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Short Comminucation

Climatic variability and extreme weather events in Bihar

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The changes in climate, which are likely to occur during future decades, may have significant consequences (positive or negative) on the development, growth and yields of various crops (Patel *et al.,* 2008). In the climate change studies scientists have revealed statistically significant warming trends in different parts of the world (Karl *et al*. 1993; Philandras *et al*., 1999). However, decreasing trends in weather parameters have also been reported in some part of the world (Solomon *et al.,* 2007). Regardless of the definition used, the characteristics of what is called an 'extreme weather event' may vary from place to place. Extreme positive departure from normal maximum temperature results in heat wave during summer season (De *et al.* 2005). In recent years due to deterioration of the air quality in urban locations of India the deaths and discomfort from cold waves have been substantial (De and Sinha Ray, 2000). Lunagaria *et al.,* (2012 and 2015) have reported the climatic trends in extreme weather events in Gujarat. Extreme rainfall events cause damages in the form of landslides, flash floods, crop loss, etc., which further have impacts on society as well as the environment. Hence understanding the pattern and frequency of heat waves, cold waves and extreme rainfall is essential for forecasting and management of extreme climatic conditions. A proper assessment of likely incidences of such events and their trends would be helpful to the planners in their disaster mitigation and implementations. This study is aimed to characterize the long- term trend of temperature and rainfall pattern and simultaneously extreme climatic events in Bihar state and their likely impact on crops considering four stations representing different stations.

The daily data for air temperature and rainfall were collected for the period 1955-2012 for Pusa and Sabour and 1969-2012 for Purnia and Patna representing different zones. After performing the quality check the daily records were processed for seasonal and annual temperature data series computation. The seasons reported are as: *kharif* season (June-October), *rabi* season (November-March). The extreme weather events like heat wave, cold wave and extreme rainfall were calculated following Rajeevan and Yadav (2015). The Theil-Sen approach (Hirsch *et al.* 1982) provides a more robust slope estimate than the least-squares method because outliers or extreme values in the time series affect is less. The Mann-Kendall test was used, assuming the observation in time series are serially independent and there is no correlation. The test determines whether the observations in the data trend to increase or decrease with time. Frequency and trends of heat waves (moderate and severe), cold waves (moderate and severe) and extreme rainfall (75-100 mm rainfall and more than 100 mm rainfall in a day) were analysed. The significance of each trend was examined at 95 % confidence level.

Trends in heat wave

There is significant decreasing trend of moderate and total heat waves for Pusa station whereas for Purnea station, there is increasing trend in moderate and total heat waves but statistically they are non-significant. For Sabour station, there is significant decreasing trend in moderate, severe and total heat waves (Table 1). For Patna station, there is increasing trend in moderate, severe and total heat waves but are statistically non-significant.

Trends in cold wave

For all the stations, Pusa, Purnea, Sabour and Patna, there is significant decreasing trend in moderate and total cold waves but there is non-significant decreasing trend in severe cold waves for all the stations except Sabour, where it is significantly decreasing (Table 1).

Trends in extreme rainfall

There is increasing trend in frequency of extreme rainfall (75-100 mm rainfall and more than 100 mm rainfall) for Sabour station but statistically non-significant (Table 1). There is also increasing trend in frequency of 75-100 mm rainfall in a year for Pusa station but statistically non-significant. For other stations, there is non-significant

Table 1: Mann Kendall test (Kendall's tau) with Theil-Sen slope for extreme weather events.

	Kharif		Rabi		Annual	
	tau	TS slope	tau	TS slope	tau	TS slope
Heat waves	**Moderate heat waves**		**Severe heat waves**		**Total heat waves**	
Pusa	-0.228	-0.111*	-0.118	-0.004	-0.210	-0.107*
Purnia	0.103	0.010	-0.019	-0.006	0.07	0.004
Sabour	-0.338	-0.144*	-0.272	-0.060*	-0.345	-0.205*
Patna	0.055	0.052	0.058	0.055	0.037	0.106
Cold waves	**Moderate cold waves**		**Severe cold waves**		**Total cold waves**	
Pusa	-0.43	-0.058*	-0.028	-0.001	-0.39	-0.057*
Purnia	-0.495	-0.157*	-0.139	-0.007	-0.492	-0.164*
Sabour	-0.433	-0.128*	-0.232	-0.012*	-0.430	-0.141*
Patna	-0.243	-0.063*	-0.18	-0.009	-0.262	-0.072*
Extreme rainfall	**Rainfall 75-100 mm**		-	-	**Rainfall >100 mm**	
Pusa	0.066	0.008	-	-	-0.054	-0.005
Purnia	-0.063	-0.014	-	-	-0.03	-0.002
Sabour	0.101	0.017	-	-	0.092	0.009
Patna	-0.052	-0.002	-	-	-0.094	-0.012

*Significant at 5%

decreasing trend in frequency of extreme rainfall in a year.

Decreasing trend of rainfall in *rabi* season at Pusa indicates that zone I may face water scarcity problem, which need suitable cropping system in the condition of less water availability whereas all the stations except Sabour shows decreasing trend (though non-significant statistically) of annual precipitation which will impact negatively agriculture of the region by decreased length of growing period with less water availability to agriculture. Unequal distribution of precipitation may cause drought in one area and flood in another area. The precipitation decrease in most of the zones in Bihar will impact negatively on Rice-wheat cropping system, which is the major cropping system in the area. Not only decrease in rainfall but also abnormal, irregular or excessive amounts of rainfall seriously reduce the quality and quantity of the yield in rainfed *rabi* crops. Extreme rainfall damages the crops making the field flooded.

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