Journal of AgriSearch 2(3): 189-194
Peer Reviewed Quarterly
ISSN : 2348-8808 (Print), 2348-8867 (Online)

Climate Variability, Extreme Rainfall and Temperature Events over Different Agro-ecological Zones of Bihar

VANDNA CHHABRA* AND A. ABDUL HARIS

ICAR Research Complex for Eastern Region, Patna,Bihar,India

ARTICLE INFO

Received on	: 12.12.2014
Accepted on	: 17.06.2015
Published online	: 01.09.2015

ABSTRACT

Extreme climate events like flood, drought, stormy rainfall and cyclone put a major impact on human society and produce widespread response to adapt and mitigate the adverse effects associated with these extremes**.** Data of 45 years for representative centres falling in three agro ecological zones of Bihar was analyzed. Trends in temperature and rainfall extremes were analyzed on the basis of series of daily data. A set of climate extreme indices that measures many aspects of a changing climate including changes in intensity, frequency and duration of temperature and rainfall events was computed. Analysis of these indices provided clear evidence that different aspects of temperature and rainfall extremes exhibited significant changes during 1961-2005. The region has been clearly warming over the last few decades and extremes of temperature have changed accordingly. Extreme maximum temperature events showed a decreasing trend for all stations except Patna (zone IIIB). Number of rainy days showed a significant increasing trend for Patna and Sabour (zone III), however, a decreasing trend for zone I and II (Pusa and Madhepura).

Key Words: Bihar, Extreme events, Temperature, Rainfall, Zones

INTRODUCTION

Climatic change is expected to boost the magnitude and frequency of extreme weather events worldwide. Developing countries are more susceptible to extreme weather events and over the decade of the 1990s, both the number and severity of such events increased (Singh and Sontakke, 2002). Synoptic weather systems produce extreme amounts of rain in different parts of the world and rainfall received from these weather systems can range from 400-900 mm in one day for different locations (Rakhecha and Pisharoty, 1996). Bhaskaran *et al*., 1995 reported that a substantial rise in moisture transport into India in a doubled CO_2 world leads to an increase in extreme precipitation events in the area. Climate models in general, have also predicted an increase in extreme precipitation events given a build-up of greenhouse gases (Houghton *et al*., 2001). Palmer and Raisanen, 2002 predicted an increase in wet summers thus, enhancing the risk of floods in already flood-prone areas. Soman *et al*. (1988) analysed annual extreme rainfall for stations in the Kerala state of southern India and generally found decreasing trends, particularly for stations in hilly terrain. Rakhecha and Soman (1994) reported that 'the extreme rainfall series at stations over Peninsula and over the lower Ganga valley have been found to show signs of a decreasing trend. In the future, a warming climate will influence the normal range of weather patterns for major regions of the globe (IPCC, 2001). As per the assessment made by World Meteorological Organisation (WMO,1996) surface temperatures for the northern hemisphere were found to be the second warmest on record, at 0.63°C above the 30-year mean (1961-90) of 14.6°C/58.3°F for the year 2007. In 2007, the annual average air temperature over India was 0.55 ^{0}C above the averages between 1900 and 1961. Cold wave continued throughout January 2007 and temperature drop of 3-5^{0}C of the average temperature resulted due to cold waves in most part of north India. Rupa *et al*. (1994) showed that there was an irregularity in the temperature trends in terms of daytime and night time temperatures 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. Dhorde *et al*. (2009) found out that some of the metropolitan cities in India recorded significant increase in minimum temperature during winter. Hingane *et al*. (1985) had

