Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.7806

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2021) *9*(5), 196-204

Indian Journal of Pure & Applied Biosciences

Peer-Reviewed, Refereed, Open Access Journal

Review Article

Scrutinizing the Climate Change through Box Plot Method in Uttar Pradesh

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Received: 4.09.2021 | Revised: 12.10.2021 | Accepted: 23.10.2021

ABSTRACT

Eastern U.P. has faced severe floods, while Bundelkhund region has faced one of worst famines of last decade. Thus, the impact of climate change has adversely affect the agricultural Production resulting in huge loss of paddy, corn and regional crops in eastern districts. The objectives were to examine the pattern of change of rainfall and temperature in eastern Uttar Pradesh. To examine the pattern of change of rainfall and temperature of India, Box plot method is used as a tool to study the change. Many extreme temperature and rainfall conditions are becoming more common. The Indian monsoon is changing, with less rainfall overall in more intense bursts, and more frequent dry spells in between. Gorakhpur, Siddharthnagar and Maharajganj were highly climatic vulnerable than other districts.

Keywords: *Climate Change, Eastern U.P. Box-plot method, Monsoon extremes.*

INTRODUCTION

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events).

The term "climate change" is often used to refer specifically to anthropogenic climate change (also known as global warming). Anthropogenic climate change is caused by human activity, as opposed to changes in climate that may have resulted as part of Earth's natural processes. In this sense, especially in the context of environmental policy, the term climate change has become synonymous with anthropogenic global warming.

Cite this article: Choudhary, H., Chandra, R., Badal, P. S., & Sharma, A. (2021). Scrutinizing the Climate Change through Box Plot Method in Uttar Pradesh, *Ind. J. Pure App. Biosci.* *9*(5), 196-204. doi: http://dx.doi.org/10.18782/2582-2845.7806

Within scientific journals, global warming refers to surface temperature increases while climate change includes global warming and everything else that increasing greenhouse gas levels affect.

Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as global warming.

Climate change affects agriculture in two ways—direct and indirect. Changes in climatic factors (for example, temperature, and rainfall) affect agricultural productivity through physiological changes in crops (Chakraborty et al., 2000). In addition, climate change also affects other factors of production agriculture, such as water availability, soil fertility, and pests (Porter, 2014). The overall effect of climate change on agriculture could be positive or negative; the magnitude of impact can also vary from very low to very high, depending on regional or geographical location and status of socioeconomic development (Mendelsohn et al., 2006; & Tripathi, 2016).

During the last one decade, Indian state of Uttar Pradesh has been witness to many climatic changes. Eastern Uttar Pradesh has faced severe floods, while Bundelkhand region has faced one of the worst famines of the last decade. Thus, the impact of climate change has adversely affected agricultural production resulting in huge loss of paddy and corn crops in eastern districts and regional crops in eastern Uttar Pradesh. Climate-related disasters have brought widespread misery and huge economic losses to Uttar Pradesh, adversely affecting public health, food security, agriculture, water resources and biodiversity in the state.

The study is an attempt of capturing the effect of climate change with objective to examine the pattern of change of rainfall and temperature in eastern Uttar Pradesh.

The study was conducted in the eastern part of Uttar Pradesh. The eastern region is characterised by low education, low per capita income, high population density, and a high number of small and marginal resource-poor farmers, which makes it likely to bear a significant impact of climate change. O'Brien et al. (2004) noted that climate sensitivity to agriculture is high in UP and recent changes in climate may be an obstacle for agricultural and rural development (Tripathi, 2014).

The secondary information was collected from Directorate of Economics and Statistics, Lucknow, Uttar Pradesh, Jila Sankhyaki Patrika, U.P. and India Water Portal sites. Meteorological data such as Daily/monthly/annual temperature and rainfall were collected from the Meteorology Department, Institute of Agricultural Sciences, and Department of Geophysics, Banaras Hindu University, Varanasi and website of India Meteorology Departments, Government of India for a period of about more than 50 years, wherever possible.

