Original Research Article

Rainfall trends of Bhadradri district in the past three decade

ABSTRACT

Bhadradri district of the central Telangana zone is monsoon dependent as like our country in the past three decades many changes and shifts in the rainfall was experienced by the district farming community. Hence, the rainfall data of the past three decades (1991-2020) was analyzed by using non parametric statistical tests *i.e* Mann-Kendall (MK) test and Sen's slope estimator for determining the trend and magnitude. The Results of the study revealed that Z test value for annual rainfall was significantly increased with Positive linear trend of Sen's slope estimator with +12.79 mm increase per year. Among the seasons Southwest monsoon period reported significantly positive trend with Z value of 2.07 and Sen's slope estimator was +9.227 mm per season. Highest rainfall variability (116.3%) was found in the winter season with negative Z value (-1.559) and decreasing Sen's estimate of -0.397 mm per season was reported. Mann Kendall test values for monthly rainfall reported that significant increase in the march month with Z value of 2.030 and Sen's slope estimator was highest during the month of August +3.988 mm per month.

Key words: Monthly, Seasonal, Annual, Mann-Kendall (MK) test and Sen's slope estimator

Introduction

Bhadradri District was mostly agriculture dependent as like the Telangana state and country, with a gross cropped area of 1,39,036 ha under the cultivation of the Paddy, Maize, chilli and redgram in *Kharif* season and Greengram, Blackgram, Groundnut in the *rabi* season. The majority of area under cropping was rainfed, largely dependent on the monsoon rainfall, Hence, the rainfall in the region is a governing factor to determine crops, cropping pattern, individual crop area production & productivity of various crops and one of the important variable in determining the occurrence of floods and drought, the changes in the precipitation pattern was not uniform (Pachauri and Meyer, 2014), In view of these the present study was aimed to analyse the variability and trend of the rainfall over Bhadradri district over past three decades (1991-2020).

MATERIALS AND METHODS

Study area:

Bhadradri district lies between 18^{o} 13^{l} and 17^{o} 13^{l} Northern latitude and 80^{o} 12^{l} and 81^{o} 18^{l} Eastern longitude in central zone of Telangana state and elevated at 109 m MSL with the normal rainfall over the district was 1155 mm.

Data sources:

Monthly mean values of the rainfall data recorded at seventeen stations in the district was collected for past three decades (1991-2020) from CPO, Bhadradri district and used for the present study.

Rainfall Seasons:

According to the IMD classification monthly rainfall of the district was summed into seasonal rainfall *i.e.* Winter Season: January – February, Pre-Monsoon Season: March – May, Southwest Monsoon Season: June – September, Post Monsoon Season: October – December and analysis was done.

Standard deviation of the rainfall:

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Comment [HUR2]: A map of the location of the study area is missing

Comment [HUR3]: What does CPO mean? It is necessary to know where the data comes from and its validity, because the institution is validated.

Comment [HUR4]: What is this classification?

An estimator for sigma sometimes used as the standard deviation of the sample, denoted by σ and define as follows. Standard deviation (SD).

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where (x_1, x_2,------,x_i) are the observed values of the sample items and is the mean value of these observations, while the denominator N stands size of the sample.

Co-efficient of variation (CV %):

Co-efficient of variation is the percentage variation between mean, standard deviation being considered as the total variation from the mean. High Co-efficient of variation indicates more variability and less stability.

$$\text{Co-efficient of variation (\%)} = \frac{\text{Mean rainfall}}{\text{Standard Deviation}} \times 100$$

In other words co-efficient of variation (CV) is defined as ratio of the standard deviation to the mean.

Test Z:

The widely accepted non-parametric test for rainfall working with time series trends was Mann-Kendall. Hence, changes in trends of monthly, seasonal and annual rainfall were detected in time series using Mann-Kendall (MK) test. Mann-Kendall test is used to test the null hypothesis H_0 of no trend, against the alternative hypothesis, H_1 of an increasing or decreasing monotonic trend. This is a rank correlation statistical test based on a comparison of the observed number of discordances and the value of the same quantity expected from a random series. In the computation of this statistical test MAKESENS exploits the normal approximation (Z)statistics (Salmi *et al.*, 2002). The absolute value of Z was compared with the standard normal cumulative distribution to detect if there is any trend at the selected level of significance (α) (Mandal *et al.*, 2013). The trend is said to be increasing or decreasing if value of Z is positive or negative respectively.

