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Research Article

Statistical analysis of long-term rainfall trends in Cherrapunji, Meghalaya, India

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Abstract
Rainfall is the key climatic variable that governs the regional hydrologic cycle and availability of water resources. Rainfall trend analysis in a localized watershed can improve many aspects of water resource management not only to the catchment itself but also to some of the related other catchments. The trend analysis of monthly rainfall data over Cherrapunji of Meghalaya in India for the period 1872-2007 has been carried out in this work. While the magnitude of the trend in the time series has been determined using Sen's estimator, the significance of the trend in monthly rainfall series has been tested using Mann-Kendall test. During the time span 1872-2007, an increasing trend has been found in the monthly rainfall for the months July, October and November, and a decreasing trend has been found in the monthly rainfall for the months February to June, August and September. On the other hand, it was found that none of Mann-Kendall Z values was significant at 5% level of significance. Therefore, from Mann-Kendall Z test, it can be concluded that there is no trend in any month in monthly rainfall for the station Cherrapunji. For the better assessment of the temporal variation in monthly rainfall trend, whole period was divided into two halves, 1872-1939 and 1940-2007. Then, trend magnitude through Sen's estimator and Mann-Kendall Z for test of significance were determined for these two time periods separately. The analysis of trends of monthly rainfall in these two halves showed large variability in the magnitude and direction of the trend in various months from one half to another. Accurate prediction of trends in monthly rainfall is an important aspect of climate research and we believe that present study could provide a scope to correlate between current rainfall trend and climate change scenario of the study area.

Keywords: Cherrapunji, Mann-Kendall Test, Monthly Rainfall, Sen's Estimator, Trend Analysis

INTRODUCTION

Climate change, particularly that of the temperature and rainfall, is possibly one of the most significant universal environmental challenges being confronted by humanity today, with its significant impact on farming, natural ecosystems, human lives, assets and other weather related calamities. The main characteristics of climate change include rising temperatures, changes in rainfall pattern, melting of glaciers and sea ice, sea level rise and increased intensity and/or frequency of extreme events. Climate change analyses of extreme daily temperature and/or precipitation can be found in the literature. One such study was made by DeGaetano (1996) who did a study of the trend of extreme high and extreme low daily maximum and minimum temperatures over 22 stations in the northeastern United States. Caprio *et al.* (2009) used the iterative chi-square method in climate change analyses to include percent change in extreme daily weather events. For the details on the statistical procedure dealing with climate change, we refer to Hennemuth *et al*. (2013). Climate model analysis indicates that an increase in global surface temperature, as a consequence of the increase in greenhouse gases, with global warming can lead to an increase in the magnitude and incidence of extreme rainfall events (Trenberth *et al*., 2003, Letcher and Chazdon (2009)). Extreme precipitation events (heavy rainstorm, cloud burst) may have their own impacts in tropical areas which are reliant on farming and vulnerable to natural threats such as floods and droughts. Thus, in recent times in India, numerous authors have studied the pattern of extreme precipitation series for periods of different sizes, using data from several rain-gauge networks and a variety of approaches (Roy and Balling (2004), Goswami *et al*., 2006, Rajeevan *et al*., 2008, Guhathakurta *et al*., 2011). Earlier study over India (Roy and Balling (2004)) showed that most of the time series exhibited increasing trends in indices of precipitation extremes and that there were coherent regions with increases and decreases. Recent studies by Goswami *et al*. (2006), Rajeevan *et al.* (2008) and Guhathakurta *et al.* (2011) found that extreme rain events exhibited an increasing trend in the frequency and magnitude during monsoon season. For a more recent analysis of rainfall trends on a global scale, we refer to Caloiero (2017), Nyaupane (2018), Myhre *et al*. (2019), Papalexiou and Montanari (2019), Alashan (2020) and references therein.