Analytical framework

Box and whisker plot method

To examine the pattern of change of rainfall and temperature of eastern Uttar Pradesh, Box plot method was used as a tool to study the change in past years.

The box-and-whisker plot is an exploratory graphic, created by John W. Tukey, used to show the distribution of a dataset. (McGill et al., 1978). A box and whisker plot is a type of graphical display that can be used to summarise a set of data based on the five number summary of this data. It is an effective way to investigate the distribution of a set of data.

The quartiles representation interprets:

- The extremes (min. and Max.), which provide the range covered by all the data; and
- The quartiles (Q1, M and Q3), which together provide the IQR, the range

covered by the middle 50% of the data.

- The combination of all five numbers (min, Q1, M, Q3, max.) is called the five number summary, and provides a quick numerical description of both the centre and spread of a distribution.

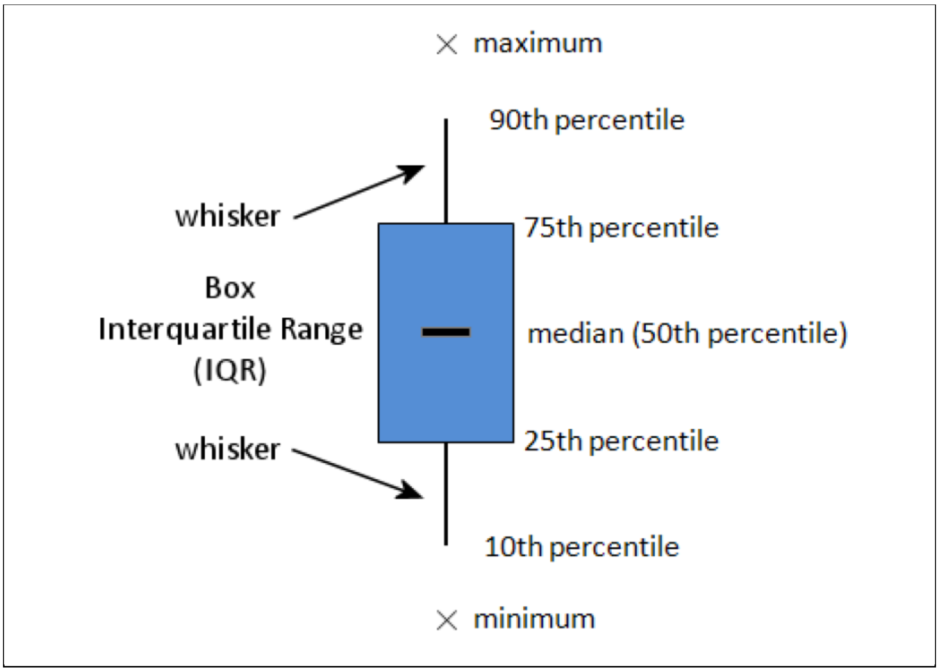


Figure 1: A generic box and whisker plot with extreme data points added. The height of the box portion is given by the inter quartile range of the dataset, and extends from the 25th to 75th percentile. The horizontal bar within the box denotes the median value. The ends of the whiskers are drawn to the 10th and 90th percentile values. The extreme values are labeled with an "x" at the maximum and minimum points