Q value:

If the linear trend is present in a time series, then the slope (change per unit time) can be estimated by using a simple non-parametric procedure, the Sen's slope estimator (Sen, 1968), These methods have become very useful in analyzing meteorological or atmospheric data, or where regular observations are to be analyzed over a long period.

RESULTS AND DISCUSSION

Annual rainfall trend:

The results of past three-decade rainfall analysis implicated that mean annual rainfall was 1213.2 mm with standard deviation of 277.1 mm *i.e* 22.8% variation. Z test value for annual rainfall was positive (2.0) with significant increase. Positive linear trend was found by the Sen's slope estimator with +12.79 mm increase per year (Fig.1), similar results were quoted by Yang *et al* for Wangmo and Xingren stations of Southwest Guizhou Autonomous Prefecture of China.

Comment [HUR5]: The coefficient of variation is the standard deviation/arithmetic mean. Not the other way around as expressed in its formula.

Comment [HUR6]: Whoever determines that this is the correct test. You have to put citations to support this.

Comment [HUR7]: What is meant by this term?

Comment [HUR8]: Once again, based on what this statement is made, which authors support this?

Comment [HUR9]: 1155mm or 1213.2mm? At the beginning of the document it mentions 1155 and here 1213.2 mm.

Comment [HUR10]: Are these stations close to the study site?

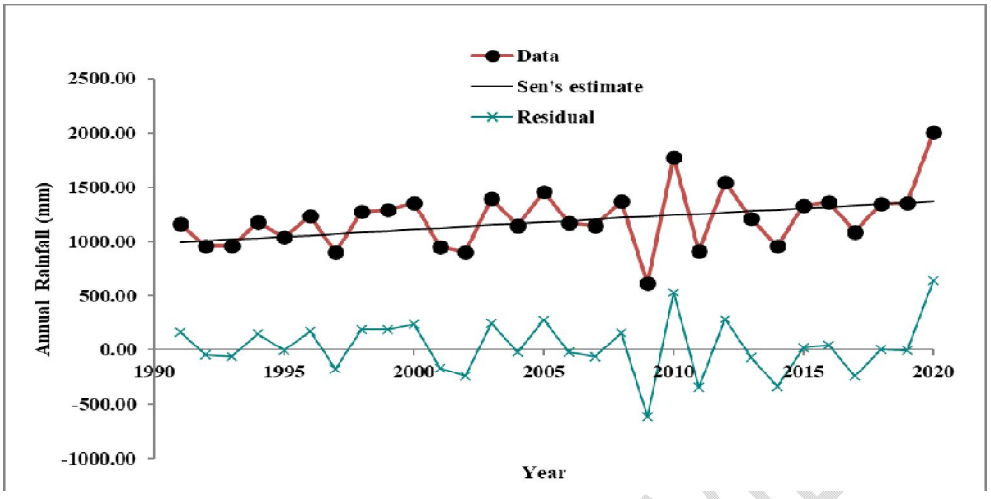

Fig:1 Annual Sen'S Estimate Trend lines for Bhadradri District of Central Telangana

Seasonal rainfall trend:

Bhadradri district receives chief amount of rainfall during the Southwest Monsoon season (June-September) fallowed by Post Monsoon period (October-December) due to the impact of Northeast Monsoon. In the Southwest monsoon period 974.5±240.5 mm with 24.7% variation receives and significantly positive trend was reported with Z value of 2.07 and Sen's slope estimator was +9.227 mm per season. Highest rainfall variability (116.3%) was found in the winter season with negative Z value (-1.559) and decreasing Sen's estimate of -0.397 mm per season was reported. Pre monsoon and post monsoon positive Z value and positive Q values but there is no significance in these seasons. (Table.1&Fig.2)