A large number of studies relating to changing pattern of rainfall have been conducted for the Indian subcontinent (Mooley and Parthasarthy (1984), Thapliyal and Kulshrestha (1991), Lal (2001)). However altogether Indian yearly and monsoon precipitation during the past 100 years showed no significant trend, significant long-term rainfall variations were acknowledged at different spatial temporal scales in few studies (Dash *et al*., 2007, Dash and Hunt (2007), Kumar *et al*., 2010). Studies of precipitation data during the period 1871-2002 showed a declining trend in monsoon rainfall and increasing trend in the pre-monsoon and post-monsoon periods (Dash *et al*., 2007). During recent decades (1979-2006), the monsoon precipitation in Indian continent was declined by 4.5% compared to the period 1949-1978 (Ranade *et al*., 2008). Dash *et al*. (2009) concluded that short and dry spells were increasing while the long spells were decreasing as a whole. Several studies on Indian rainfall trend was carried out recently, and we refer to Bisht *et al*. (2018), Malik *et al*. (2019), Machiwal *et al*. (2019), Mallick *et al*. (2020), Panda and Sahu (2020).

The northeast region (NER) of India covers an area of 0.26 million km^2. This land is one of the maximum rainfall-receiving provinces on the planet. Trends in monthly, seasonal, and annual rainfall and temperature on the subdivision and local scale for the NER were observed in Jain *et al*. (2013). Trend analysis of precipitation data series for the period 1871–2008 did not indicate any clear trend for the NER as a whole, though there are seasonal trends for some seasons over a few hydrometeorological stations. For the extreme rainfall occurrences in NER (Mahanta *et al*., 2013). Cherrapunji region on the Meghalaya plateau of northeastern India is considered to be one of the world's wettest place. The Meghalaya plateau is situated in the northeastern part of India and consists of high hills. The highest peak of the area is around 1,965 m above sea level. The average annual precipitation over the northeastern part of India, located at 80^{o}E and 21^{o}N, varies between 2,000 to 4,000 mm, with a maximum of 11,000 mm in Cherrapunji of Meghalaya, India. This amount of rainfall places it behind only nearby Mawsynram, Meghalaya, whose average is 11,873 mm and Mount Waialeale (USA) located on the Hawaiian island of Kauai, whose average is 11,684 mm. Most of Cherrapunji's shower is the consequence of air being lifted as a large body of water vapour. Extremely large amounts of precipitation at Cherrapunji are conceivably the most well-known feature of orographic rain in the NER. As Cherrapunji is situated on the southern slope of the Meghalaya plateau, most of the rain flows directly down into Bangladesh. The amount of precipitation in the catchment area upstream of rivers is significant for the prediction of severe floods in Bangladesh. Murata *et al*. (2007) investigated the direct effect of the rainfall over Cherrapunji and the water level in adjoining rivers in Bangladesh. Monthly rainfall data from January 2003 to December 2003 were analyzed and concluded that water level in Bangladeshi rivers was significantly related to rainfall over Cherrapunji. Variation in the extreme rain events over the Meghalaya hills in the two halves of the twentieth century was studied by Prokop *et al*. (2015). A close-to-significant increase in the occurrence of extreme rainfall in Cherrapunji probably reveals a rise in the trend of cyclone incidence over the North Indian Ocean, including the Bay of Bengal, during the past few decades. For these reasons, it is imperative to understand the trends in precipitation over the Meghalaya state. However, the long-term rainfall trend in Meghalaya are not well explored. More recently, Marak *et al*. (2020) took up two important watersheds Umiam and Umtru in Meghalaya, and studied the spatial and temporal rainfall variations. The importance of trend analysis of rainfall over NER region can be found from the recent studies of Laskar *et al*. (2014), Das *et al*. (2015), Gharphalia *et al*. (2018), Yadav *et al*. (2016), Pradhan *et al*. (2019), Datta and Bose (2020). Although reasonable numbers of statistical analysis on seasonal rainfall data over different watersheds of Meghalaya districts have been proposed and studied in the literature, surprisingly, there has been considerably less work on the trend analysis of monthly rainfall data over Cherrapunji. In this study, the variation of monthly rainfall over Cherrapunji for the period of 1872 to 2007 was analyzed using Sen's estimator and Mann-Kendall method.