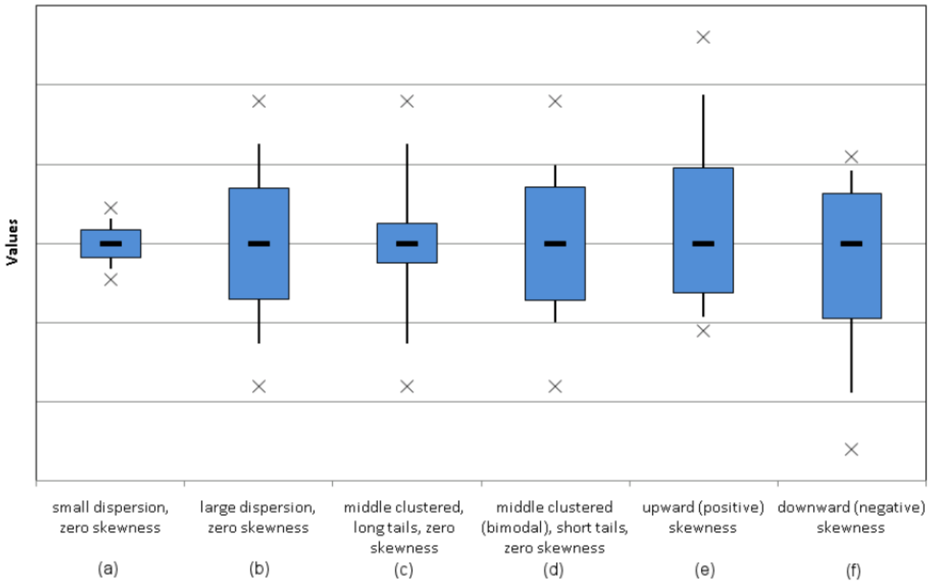


Figure 2: Idealized box and whisker plots for six data distributions. The datasets exhibit (a) small dispersion, (b) large dispersion, (c) middle clustering (with long tails), (d) middle clustering based on a bimodal distribution (with short tails), (e) upward (positive skewness), and (f) downward (negative) skewness. Datasets (a)-(d) are symmetric about the median and have zero skewness. The value scale along the ordinate is arbitrary, but linear

1. To examine the pattern of change in rainfall and temperature in eastern U.P.

Rainfall and temperature does not show any significant change in months over the years but due to climate change it becomes more erratic and unpredictable.

Long-term changes in temperature and rainfall in eastern districts of Uttar Pradesh were analyzed using observational records of IMD from 1980 to 2015 using the box and whisker plot method. Box and whisker plots offer a pictorial summary of important dataset characteristics including the central tendency, dispersion, asymmetry, and extremes, arrived at through percentile rank analysis and the plotting of maximum and minimum dataset values. Since box and whisker plots display measures of central tendency and spread free from the assumption of a normal distribution, they provide an effective way of identifying asymmetrical attributes in meteorological datasets (Banacos, 2011).

2. Pattern of change in maximum temperature over the years

The box and whisker plot is advocated here in the study to examine the maximum temperature, minimum temperature and rainfall for the period of 35 years (1980-2015). The results of the same have been presented in Tables 1 and 2. Maximum temperature quartiles and data plot is shown in table 1 and figure 1.