*Corresponding Author Email: vagromet@yahoo.com

prepared an all-India mean series of seasonal and annual surface air temperature for a long-term trend studies and indicated a significant warming of 0.4°C per hundred years in mean annual temperatures of the country as a whole. Srivastava *et al*. (1992) also reported an increasing temperature trends in India on decadal basis. India will also begin to experience greater seasonal variation in temperature, with more warming in winter than summer. Increasing trends of rainfall and minimum temperature in Gangetic plains of Bihar observed by Haris *et al*., 2010a. Weather generators can be used to generate long term weather data wherever data is not available for impact studies. One such generator is LARSWG which was used and produced similar observations of rainfall and temperature as actual weather data for Bihar in eastern India (Haris *et al*., 2010b). Extreme climatic events create a burden on developing countries; increased efficiency to manage extreme weather events can reduce the loss of money, time and human capital. Vulnerability to extreme weather events, disaster management and adaptation must be part of long-term sustainable development planning in developing countries. The impression that climate change would bring about increases in the occurrence of extreme rainfall, it was worthwhile to investigate whether identifiable fluctuations or trends in the annual extreme rainfall amounts over Bihar exist. The purpose of this paper is to analyse the annual extreme events and identify the trends for stations in Bihar and their impact on agricultural productivity.

DATA AND METHODOLOGY

Bihar lies in the eastern region of India (Fig.1) extending from $24^{0}20'10''$ to $27^{0}31'15''$ North latitude and $83^{0}19'50''$ to $88^{0}17'40''$ East longitude, covering a total area of 94,163 sq. km

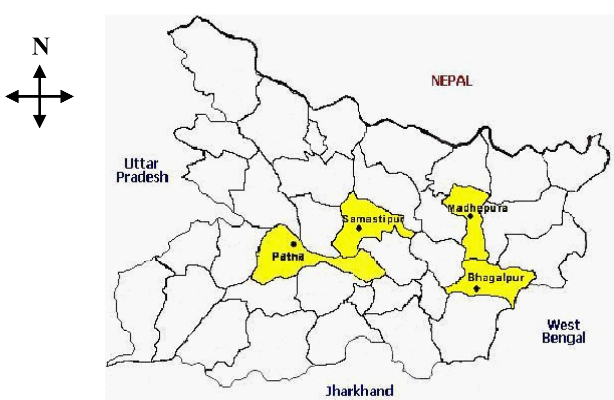

Fig.1: Geographical distribution of selected stations

lying at an altitude of 52.73 m above sea level. The state lies in the Indo-Gangetic plains having sub humid tropical climate and divided into three agro-ecological zones namely North West alluvial plains (zone I), North East alluvial plains (zone II) and South Bihar alluvial plains (zone III). Pusa, Madhepura, Patna and Sabour lies in zone I, II, IIIA and IIIB respectively. Temperature varies from 6 ^{0}C to 45 ^{0}C. Normal annual rainfall received by the state is 1176.4 with an average number of rainy days approximately equal to 43. Daily Maximum temperature, daily minimum temperature and rainfall data for four stations of Bihar, was obtained from Rajendra Agriculture University (RAU); Pusa, RAU regional station; Mithapur and Bihar Agriculture College; Sabour Data for the period 1961 to 2005 was utilized for the analysis except for Sabour where only data available was from 1972-2005. The indices were chosen primarily for assessment of many aspects of a changing climate which include changes in intensity, frequency and duration of rainfall events. They represent events that occur several times per year giving them more robust statistical properties. Of the five extreme rainfall indices, four of them relate to 'wetness' heavy rainfall days (R90), maximum 1-day rainfall total (R1d), simple daily intensity index (SDII) and very wet days (R95)]. R90 is an indicator of the frequency of significant rainfall days for a given year, whereas R95 and R1d represent the magnitude of the more intense rainfall events. In contrast, the SDII is a measure of the average rainfall amount that falls on a wet day in a given year (Table 1).

RESULTS AND DISCUSSION

Rainfall Extremes

During monsoon season Pusa received highest rainfall (1016 mm) followed by Patna, Sabour and Madhepura. The number of rainy days was maximum 46 days for Sabour. The maximum rainfall amount in a day (R1d) ranged between 111 to 123 mm/day (Table 2).