MATERIALS AND METHODS

Data

Series of monthly rainfall data over Cherrapunji (Fig 1) for the period of 1872 to 2007 was considered for this study. Monthly rainfall data (1872–2007) for the station Cherrapunjiare was obtained from the Regional Meteorological Centre, Guwahati. Compared to the number of total records, the number of missing data is much low. In literature, missing rainfall data are filled from the data of the nearest high correlating neighbouring stations. But in practice, it is very difficult to find a reference station with a high correlating and a homogeneous structure. In this study, missing data are filled using the fourth order accurate interpolation scheme from

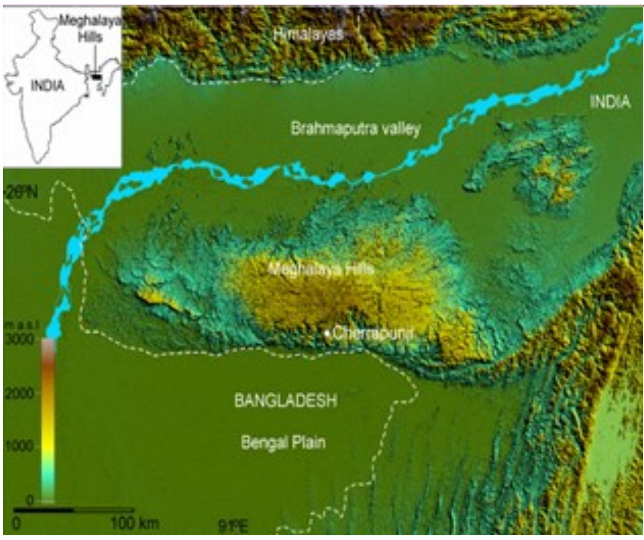

Fig. 1. *Location map of the station Cherranjunji,Meghalaya Hills, India (Source: Prokop and Walanus (2015).*

data of the nearest available data set. We suppose that data correction would have no significant influence on our analysis and conclusion.

Methodology

In this study, the magnitude of trend in a time series was determined using a nonparametric method known as Sen's estimator (Sen (1968)) and statistical significance of trend in the time series was analyzed using a non-parametric test known as Mann-Kendal (MK) test (Mann (1945), Kendall (1975)). Non-parametric tests are preferred over parametric tests because the problems aroused due to data skew can be evaded by non-parametric ones.

Sen's Estimator

Sen's method assumes a linear trend in the time series and has been widely used for determining the magnitude of the trend in hydro-meteorological time series (Lettenmaier *et al*. (1994), Yue and Hashino (2003), Partal and Kahya (2006)). In this method, the slopes (T_i) of all data pairs are first calculated by

$$T_i = \frac{x_j - x_k}{j-k} \quad for\ i = 1, 2, ...N$$

(1)

Where x_j and x_k are data values at time *j* and *k* (*j*>*k*), respectively. The median of this N of $T_i$is Sen's estimator of the slope, which is calculated as follows

$$\beta = \begin{cases} (x_1, x_2, \ldots x_n)\ T_{\frac{N+1}{2}} & N \text{ is odd} \\ \frac{1}{2}(T_{\frac{N}{2}} + T_{\frac{N}{2}+1}), & N\ is\ even \end{cases} \quad (2)$$

A positive value of β indicates an upward (increasing) trend and a negative value of β indicates a downward (decreasing) trend in the time series.

Mann-Kendall test

Mann-Kendall test is the most commonly used test for trend analysis of any hydro-climatic series for checking spatial variation and temporal deviation. This formula was derived by both Mann and Kendall. Mann formulated it as a non-parametric test to detect trend whereas Kendall gave the test statistic distribution to test non-linear trend and turning point. Mann described a non-parametric test for randomness against trend. The test is a particular application of Kendall's test for correlation commonly known as Kendall's Tau. According to Mann, the null hypothesis of randomness H_0 states that the data are a sample of n independent and identically distributed random variables. The alternative hypothesis $H_1$of a two-sided test is that the distribution of x_k and x_j are not identical for all *k, j* ≤ *n* with *k* ≠ *j*. The test statistic S is defined as

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k) \quad (3)$$

where

$$\operatorname{sgn}(\theta) = \begin{cases} 1, if\ \theta > 0 \\ 0, if\ \theta = 0 \\ -1, if\ \theta < 0 \end{cases}$$

Mann shows that the distribution of S is symmetrical and is normal in the limit as n→ ∞. Kendall gives the mean and variance of S under H_0 given the possibility that there are ties in the values of x