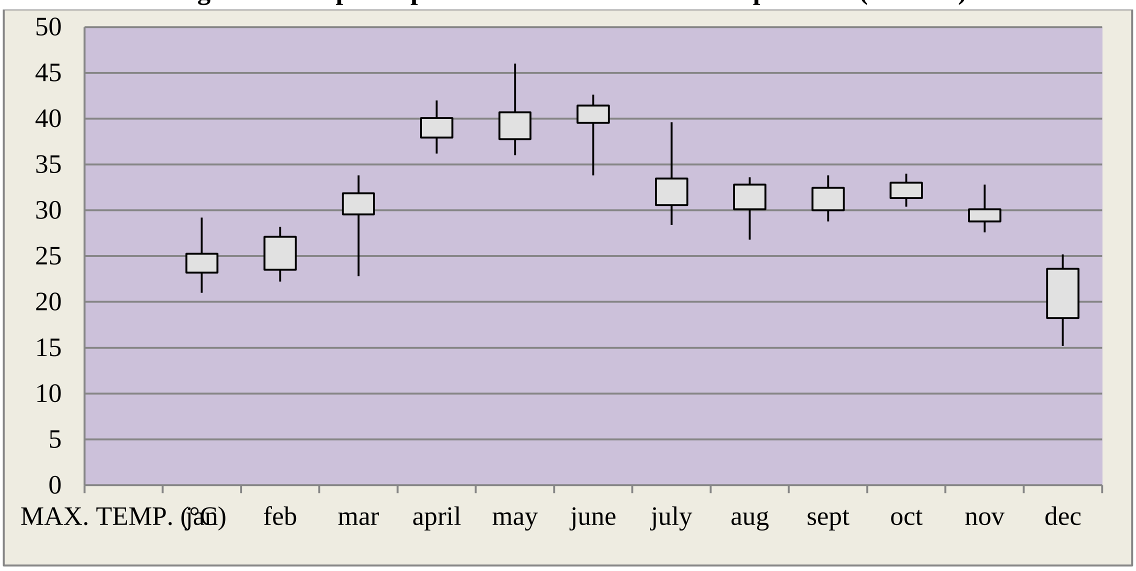
The quartiles representation interprets

- The extremes (min. and Max.), which provide the range covered by all the data; and
- The quartiles (Q1, M and Q3), which together provide the IQR, the range covered by the middle 50% of the data.
- The combination of all five numbers (min, Q1, M, Q3, max.) is called the five number summary, and provides a quick numerical description of both the centre and spread of a distribution.

Table 1: Maximum Temperature quartile ranges for period (1980-2015)

Months	Open (q1)	High (q0)	Low (q4)	Close (q3)
JAN	23.2	21	29.2	25.25
FEB	23.5	22.2	28.2	27.1
MAR	29.55	22.8	33.8	31.85
APRIL	37.95	36.2	42	40.05
MAY	37.75	36	46	40.7
JUNE	39.55	33.8	42.6	41.42
JULY	30.55	28.4	39.6	33.45
AUG	30.1	26.8	33.6	32.8
SEPT	30	28.8	33.8	32.45
OCT	31.35	30.4	34	33
NOV	28.8	27.6	32.8	30.1
DEC	18.25	15.2	25.2	23.6

Figure 3: Box plot representation of maximum temperature (1980-15)



The box plot displayed in Figure 3 represents summary statistics for the analysis variable; each of the 12 box-and-whisker plots describes the average maximum temperature for a particular month for duration 1980-2015. The plot elements and the statistics they represent as the range as shown by the graph lies within range of 20-40°C. The width of box has no meaning. December- January months marked out to be coolest months and May-June emerged as the hottest months of years with average max temperature of 40°C. The graphical representation shows that degree of difference in skewness (distribution) over different months. Knowledge of skewness tells the user whether deviations from median are more likely to be positive or negative. Months of January, October, November and April showed small dispersion or zero skewness. Boxes with long tails i.e. March, May, June and July showed negative and positive skewness(outliers). The upward long tail explains positive skewness distribution and downward long tail illustrates the negative distribution. Open, high, low and close are the standard names given to each quartile range.

Table 2 shows how change in maximum temperature contributing to climate change by comparison of maximum average temperature with the extreme. On assessment of 2 years i.e. 1980 with 2015 it can be inferred that in summer a gradual increase of 2-4°C has been seen and also the extreme (maximum temperature) is recorded highest and is more around 3°C in May-June. This unusual and unprecedented spell of hot weather temperature is occurring more frequently and signifies the climate change.

Table 2: Comparison in Average Monthly Maximum Temperature and the Extremes over the period of 35 years (1980 and 2015)

