T Max ≥45 °C
Dry Spell	Rainfall ≤2.5mm for 10 days
Wet Spell	Rainfall ≥10mm for 7 days
	Rainfall ≥25mm for 3 days
	Rainfall ≥50mm for 2days
	Rainfall ≥100mm for 1 day

2. Jharkhand state extends from 21°28' to 25°30' N and 83°22' to 87°40' E with an altitude 1142 m above msl and having humid to sub humid tropical monsoon type of climate. The state has 3 agro-climatic sub-zones *viz*., Central and North Eastern Plateau sub zone (zone IV), Western Plateau sub-zone (zone V) and South Eastern Plateau sub-zone (zone VI) falling under agroecological regions XI, XII and XIII. Zone IV is having 15 districts; Zone V has 6 and Zone VI have 3 districts (Table 1). Daily rainfall, maximum and minimum temperature for 24 districts of Jharkhand for the available time series from 1982 to 2014 except Ranchi district (1961-2015) have been utilized to analyze the indices of various extreme temperature events prevailed in the state. The indices were chosen primarily for assessment of few aspects of climate change related to rainfall and temperature which include changes in intensity, frequency, duration and trends of events of these two parameters (Table 2). Trend analysis of rainfall and

TABLE 3

Increase (I) / Decrease (D)in cold wave and heat wave with significance level at different stations of Jharkhand

S. No.	District	Cold wave	Heat wave (≥40 °C)	Severe heat wave(≥45 °C)
1.	Bokaro	I	I	I **
2.	Chatra	I	I	I ***
3.	Deoghar	I	I	I **
4.	Dhanbad	I	I	I **
5.	Dumka	I	I	I ***
6.	E. Singhbhum	I	I	I **
7.	Garhwa	I	I	I ***
8.	Giridih	I	I	I **
9.	Godda	I	I	I ***
10.	Gumla	I+	I	I
11.	Hazaribagh	I	I	I **
12.	Jamtatara	I	I	I **
13.	Khunti	I	I	I **
14.	Koderma	I	I	I **
15.	Latehar	I*	I	I
16.	Loherdaga	I*	I	I
17.	Pakur	I	I	I ***
18.	Palamu	I	I	I ***
19.	Ramgarh	I	I	I **
20.	Ranchi	I***	I	I
21.	Sahebgunj	I	I	I **
22.	Saraikela	I	I	I **
23.	Simdega	I	I+	I **
24.	W. Singhbhum	I	I	I **

temperature pattern has been studied and significance level tested by Mann- Kendell test.

3. *Temperature Extreme* - In Jharkhand state, analysis of temperature data (maximum and minimum temperature) showed an increasing trend in all districts. Heat waves having temperature more than or equal to 40 °C increased but non-significantly. However, significant increasing trend for more severe heat waves was observed for almost whole state except few districts like Gumla, Latehar, Lohardaga (Agroclimatic zone V) and Ranchi (Zone IV). Severe cold wave event was not observed at all, however, significant increase in cold wave (T Min ≤ 4° C) was observed for Gumla, Latehar, Lohardaga and Ranchi districts (Table 3). It is noteworthy that districts Gumla, Latehar, Lohardaga and Ranchi faced both extremes heat and cold waves may be due to their presence on an altitude of about 600 meters.

4. *Rainfall* - Average rainfall during monsoon seasons varied from 929 mm (Bokaro) to 1375 mm (Sahebganj) districts of Jharkhand during the study period. However lowest average annual rainfall received was 1053 mm in Bokaro district and highest average annual rainfall was 1754 mm received in Godda and Pakur districts. Among the three agroclimatic sub zones, highest amount of rainfall during monsoon season as well as annually received by sub zone IV (Table 4). Among 15 districts of zone IV, nine districts showed a decreasing trend in monsoon rainfall, which was significant for

TABLE 4

Average monsoon, annual rainfall and rainy days in different districts of Jharkhand