E(S) = 0,

$$Var(S) = [n(n-1)(2n+5) - \sum_t t_i(i)(i-1)(2i+5)]/18 \quad (4)$$

where t_i is the extent of any given tie (number of x's involved in a given tie) and $\sum_t$ denotes the summation over all ties. For example (see, Hirsch *et al*. (1982)), if there were four ties of two and one tie of three, then

$$\sum_t t_i(i)(i-1)(2i+5)$$

=4(2×1×9)+1(3×2×11)=4×18+1×66=138 (5)

Mann and Kendall derived the exact distribution of S for n≤10 and shows that even for n=10 the normal approximation is excellent, provided one uses a continuity correlation of one unit. That is, one computes the standard normal variate Z by

$$Z = \begin{cases} (S-1)/\sqrt{Var(S)}, & if\ S > 0 \\ 0, & if\ S = 0 \\ (S+1)/\sqrt{Var(S)}, & if\ S < 0 \end{cases}$$

Thus, in a two-sided test for trend, H_0 should be accepted if $|Z| \leq Z^{\alpha/2}$. A positive value of S indicates an 'upward trend' (increasing values with time) and a negative value of S indicates 'downward trend'.

If the time series data of interest are monthly rainfall data, then the null hypothesis Ho given above may be too restrictive. Examination of monthly rainfall time series suggests very strongly the presence of seasonality. Hirsch *et al*. (1982) proposed a test, the 'Seasonal Kendall test' for trend which is insensitive to the existence of seasonality. The null hypothesis $H_o^{'}$ for this is a relaxed form of H_o(which any seasonal but otherwise trend process will not violate). Let X= $(X_1, X_2,......X_{12})$ and $X_i = (x_{i1}, x_{i2}, ...x_{in_i})$. That is, X is the entire sample, made up of subsamples X_1 through X_{12} (one of each month) and each subsample X_i contains the n_i annual values from month i. It is to be that there is no restriction that $n_i = n_l, i \neq l$ or that there be a value for every and month combination in the sampling period. However, there may be no more than one each year and month.

The null hypothesis $H_o^{'}$ for seasonal Kendall test is that X is a sample of independent random variables (x_{ij}) and that X_i is a subsample of independent and identically distributed random variables i = 1, 2, · · ·, 12. We define the statistic S_i

$$S_i = \sum_{k=1}^{n_i - 1} \sum_{j=k+1}^{n_i} \text{sgn}(x_{ij} - x_{ik}) \quad (6)$$

Now, under $H_o^{'}$ the subsample X_i satisfies the null hypothesis H_o of Mann's test. Therefore, relying on Mann and Kendall we have

$$E(S_i) = 0 \text{ ,} \quad (7)$$

$$Var(S_i) = \frac{n_i(n_i - 1)(2n_i + 5) - \sum_{t_i} t_i(i)(i-1)(2i+5)}{18} \quad (8)$$

Distribution of S_i is normal in the limit as $n_i \rightarrow \infty$ (t_i is the extent of a given tie in the month *i*).

Following Hirsch *et al*. (1982), we define

$$S' = \sum_{i=1}^{12} S_i$$

and can derive its expectation, variance, and limit distribution.

$$E(S') = \sum_{i=1}^{12} E(S_i) = 0 \quad (9)$$

$$Var(S') = \sum_{i=1}^{12} Var(S_i) + \sum_{i=1}^{12}\sum_{l=1}^{12} Cov(S_i S_l) \quad (10)$$

Here S_i and S_l $(i \neq l)$ are functions of X_i and X_l respectively, X_i are the data from the i^{th} month and X_l are the data from the l^{th} month and $X_i \cap X_l = \phi$. Thus S_i and S_l are also independent and hence $Cov(S_i S_l) = 0$. Further S′ must be normal in the limit as $n_i \rightarrow \infty$, i=1,2,....12 being the sum of 12 distributions which are normal in the limit.

The exact distribution of S′ is arrived at by enumerating all possible permutations and combinations of S_i for the 12 months, summing the's, multiplying the independent probabilities, and adding the probabilities of all of the S_i sequences that sum to each particular value of S′. On the basis of visual inspection, Hirsch *et al*. (1982) have shown that even for records as short as 3 years the normal approximation works quite well for estimating $p = \Pr ob[|S'| \geq s]$ and hence we assume that normal approximation will be a close agreement to detect the trend of long term monthly rainfall series. For the normal approximation, the standard normal variate Z′ is defined as

$$Z' = \begin{cases} (S'-1)\big/\sqrt{Var(S')} \text{ , } if \;\; S' > 0 \\ 0 \qquad\qquad\qquad \text{ , } if \;\; S' = 0 \\ (S'+1)\big/\sqrt{Var(S')} \text{ , } if \;\; S' < 0 \end{cases}$$

The conclusions are made accordingly.