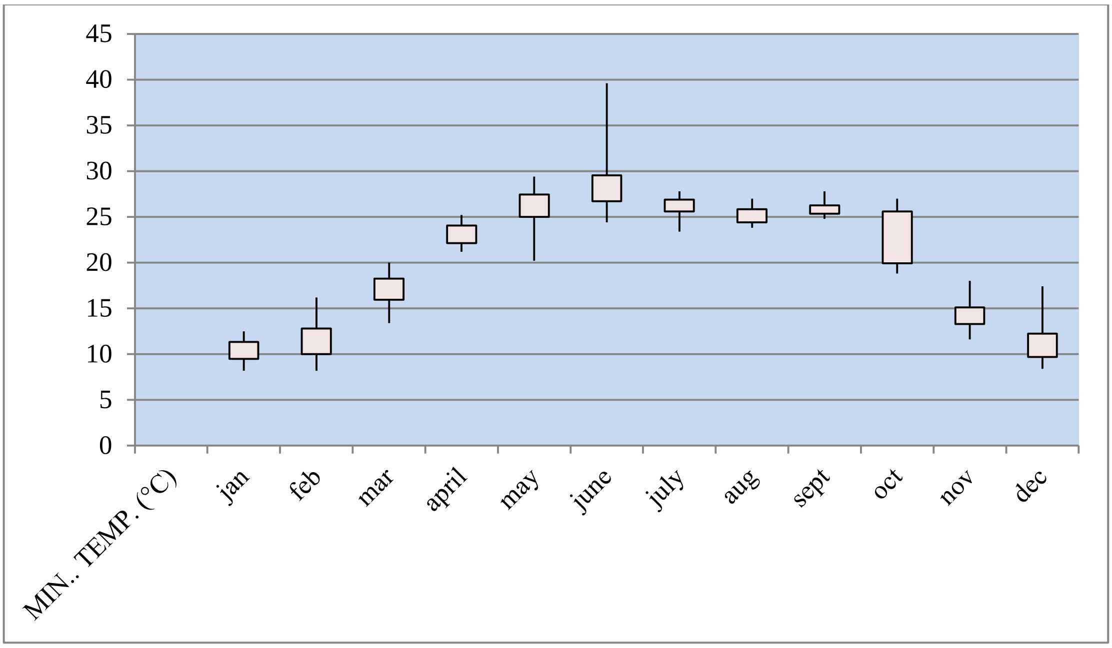
1980	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average	21.5	24.7	30.2	39.1	**40.5**	**34.4**	30.7	30.1	30.8	30.4	27.7	22.5
Extreme	27.2	28.9	35.6	40.1	**41.5**	**41.1**	34.1	32.2	32.8	33.3	31.7	30.6
2015	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average	16.5	17.9	29.5	35.2	**42.5**	**38.10**	29.7	32.9	33.9	32.3	29.7	23.38
Extreme	22.6	31	36.8	40	**44.6**	**44.9**	38	35.8	36.6	35.6	32.4	26.1

Table 3: Minimum Temperature quartile ranges for period (1980-15)

Months	**Open (q1)**	**High(q0)**	**Low(q4)**	**Close(q3)**
Jan	9.5	8.2	12.5	11.35
Feb	10	8.2	16.2	12.8
Mar	15.95	13.4	20	18.25
April	22.15	21.2	25.2	24.05
May	25	20.2	29.4	27.45
June	26.7	24.4	39.6	29.55
July	25.6	23.4	27.8	26.9
Aug	24.4	23.8	27	25.85
Sept	25.35	24.8	27.8	26.25
Oct	19.95	18.8	27	25.6
Nov	13.3	11.6	18	15.12
Dec	9.7	8.4	17.4	12.25

The table 5.3 summarizes the average minimum temperature for the months during the period 1980-2015. In December-January temperature is minimum up to 8°C and maximum to 39°C in months of summer i.e. June-July. It is clearly inferred from the figure that over the months from May to September the temperature on an average do not fluctuates much over the years.

Figure 4: Box plot representation of minimum temperature (1980-15)



The figure 4 represents the Box and Whisker plot for minimum temperature and illustrates the skewness or distribution over the months. January, April, July, August, September months showed the zero or small dispersion as the size of boxes is small whereas February, May, June, October months show high variability in the data set. These months depicts unpredictability in the temperature range over the months in different time periods.

Table 4: Comparison in Average Monthly Minimum Temperature and the Extremes over the period of 35 years

1980	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average	9.1	11.1	15.2	22.2	26.9	27.2	26.2	25.7	24.7	20.5	14.47	10.6
Extreme	13.8	18.5	20.9	25.3	29.9	32.8	28.5	27.5	27	23.4	18.2	15.4
2015	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average	10.3	13.5	16.9	22.2	26.7	28.2	26.8	26.3	26.1	21.0	17.4	11.0
Extreme	5.9	7.3	12	17.6	22.4	23.6	24.8	22.4	22.2	15.8	12.4	5.4

Table 4 depicts the average monthly minimum temperature and the extremes over the period of 35 years. In months of December- January a huge degree change in extremes is witnessed, although the average being same for the 2 years. Climate experts blame rising global temperature for erratic weather pattern, leading to these instances. Hot months are expected to be hotter and cold months more colder.