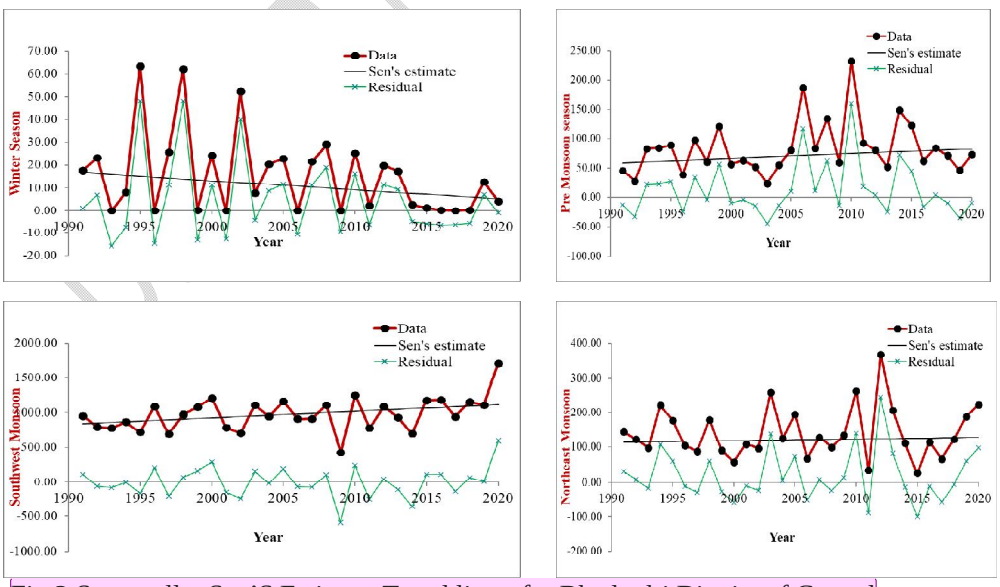

Fig:2 Seasonally Sen'S Estimate Trend lines for Bhadradri District of Central

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Monthly rainfall trend:

Monthly rainfall pattern of past three decades (1991-2020) showed that August month received highest amount of rainfall 315.7±144.4mm fallowed by July month with 291.9±92.0 mm and lowest rainfall received February 6.8±12.9. the rainfall variability was highest during the December (236.2%) fallowed by march (209.4%) and February (190.9%).

Mann Kendall test values for monthly rainfall reported that significant increase in the march month with Z value of 2.030 and non-significant positive values were reported in April-June, August and September months and non-significant negative values were reported in January, February, July, October and November months.

Sen's slope estimator was highest during the month of August +3.988 mm per month fallowed by September and June with +3.178 mm and +2.456 mm respectively. Increasing trend slope was reported from March-May and decreasing trend slope was reported in July, October and November months. Trend line was linear in December, January and February months.

Comment [HUR12]: All the trends shown in the graphs, annual, seasonal and monthly are linear. Perhaps what is meant is that the tendency is to maintain the same levels, without ascending or descending.

Table.1: Monthly, Seasonal, and annual rainfall characteristics and trends for Bhadradri District

Month	**Mean**	**SD**	**CV**	**Test Z**	**Q**
January	8.7	15.8	180.6	-0.933	0.000
February	6.8	12.9	190.9	-0.739	0.000
March	11.0	23.0	209.4	2.030*	0.207
April	24.8	20.3	82.0	0.464	0.223
May	47.6	44.0	92.5	0.607	0.354
June	171.6	111.4	64.9	1.213	2.456
July	291.9	92.0	31.5	-0.143	-0.338
August	315.7	144.4	45.7	1.035	3.988
September	195.3	102.1	52.3	1.463	3.178
October	103.6	55.2	53.3	-0.036	-0.080
November	26.7	45.7	170.8	-0.089	-0.017
December	9.6	22.8	236.2	0.991	0.000
Season	**Mean**	**SD**	**CV**	**Test Z**	**Q**
Winter	15.5	18.0	116.3	-1.559	-0.397
Pre Monsoon	83.3	45.7	54.8	0.999	0.780
SWM	974.5	240.5	24.7	2.070*	9.227
Post Monsoon/ NEM	139.9	74.9	53.5	0.357	0.469
Annual	1213.2	277.1	22.8	2.0*	12.79

Z=Mann Kendall test Q=Sen's Slope (mm/year) *=0.05 level of significance.

CONCLUSION

Rainfall trend analysis study concluded that Significant increase in the annual rainfall and Sothwest Monsoon season rainfall were reported with positive increase in the Sen'S trend for the Bhadradri District of Central Telangana zone.

Comment [HUR13]: It would be necessary to conclude on the three types of analysis carried out, annual, seasonal and monthly.

REFERENCES

Comment [HUR14]: Very few references consulted

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