Significant increasing trend was observed for Sabour in maximum rainfall/day during monsoon season and number of rainy days (Fig.2). Very wet days (R95) showed no trend for stations except Sabour where a significant (at 10% level of significance) positive .trend was observed over the years. SDII (Simple daily intensity index) showed no trend over the years and remained almost constant. By dividing the whole period of study into five years group each (pentad), it was observed that frequency of extreme rainfall events (R90) was maximum during the pentad 1996-2000. R90 was at par

Table 1: Temperature and rainfall indices with their definitions and units

Indices	Indicator name	Definitions	Units
SU40	Summer days	Seasonal count when TX (daily maximum) > 40 ^{0}C in the months of March, April and May	d
CN	Cold nights	Seasonal count when TN (daily minimum) < 5 ^{0}C in the months of November, December, January and February	d
AMAX	Tmax	Annual mean of TX	^{0}C
AMEAN	Tmean	Annual mean of TMN	^{0}C
AMIN	Tmin	Annual mean of TN	^{0}C
R1d	Max. 1 day rainfall amount	Maximum 1-day rainfall in monsoon season	mm
SDII	Simple daily intensity index	Annual total rainfall divided by the mm number of rainy days (defined as the days when rainfall amounts > 2.5 mm)	mm
R90	Number of heavy rainfall days	Annual count of days when rainfall > 90 mm in the monsoon season	d
R95	Very wet days	Annual total rainfall when rainfall > 95th percentile	mm
RAIN tot mm (rainfall > 2.5 mm)	Annual total rainy day rainfall	Annual total rainfall in rainy days(rainfall > 2.5 mm)	mm
WET tot	Annual total rainy days	Annual count of days when rainfall > 2.5 mm	d

*Significant at 90% confidence level as per the Mann-Kendall test.

Table 2: Characteristics of monsoonal rainfall for stations under study

Variables	Pusa	Mad-hepura	Patna	Sabour
Average amount of rainfall (mm) during monsoon	1016	945	967.5	965.5
Average number of rainy days during monsoon	42	43.5	41	46.5
Maximum average rainfall (mm) of a day during monsoon	123	115	115	111

for Pusa and Patna (16 d) and the highest, however least for Madhepura i.e. 3 days. No trend was observed for R90 also. Number of rainy days showed a significant increasing trend for Patna, while a decreasing trend for Pusa and Madhepura.

Temperature Extremes

Highest values of annual mean of maximum (TX), minimum (TN) and mean temperature (MN) were recorded for Patna. Non-significant decreasing trend in maximum temperature was observed for Pusa, Patna

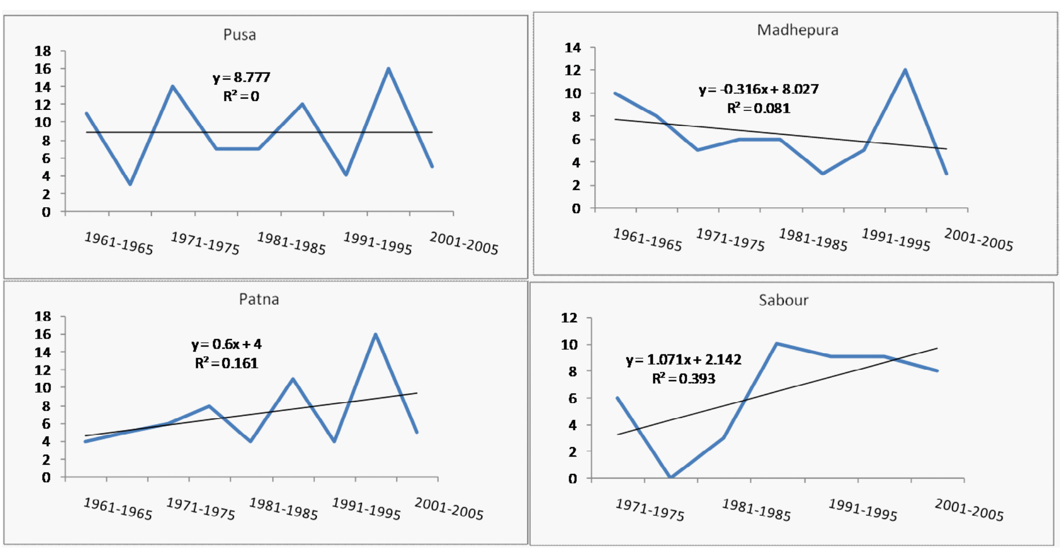

Fig. 2: Number of days with extreme rainfall

as well as Sabour, however, a significant decreasing trend for Madhepura was observed. An increasing trend in minimum temperature was observed for all stations except Madhepura while significant increase in minimum temperature observed for Patna and Pusa stations (Table 3).