RESULTS AND DISCUSSION

This section deals with results obtained from different statistical tools applied to analyze the monthly rainfall data for Cherrapunji region. The magnitude of the trend in the time series has been determined using Sen's estimator. The statistical significance of the trend in monthly series has been tested using the non-parametric Mann-Kendall (MK) test. Firstly, we analyze long-term (1872–2007) monthly rainfall trends. Then the monthly rainfall series for the time span 1872–2007 has been split into two equal halves, 1872-1939 and 1940–2007, in order to search for temporal variability. Further, to determine monotonic trend, modified Mann-Kendall test, popularly known as seasonal Kendall test has been applied for all the three series separately.

In the first phase of this work, we calculated the month wise mean, standard deviation and coefficient of variation of the monthly rainfall data of Cherrapunji for three series of data. One series contains all monthly rainfall data during the period 1872-2007 and then the other two series are obtained by dividing these data into two equal halves, 1872-1939 and 1940- 2007, as presented in Table 1. From the mean rainfall analysis, it was observed that Cherrapunji received maximum rainfall during the months from May to September. The variability in monthly rainfall data was high during the period 1940 -2007 as compared to the period 1872-1939 for all months except January, September, November and December.

In the next phase of the analysis, the magnitude of the trend in the monthly rainfall is determined using Sen's estimator and the statistical significance of the trend in monthly rainfall are analyzed using the value of Z under the Mann-Kendall test. The values of Z and Sen's estimator β for different months during the period 1872-2007 are presented in Table 2. On observing the values of the Sen's estimator β during the period 1872-2007, there was an increasing trend in the monthly rainfall for the months July, October and November, and a decreasing trend in the monthly rainfall for the months February, March, April, May, June, August and September. The values of β for the months January and December were found to be zero which showed that there was no trend, increasing or decreasing, in these months. For the test of significance, the null hypothesis, as discussed in Section 2.2, is rejected at 5% level of significance if the calculated |Z|>1.96. But, it was found that none of Mann-Kendall Z values was significant at 5% level of significance. Therefore, from Mann-Kendall Z test it can be concluded that there was no trend in any month in monthly rainfall data for the station Cherrapunji. The values of Z for the period 1872 -2007 are also shown in Fig.2, for the period 1872 to 1939 in Fig.3 and for the period 1940 to 2007 in Fig. 4 for better illustration.

In order to search for temporal variability, monthly rainfall data for the time span 1872-2007 were split into two halves, 1872-1939 and 1940-2007. Trend magnitude through Sen's estimator and Mann-Kendall Z for test of significance were determined for these two time periods separately. The results are presented in Table 2. As expected, the analysis of trends of monthly rainfall in these two halves showed large variability in the magnitude and direction of the trend in various months from one half to another. The values of Sen's estimator, for the months' May, June and October, depicted the decreasing trend during 1872-1939 and increasing trend during 1940-2007. On the other hand, for the months' March, April and July, an increasing trend during 1872-1939 and decreasing trend during 1940-2007 was observed. Almost no trend in both halves was found for the months November to February, August and September. However, none of the values of Mann-Kendall Z was found to be significant in both periods.

Finally, to observe the monotonic trend in monthly rainfall data of Cherrapunji, we have applied the seasonal Kendall test, which eliminates the effect of seasonality, proposed by Hirch *et al*. (1982). The values of seasonal Kendall statistic Z' for the three series are presented in the last row of Table 2. From the values of Z', which was indifferent to the presence of seasonality, it was observed that there was no monotonic trend, increasing or decreasing, in the monthly rainfall data of Cherrapunjii.

Table 1. Mean and variation in Monthly rainfall data of Cherrapunji.