S. No.	District	Average rainfall (mm) during monsoon	Average number of rainy days during monsoon	Average annual rainfall (mm)
1.	**Bokaro**	**929**	50	**1053**
2.	Chatra	1074	56	1297
3.	Deoghar	1233	62	1546
4.	Dhanbad	1301	65	1664
5.	Dumka	1207	59	1544
6.	E. Singhbhum	1258	65	1641
7.	Garhwa	1149	58	1325
8.	Giridih	1249	63	1557
9.	Godda	1345	64	1754
10.	Gumla	1052	59	1271
11.	Hazaribagh	1169	58	1414
12.	Jamtatara	1156	53	1458
13.	Khunti	1187	64	1453
14.	Koderma	1034	58	1202
15.	Latehar	1052	59	1271
16.	Loherdaga	1052	59	1271
17.	**Pakur**	**1343**	64	**1754**
18.	Palamu	989	**45**	1131
19.	Ramgarh	1176	64	1442
20.	Ranchi	1149	54	1410
21.	Sahebgunj	1375	66	1735
22.	Saraikela	1162	67	1430
23.	Simdega	1159	65	1416
24.	W. Singhbhum	1231	**69**	1540

Giridih, Godda, Sahebganj and Pakur districts (Figs. 1&2). Significant increasing trend was observed for Koderma, Dumka and Jamtara districts. Saraikela, East and West Singhbhum, which comes under zone VI showed an upward rainfall trend however, significant for Saraikela and East Singhbhum. Similar trend with almost same significance level has been observed for annual rainfall also except Bokaro district where, although rainfall during monsoon season showed a decreasing trend, but annual rainfall is increasing. This may be due to rainfall is well distributed throughout the year instead of monsoon season in Bokaro district.

5. Occurrence of dry spells, *i.e.*, less than 2.5 mm rainfall for 10 days was increasing in Zone V. Under zone IV, wherever monsoon as well as annual rainfall showed a decreasing trend, occurrence of dry spell was more. In other words, we can say that decreasing trend in monsoon as well as annual rainfall was only due to increase in occurrence of dry spells for those particular districts. A decreasing trend in occurrence of dry spells was observed in Chatra, Koderma, Hazaribagh, Deoghar, Dumka and Jamtara district with different levels of confidence. East Singhbhum and Saraikela showed a decreasing trend in occurrence of dry spell under zone VI except West Singhbhum (Fig. 3). Wet spell (≥10mm rainfall for 7 days and ≥25 mm rainfall for 3 days) showed similar trend. Occurrence of wet spell events was decreasing in Zone V except Simdega (7 day spell) and Garwha (3 day spell) where it showed an increasing trend. An increasing trend