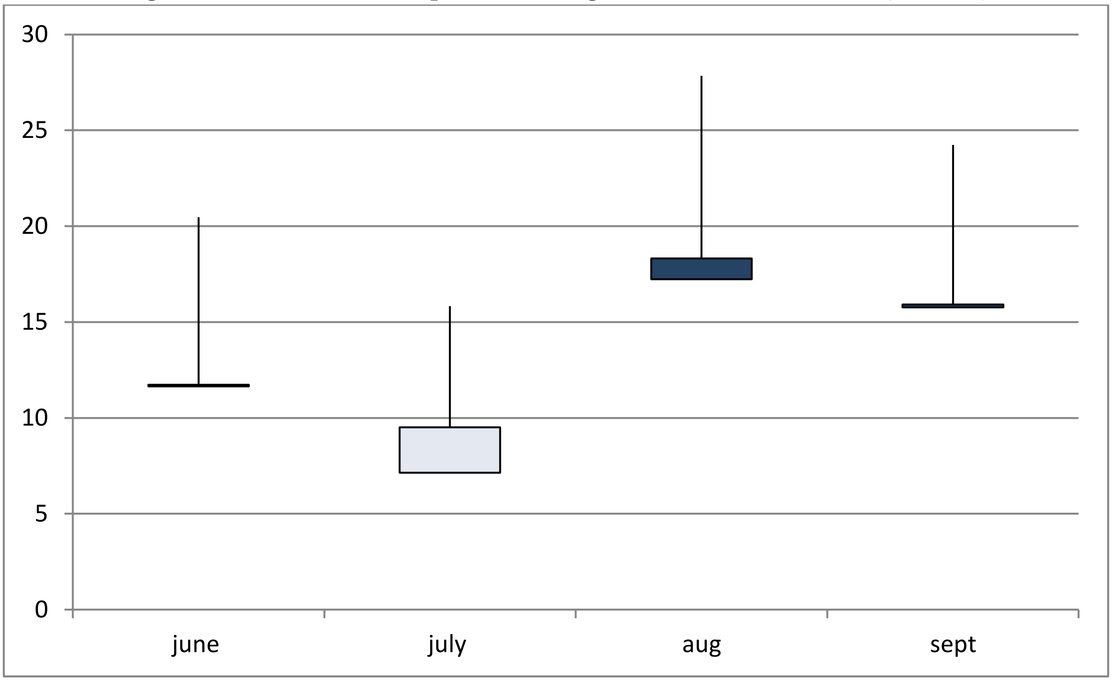
The other important variable to study under the climate change pattern is rainfall. Monsoon or rainy season lasts from July to September in India. The season is dominated by the humid southwest summer monsoon, which slowly sweeps across the country beginning in late May or early June. Monsoon rains begin to recede from North India at the beginning of October.

Table 5. Monthly quartile ranges for the rainfall in mm (1980-15)

Months	Open (q1)	High (q0)	Low (q4)	Close (q3)
June	11.73	7.14	18.31	15.91
July	20.47	12.18	27.84	24.23
August	18.71	15.84	23.74	21.93
September	11.64	9.51	17.24	15.77

The perusal of the Table 5 illustrates the average quartile ranges for the rainfall for the time period 1980 to 2015. July-August receive the average maximum rainfall range from 23.73–27.84 mm monthly whereas June-September receives an average maximum rainfall of around 17-18 mm as depicted by the fourth quartile.

Figure 5: Box and whisker plot for averagerainfall in eastern U.P. (1980-15)



The interpretation of box and whisker plot in Figure 5 shows the variability (skewness) in the rainfall datasets over the months in eastern Uttar Pradesh. The plot elements and the statistics they represent as the range as shown by the graph lies within range of 7 to 27 mm. The width of box has no meaning. The graphical representation shows that degree of difference in skewness (distribution) over different months. All months show high variability in the dataset. All boxes are with long tails i.e. showed negative and positive skewness (outliers). This illustrates that distribution is more within the months. It has been revealed that rainfall does not show any significant change in months over the years but due to climate change it becomes more erratic and unpredictable.