Table 3: Trend Test for temperature and rainfall indices

Parameters	Pusa	Mad-hepura	Patna	Sabour
Days with min. temperature ≤ 5^{0}C	D	I	D	I
Days with max. temperature ≥40^{o0}C	D	D	I	D*
Max. RF in a day	I	D	I	I*
Number of rainy days	D	D	I*	I*
SDII	NS	NS	NS	NS
R90	NS	NS	NS	NS
R95	NS	NS	NS	I*

A significant increase in mean temperature was observed for Pusa only. Minimum temperature during winter varied from zero to around 7°C while maximum temperature for summer season ranged from 37 to 46 ^{0}C. The instances of minimum temperature less than or equal to 5 ^{0}C (CN) were seen to be highest in Madhepura (69 days) during the pentad 1996-2000. During 1976-80 pentads, Pusa and 1981-85 for Patna not have a single day with extreme temperature value. Pusa and Patna showed a decreasing trend in the days with extreme minimum temperature, thus indicating an increase in night temperatures during winters, while Madhepura and Sabour showed an increasing trend (Fig. 3 & 4).

The instances of extreme maximum temperature (SU40) were seen to be highest in Patna (301 days) in the period of 5 years (1996-2000) i.e. around 60 events per year on an average and thereafter a sharp decrease was found for 2001-2005. Madhepura remained coldest during daytime among all the stations having least values of extreme daytime temperature as stated. All stations except Patna showed a decreasing trend in days with extreme values of maximum temperature during summer season (March, April and May) though decrease was significant at Sabour only (Fig.5).

Impact of extreme weather on agricultural productivity

Climate change is likely to affect the agricultural production for developing countries not having enough resources to mitigate the adverse effect of climate change. In India more than 700 million populations directly depend on agriculture and allied activities and this sector is most sensitive to climate change Productivity of rice, maize, sorghum, and ragi crops negatively influenced with increase in actual average