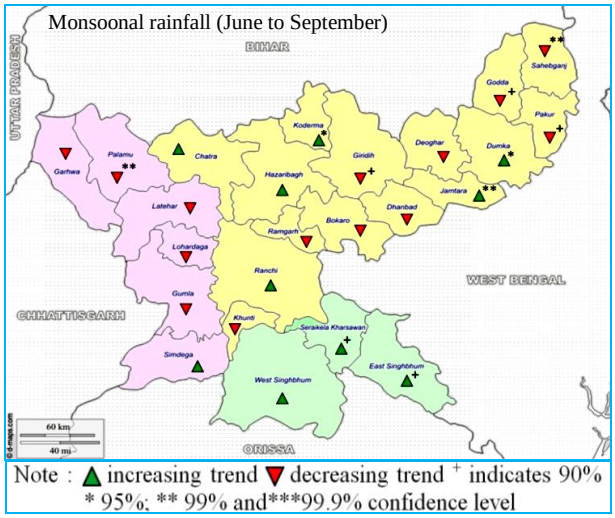

Fig. 1. Trend of monsoonal rainfall

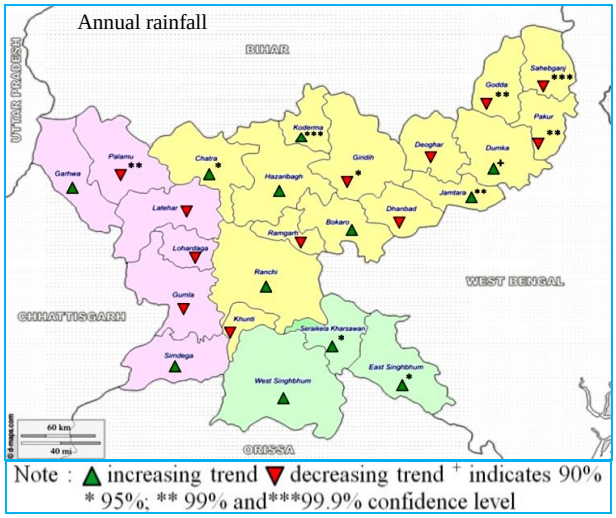

Fig. 2. Trend of annual rainfall

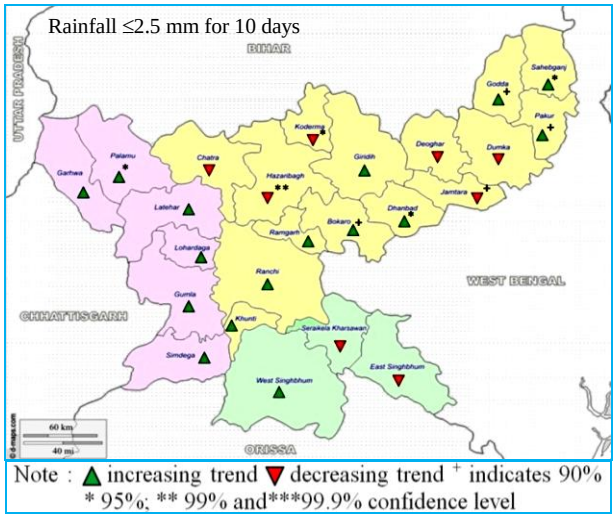

Fig. 3. Trend of dry spells (rainfall ≤2.5 mm)

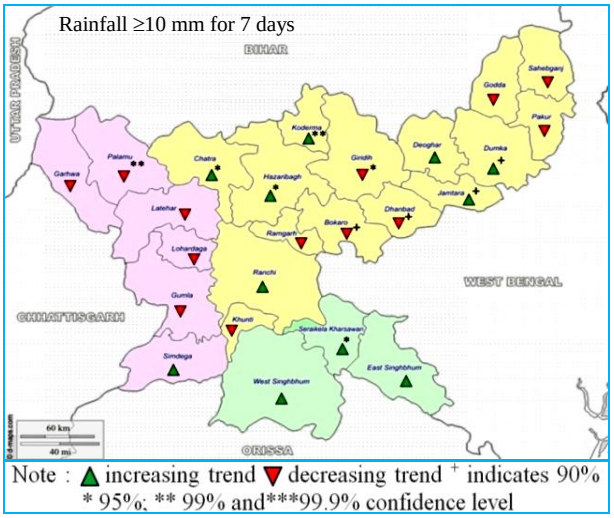

Fig. 4. Trend of wet spells (rainfall ≥ 10 mm)

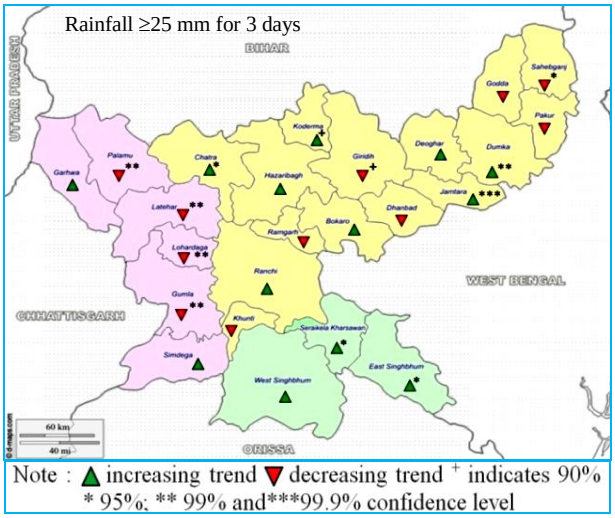

Fig. 5. Trend of wet spells (rainfall ≥25 mm)