Period (Year)		Jan.	Feb.	Mar.	Apr.
	Mean	19.428919	48.495343	224.88637	725.99191
1872-2007	S.D.	28.904972	63.944352	227.0898	437.87666
	Coeff . of Var.	149	132	101	60
	Mean	19.788235	50.116176	227.63824	782.64412
1872-1939	S.D.	31.361163	44.87149	217.69309	443.89561
	Coeff . of Var.	158	90	96	57
	Mean	19.069603	46.87451	222.09343	669.33971
1940-2007	S.D.	26.451471	78.867009	237.86181	427.52264
	Coeff . of Var.	139	168	107	64
Period (Year)		**May**	**Jun.**	**Jul.**	**Aug.**
1872-2007	Mean	1269.225	2683.6676	2526.0654	1842.9868
	S.D.	761.04314	1132.1911	1105.5462	839.83605
	Coeff . of Var.	60	42	44	46
1872-1939	Mean	1240.0397	2645.8235	2441.5588	1871.025
	S.D.	683.62802	962.99896	846.34735	690.80693
	Coeff . of Var.	55	36	35	37
1940-2007	Mean	1298.4103	2721.5118	2610.5721	1814.9485
	S.D.	835.42902	1285.5238	1316.0194	970.75561
	Coeff . of Var.	64	47	50	53
Period (Year)		**Sep.**	**Oct.**	**Nov.**	**Dec.**
1872-2007	Mean	1115.1662	458.36397	58.038971	12.66912
	S.D.	645.07281	427.69758	98.04353	31.96718
	Coeff . of Var.	58	93	169	252
1872-1939	Mean	1165.7662	432.68382	52.405882	10.28971
	S.D.	694.2693	379.07726	97.415949	32.03413
	Coeff . of Var.	60	88	186	311
1940-2007	Mean	1064.5662	484.04412	63.672059	15.04853
	S.D.	592.65637	472.80279	99.06695	31.95897
	Coeff . of Var.	56	98	156	212

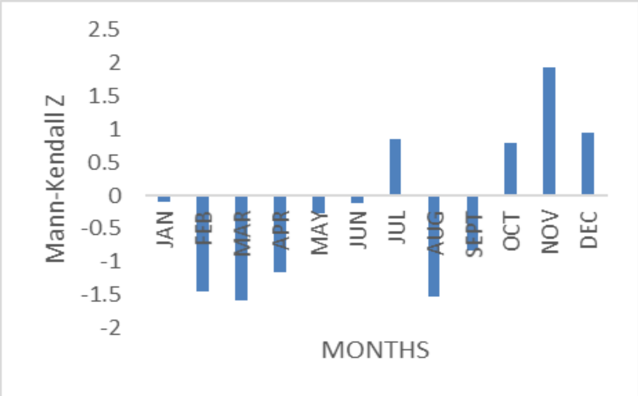

Fig. 2. *Mann-Kendall Z for Monthly Rainfall Data of Cherrapunji for the Period 1872-2007.*

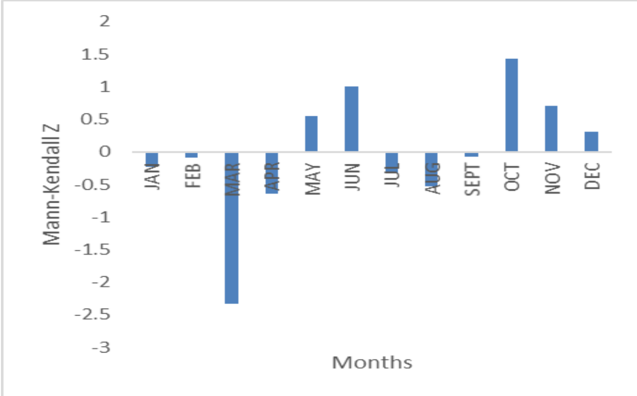

Fig. 3. *Mann-Kendall Z for Monthly Rainfall Data of Cherrapunji for the Period 1872-1939.*

Most tropical regions in the world are vulnerable to climate variability, given their dependence on rain-fed agricultural production and limited adaptive capacity owing to socio-economic conditions. In contrast to floods, all climatic zones irrespective of rainfall patterns can experience drought characterized by the reduction in the amount of precipitation received over an extended period of time which can range from a season, a year, to even a decade (Bond *et al*. 2008). The global increase in trends of floods and droughts have been linked to the changes in precipitation trends (Nyaupane *et al*. (2018), Papalexiou and Montanari (2019)). For these reasons, it is imperative to understand and identify the trends in precipitation for proper management and decision-making with regard to the efficient use of water resources. Despite the developments in studies concerning the climatology in other parts of the world, studies on a local scale are still very limited in the North East Region (NER) of India. For these reasons, it is imperative to understand and identify the trends in precipitation for proper management and decision-making with regard to the efficient use of water resources.