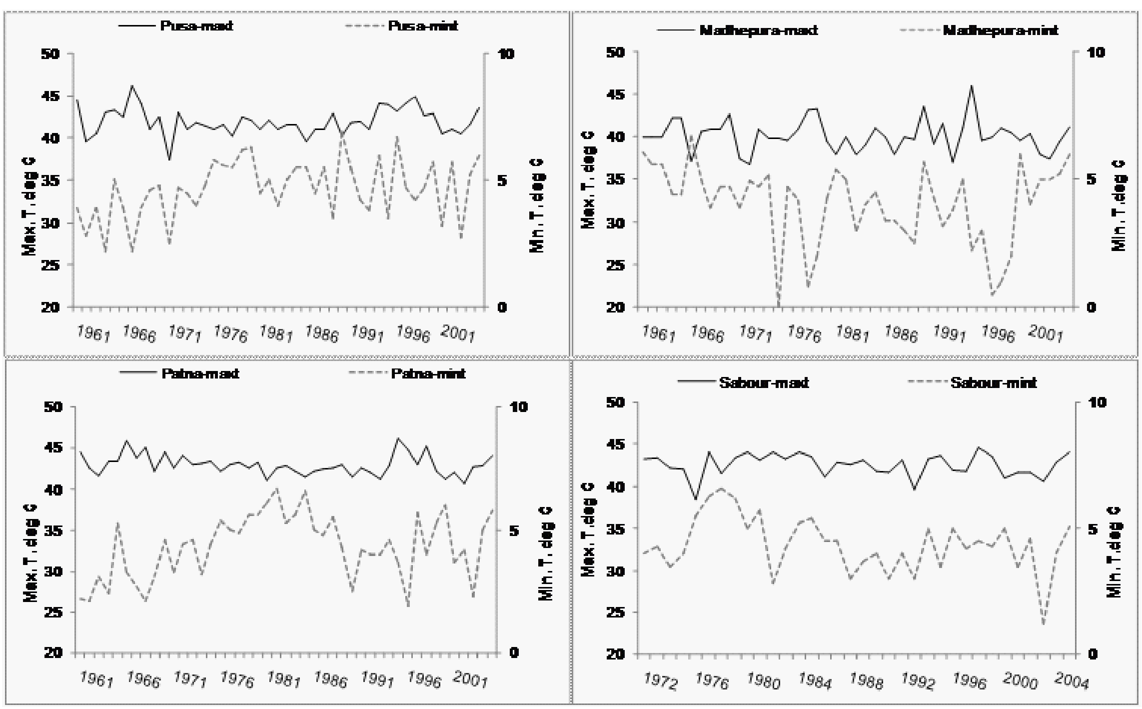

Fig. 3: Minimum and maximum temperature range for all selected stations

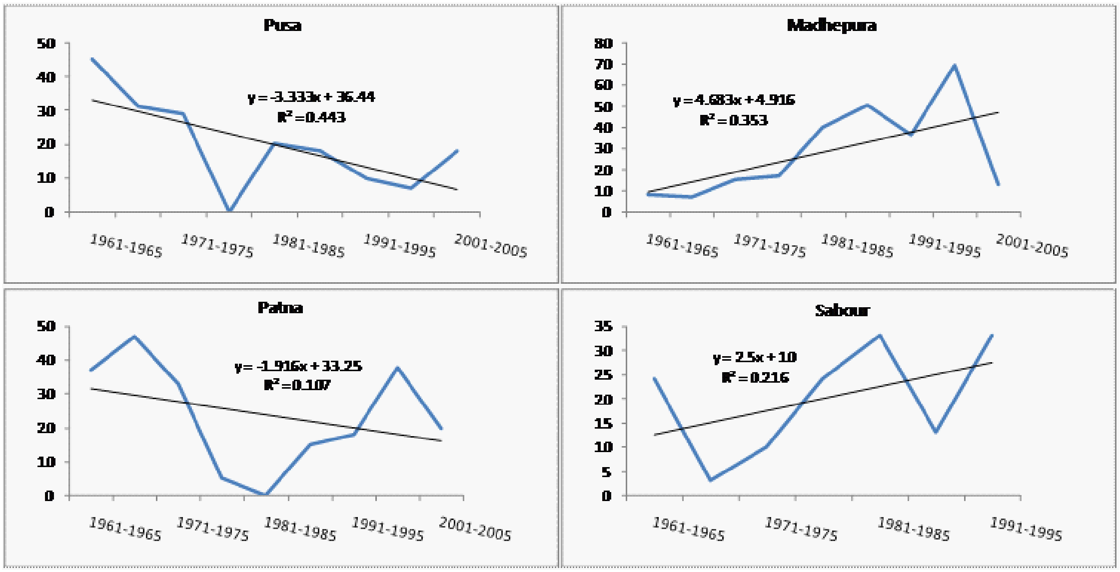

Fig. 4: Number of days with extreme minimum temperature

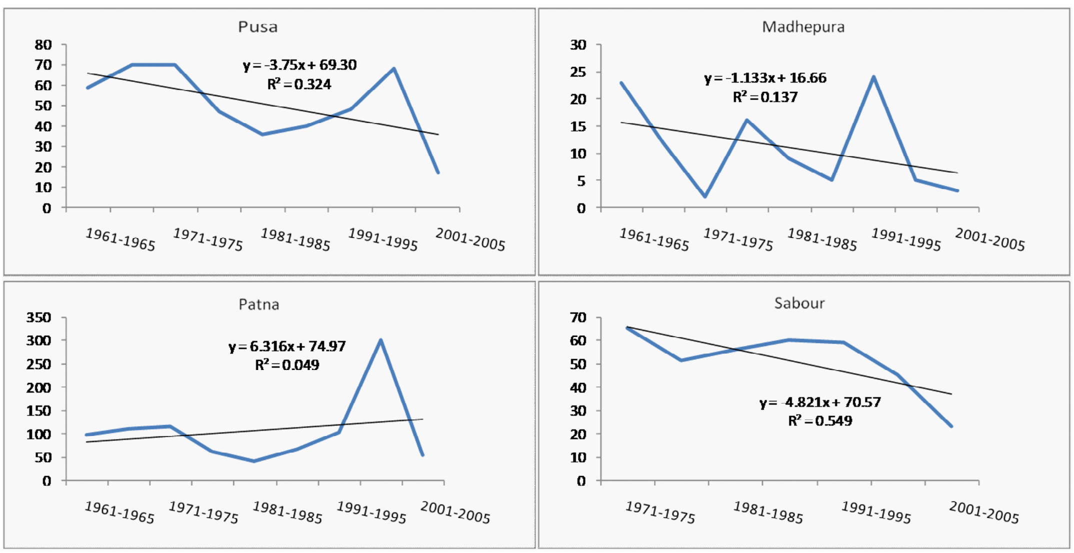

Fig. 5: Number of days with extreme maximum temperature

maximum temperature. Actual average minimum temperature has negative and statistically significant effects on wheat, barley, gram, and rice crops (Kumar *et al.*, 2014). Simulation studies are useful in predicting future climate scenario based on changing trends in temperature, CO_2 and rainfall and other meteorological parameters. Simulation studies showed that long duration rice varieties are more prone to yield decline under future climate scenarios (Elanchezhian *et al.*, 2012). Eastern states of India are likely to be worst hit by climate change. Significant decline in wheat production is expected by 2050 due to climate change. It may result into price rise and jeopardizing the food and nutrition security of the masses. Rice area in eastern region may increase slightly (from 21.7m ha to 22.9 m ha by 2050) with 18 % increase in production and 12.2% increase in productivity, respectively. In case of wheat, simulated yield showed decline of 3 to 38% for Patna and 3 to 28% for Ranchi from 2020 to 2080 time periods though the area is projected to increase by 24% in 2050 the productivity may decline by 20.93%. Simulated yield of winter maize showed an increase from the baseline period. This increase was in the range 8.4–18.2%, 14.1–25.4% and 23.6–76.7% for 2020, 2050 and 2080 respectively. Predicted increase in temperature for future time periods may prove to