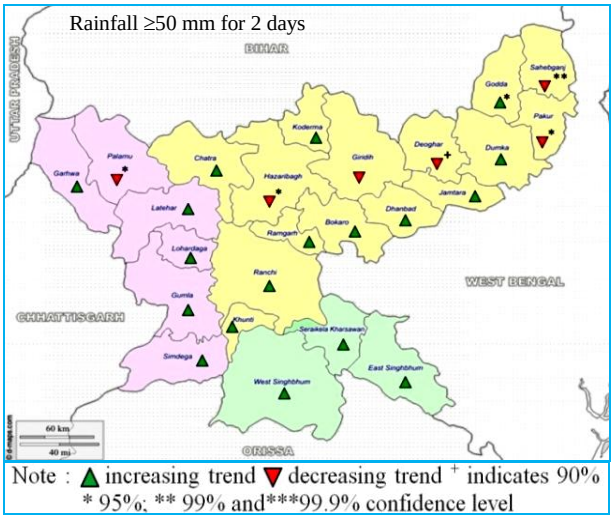

Fig. 6. Trend of wet spells (rainfall ≥50 mm)

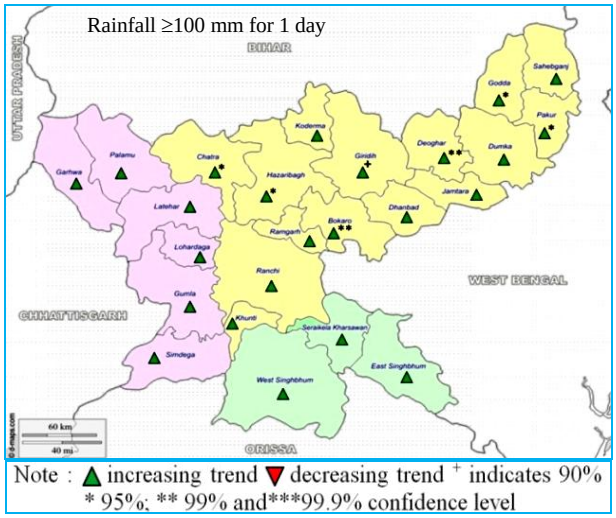

Fig. 7. Trend of wet spells (rainfall ≥100 mm)

was observed in Zone VI. Under zone IV a mixed trend was found. Ranchi, Charta, Hazaribagh, Koderma, Bokaro, Deoghar, Jamtara and Dumka district showed increasing trend whereas Ramgarh, Giridih, Dhanbad, Godda, Sahebganj and Pakur district (Figs. 4 & 5) exhibited a decreasing trend in wet spell. Soil of the region is characterized by undulating topography, deep ground water with varying texture from sandy loam to clay loam with inherent poor soil fertility. It is very tough to till the land for sowing of kharif crops in absence of pre-monsoon shower. An amount of 10 mm rainfall per week could be taken as the minimum requirement for seedbed preparation/sowing of rainfed kharif crops (Ahmed *et al.*, 2009).

6. Very wet spell (≥50 mm for 2 days) was increasing in almost all the districts of Jharkhand except Hazaribagh, Giridih, Deoghar, Pakur, Sahebganj of zone IV with different significance levels (Fig. 6). Increasing trend of very wet spell prove a great prospective of cultivation of rainfed rice in these districts. Extreme rainfall events (≥100 mm for 1 day) showed an increasing trend in all districts of Jharkhand (Fig. 7). Significant increase was observed in Chatra, Hazaribagh, Bokaro, Giridih, Deoghar, Godda and Pakur districts. As stated earlier, monsoon rainfall is decreasing in Giridih, Deoghar, Godda and Pakur districts but instance of extreme events increasing. Light texture soils of Jharkhand having shallow depth are very prone to erosion in case of high intensity rainfall under the undulating terrain condition. It is apprehended that such increase in number of erosive events may worsen the situation by leaving the top fertile soil barren and unproductive.

7. Following conclusions can be drawn from the study:

(*i*) Study of temperature (maximum and minimum) showed significant increasing trend for more severe heat waves for almost whole state. Severe cold wave events were not observed at all, however, significant increase in cold wave (T Min ≤4 °C) was observed for Gumla, Latehar, Lohardaga and Ranchi districts.

(*ii*) Incidence of extreme rainfall events is increased over Jharkhand and rainfall was more variable in zone V. Zone V was observed to be a deficit region in terms of rainfall whereas variability in rainfall was not much in Zone VI.

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