Meghalaya is known to receive the most torrential rainfall in the world. Limitations are found in the available literature while analyzing trend analysis of rainfall over Meghalaya. However, here we briefly compare the findings of the article with those of available literature on rainfall analysis over the state Meghalaya. Choudhury *et al*. (2012) analyzed the rainfall data of a watershed Umiam in Meghalaya for the period 1983–2010. In their study, it was reported decreasing trend in monsoon rainfall, while non-significant increase in pre-monsoon and post-monsoon rainfall. Similar results were obtained in the study of Marak *et al*. (2020). Seasonal and annual rainfall variation in two important watersheds Umiam and Umtru in Meghalaya was analyzed using Innovative Trend Analysis (ITA) by Marak *et al*. (2020). Test results of Marak *et al*. (2020) for the gridded rainfall data from 1901 to 2018 showed that annual, winter, pre-monsoon, and monsoon rainfall is decreasing, whereas the post-monsoon rainfall is increasing. The decreasing trend in monsoon rainfall was also testified by Jain *et al*. (2013) for Assam and Meghalaya areas in their analysis for 1871-2008 period. These observa-

Table 2. Mann-Kendall Z and Sen's estimator of slope (mm/year) for monthly rainfall data of Cherrapunji.

Period Months	1872-2007		1872-2007		1940-2007	
	Mann-Kendall Z	**Sen's Estimator**	**Mann-Kendall Z**	**Sen's Estimator**	**Mann-Kendall Z**	**Sen's Estimator**
JAN	-0.0953	0	-0.2269	0	-0.4703	-0.0120
FEB	-1.4494	-0.0900	-0.089	-0.0197	-0.19	0
MAR	-1.595	-0.6069	-2.3362	-2.5000	0.2043	0.2355
APR	-1.1671	-1.0220	-0.6363	-1.6810	1.1069	2.4003
MAY	-0.2643	-4.479	0.5562	2.3571	-1.715	-9.6009
JUN	-0.1241	-0.2645	1.0057	6.1389	-1.3492	-9.8999
JUL	0.8614	1.9445	-0.3159	-1.6333	1.2875	9.1387
AUG	-1.5357	-2.6897	-0.5295	-2.2730	-1.0024	-4.8386
SEPT	-0.8362	-0.9672	-0.0801	-0.2452	-1.2162	-4.6116
OCT	0.7984	0.5388	1.4329	2.3808	-0.2993	-0.6667
NOV	1.9403	.0339	0.712	0	0.6604	0.0488
DEC	0.9567	0	0.3026	0	1.4632	0
Seasonal Kendall Z'	-0.7262		-0.0604		-0.4402	

tions were consistent with our findings for monthly rainfall data. The results of Marak *et al*. (2020) were also consistent with the findings in the study of Prokop and Walanus (2015).

Conclusion

In the present study, high variation in monthly rainfall data was observed during the period 1940-2007 for all months except January, September, November and December. For the study period 1872-2007, there was an increasing trend in the monthly rainfall for the months July, October and November, and a decreasing trend in the monthly rainfall for the months February, March, April, May, June, August and September. The monthly rainfall trend analysis for the two halves (1872-1939 and 1940-2007) showed large variability in the magnitude and direction of trend in various months from one half to another. On the other hand, Mann-Kendall Z values were found to be insignificant at 5% level of significance, which suggest that there was no trend in any month in monthly rainfall data for the station Cherrapunji. Finally applying the seasonal Kendall test, eradicating the influence of seasonality, it was observed that there was no monotonic trend in the monthly rainfall data of Cherrapunjii. Any crop-producing potentiality of an area depends primarily on the prevailing climate and soil conditions. A fore-knowledge of rainfall pattern is of immense help not only to farmers but also to the authorities concerned with planning and management of water resources projects. The rainfall trend known for a particular station would help to predict the return value of rainfall event at a specific time in the future.

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Conflict of interest

The author declares that their is no conflict of interest.

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