Similarly, on comparing the average monthly rainfall and the extremes over the period of 35 years i.e. for 1980 and 2015 as shown in Table 6, it can be inferred that average precipitation has more or less remained the same. The dry spell has increased but extremes have huge difference in 2 years. In 1980, July receive an extreme of 82.2 mm in a day whereas 2015 July received around 114.4 mm.

Table 6: Comparison in Average Monthly Rainfall and the Extremes over the period of 35 years

	Jun	Jul	Aug	Sep
1980 (mm)				
Average	11.3	18.9	12.7	10.3
Extreme (max)	58.8	82.2	46.7	19.9
2015(mm)				
Average	10.6	16.9	9.9	0.39
Extreme (max)	129.4	114.4	92.6	147.4

Further it can be concluded that the Indian monsoon is changing, with less rainfall overall in more intense bursts, and more frequent dry spells in between. It is seen that while the average total rainfall during the monsoon season had declined, the variability of rainfall during the peak monsoon months had increased.

REFERENCES

Arya, R., Gupta, A., & Mohammad, Y. (September, 2012). Flood Resilience through Climate-change adaptation: A case of Gorakhpur, Eastern Uttar Pradesh in India. *International Research Journal of Environment Sciences. 1*(2), 25-28.

Atkins, J. M. S., & Ramlogan, C. (1998). A Study on the Vulnerability of Developing and Island States: A Composite Index, Commonwealth Secretariat, UK.

Benedictor, A., Laderach, P., Eitzinger, A., Cook, S., Quiroga, A., Pantoja, A., & Bruni, M. (2012). Global Climate Change and Food Supply Chains: Policies for Collective Adaptation. CIAT Policy Brief Page No. 1-6, 2012.

Birthal, P. S., Khan, Tajuddin. Negi, Digvijay & Agarwal, (2011). Shaily Impact of Climate Change on Yields of Major Food Crops in India: Implications for Food Security. *Agricultural Economics Research Review 27* (No.2) July-December 2014 pp 145-155. DOI: 10.5958/0974-0279.2014.00019.6.

Brenkert, A. L., & Malone, E. L. (2005). Vulnerability and Resilience of India and Indian States to Climate Change: A First-Order Approximation, Washington, DC, Joint Global Change Research Institute.

Aromar, R. (2008). Climate change risk: an adaptation and mitigation agenda for Indian cities. *International Institute for Environment and Development (IIED) 207 20*(1), 207–229. DOI: 10.1177/0956247808089157.

Roco, L., Engler, A., Bravo, B., & Rojas, R. (2015). Farmers' perception of climate change in mediterranean Chile. *Environmental Change. 15*, 867–879. DOI 10.1007/s10113-014-0669-x.

Sahu, N. C., & Mishra, D. (2013). Analysis of Perception and Adaptability Strategies of the Farmers to Climate Change in Odisha, India, APCBEE Procedia. 5, pp: 123–127.

Shankara, M. H., Shivamurthy, M., & Kumar, Vijaya. (2013). Farmers' perception on climate change and its impact on agriculture in eastern dry zone of Karnataka. *International Journal of Farm Sciences 3*(2), 100-107.

Taylor, A. L., Dessai, S., & Bruine de Bruin, W. (2014). Public perception of climate risk and adaptation in the UK: A review of the literature. *Climate Risk Management, 4-5*, 1-16. doi:10.1016/j.crm.2014.09.001.

Tripathi, A., & Mishra, A. K. (2017). Knowledge and passive adaptation to climate change: An example from Indian farmers. Climate Risk Management.

Udmale, P., Ichikawa, Y., Manandhar, S., Ishidaira, H., & Kiem, A. S. (2014). Farmers′ perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction, 10*, 250-269. doi:10.1016/j.ijdrr.2014.09.011.

Vanwijk, & Mark T. (2012). "A review on farm household modelling with a focus on climate change adaptation and mitigation".