be detrimental in future time periods for *rabi* crops, however, crop like winter maize may be benefitted due to increase in temperature upto some extent, i.e. there is possibility of substituting wheat in marginal areas by winter maize in Bihar (Chhabra and Haris, 2014). Generally, chickpea adapts to high temperatures, however, heat stress during reproductive phase can cause significant yield loss.

CONCLUSION

Current study describes the occurrence of extreme events as experienced by the four sites of agroecological zones of Bihar falling under sub-humid climatic environment. The study also analyzed the trends of extreme events in the study area. Representative station of zone I i.e. Pusa received highest monsoonal rainfall over the period under consideration, however; Sabour (zone IIIA) received the rainfall for maximum number of days, annually. A decreasing trend in extreme minimum temperature events for Pusa and Patna, while an increasing trend for Madhepura and Sabour was observed. No significant change was observed for extreme minimum temperature events in any of the zones. Extreme maximum temperature events showed a decreasing trend for all stations except Patna (zone IIIB). Significant decrease in events was observed only for Sabour (zone IIIA). Number of rainy days showed a significant increasing trend for Patna and Sabour (zone III), however, a decreasing trend for zone I and II (Pusa and Madhepura). Bird's eye view of the results makes the region highly probable for an increase in rainfall amounts. To avert the adverse impact of climatic extreme events proper management strategies should be adopted by farmers as suggested by the experts of this field.

ACKNOWLEDGEMENT

The work was carried out at ICAR Research Complex for Eastern Region, Patna. The authors are grateful to Network Project of Climate Change for all the facilities and data provided for the study.

REFERENCES

Bhaskaran B, Mitchell JFB, Lavery JR and Lal M. 1995. Climatic response of the Indian subcontinent to doubled CO_2 concentrations. *International Journal of Climatology* **15**: 873–892.

Chhabra V and Haris AA. 2014. Temperature Trends and their impact on rabi crops in changing climatic scenario of Bihar. *Scholars Journal of Agricultural and Veterinary Sciences* **1**(4A): 230-234.

Dhorde A, Dhorde A and Gadgil AS. 2009. Longterm temperature trends at four largest cities of India during the twentieth Century. *J.Ind.Geophys.Union* **13**(2): 85-97.

Elanchezhian R, Haris AA, Biswas S and Chhabra V. 2012. Simulation of yield and its component traits of rice (*Oryza sativa L.*) varieties grown in Indo-Gangetic plains of Bihar under projected climate change. *Indian Journal of Plant Physiology* **17**(3 &4): 195-202.

Haris AA, Chhabra V and Biswas S. 2010a. Rainfall and temperature trends at three representative agroecological zones of Bihar. *Journal of Agrometeorology* **12**(1): 37-39.

Haris AA, Khan MA, Chhabra V, Biswas S and Pratap A. 2010b. Evaluation of LARSWG for generating long term data assessment of climate change impact in Bihar. *Journal of Agrometeorology* **12**(2): 198-201.

Hingane CS, Rupa Kumar and Ramana Murthy Bh.V. 1985. Long term trends of surface air temperature in India. *International Journal of Climatology* **5**: 521–528.

Houghton JT, Ding Y, Griggs DJ, Noguer M, van der Linden PJ, Dai X, Maskell K and Johnson CA (eds). 2001. Climate Change 2001: The Scientific Basis. Cambridge University Press: Cambridge, UK. http://www.rediff.com/news/2007/de.

Intergovernmental Panel on Climate Change (IPCC), 2001. Climate Change 2001-Impacts, Adaptation, and Vulnerability: Summary for Policymakers and Technical Summary of the Working Group II Report. IPCC, Geneva, 89 pp.

Kumar A, Sharma P and Ambrammal SK. 2014. Climate effect on food grain productivity in India: A crop wise analysis. *Journal of studies in dynamics and change* **1**(1).38-48.

Palmer TN and Raisanen J. 2002. Quantifying the risk of extreme seasonal precipitation events in a changing climate. *Nature* **415**: 512-514.

Rakhecha PR and Soman MK. 1994. Trends in the annual extreme rainfall events of 1 to 3 days duration over India. *Theoretical and Applied Climatology* **48**: 227–237.

Rakhecha PR and Pisharoty PR. 1996. Heavy rainfall during monsoon season: Point and spatial distribution. *Current Science* **71**: 177-186.

Rupa KK, Pant GB, Parthasarathy B and Sontakke NA. 1994. Spatial and Subseasonal patterns of the long term trends of Indian summer monsoon rainfall. *Int. J. Climatol*. **12**: 257-268.

Soman MK, Krishnakumar K, Singh N. 1988. Decreasing trend in the rainfall of Kerala. *Current Science* **57**: 5–12.

Singh N and Sontakke NA. 2002. On climate change fluctuations and environmental changes of Indo-Gangetic plains, India. *Climatic Change* **52**: 287-313.

Srivastava HN, Denian BN, Dikshit SK, Rao GSP, Singh SS and Rao KR. 1992. Decadal trends in climate over India. *Mausam* **43**: 7–20.

WMO. 1966. Climate Change, WMO, Tech. Note No 79, pp 1-79.

Citation:

Chhabra V and Haris A A. 2015. Climate variability, extreme rainfall and temperature events over different agroecological zones of Bihar. *Journal of AgriSearch* **2** (3): 189-194