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Short Communication

Trend analysis of rainfall (1984-2023) of Tlawng River basin of Mizoram, India using Man-Kendall test

IMANUEL LAWMCHULLOVA*, LAL RINKIMI and CH. UDAYA BHASKARA RAO

Department of Geography and Resource Management, Mizoram University, Aizawl 796004, India
Corresponding author: lawmchullova@gmail.com

One of the most serious topics of debate in recent years is the climate change and its impact from global level to regional and local level. The precipitation distribution pattern in north-east India during the summer monsoon mainly depends on the Indian Ocean Dipole (IOD) and El Niño-Southern Oscillation (ENSO) (Rajeevan *et al.,* 2022). However, monthly and annual rainfall distribution is highly dependent on the air circulation and regional geography (Lawmchullova *et al.,* 2024a). The amount of rainfall distribution in India also varying from state to state. Rajasthan in western part of India receives below annual rainfall of 100 mm, while Meghalaya from northeast India receives rainfall of above 4000 mm, which signifies the large variation of rainfall distribution pattern in India. In the same manner, rainfall distribution in Mizoram also significantly varies from south to north. The detailed analysis of characteristics of rainfall intensity and concentration over the monthly and seasonal distribution patterns is crucial prior to understanding surface water resources worldwide for its effective management.

To analyze climate change, hydro-meteorological time series data is essential for determining trends in rainfall, such as decreasing or increasing and trendless behavior. Several studies were performed to detect time series rainfall trends using parametric (i.e., linear regression), non-parametric (Mann-Kendal) and Innovative Trend Analysis (ITA) (Al-Lami *et al.,* 2024; Ray *et al.,* 2024) methods. However, MK test is a frequently employed to determine trends and changes in time-series data. Additionally, the Mann-Kendall test is particularly useful for trend analysis in hydro-meteorological variables as it can handle outliers and missing data effectively (Das *et al.,* 2019). Furthermore, its higher confidence level compared to linear regression (Kumar *et al.,* 2010) makes it a preferred choice for trend identification in time series data.

The present study was undertaken for the Tlawng River basin which is the longest river and biggest watershed in Mizoram. Geographically, it is located in between of 22º 49'58"- 24º 07'18" North latitudes and 92º 32'10"- 92º 50'23" east longitudes (Fig. 1). Historical long-term time series rainfall data (1984 – 2023) was acquired from POWER NASA (https://power.larc.nasa.gov/data-access-viewer/) (Lawmchullova *et al.,* 2024b). The daily precipitation collected data was analyzed by microsoft excel. The rainfall data was categorized into monthly, seasonal and annual, which are performed at R-studio programming using non-parametric Mann-Kendall (MK) (Mann, 1945; Kendall, 1975) and Sen's estimator (Sen, 1968). The present study followed Mizoram seasonal classification such as summer season (March – May), monsoon (June – October) and winter (November – February) (Lawmchullova and Rao, 2024).

The study reveals that the annual rainfall received in Tlawng river basin is about 1741.6 mm at each station in the previous 40 years. The descriptive statistics of mean monthly, seasonal and annual precipitation along with MK and Sen's slope tests are presented in Table 1. The MK test revealed that the increasing trend on annual basis from the years 1984 to 2023 it has a Z value of 5.7 with a slope of 26.9 mm. However, the p-value ($P > 0.05$) lower than 95% significance level, it denotes that increasing with not significant rising trend. While, monsoon and summer season depicting rising trends, however the $P > 0.05$ indicate not statistically significant upward trend, while upward trend showing in winter season with $P < 0.05$ indicates statistically significant. Monsoon, summer and winter seasons the percentage contribution of 63.5%, 32.5% and 3.9% of annual rainfall, respectively. Precipitation is highly concentrated during the six months, from May to October, contributing about 87% of annual precipitation and starting to decline after the retreating monsoon (which usually occurs in October). For months wise, July has significant rising trend ($P < 0.05$), while February has negative trend but the $P > 0.05$ depicts declining insignificantly, the remaining months are showing increasing but the $P > 0.05$ signifies statistically insignificant.

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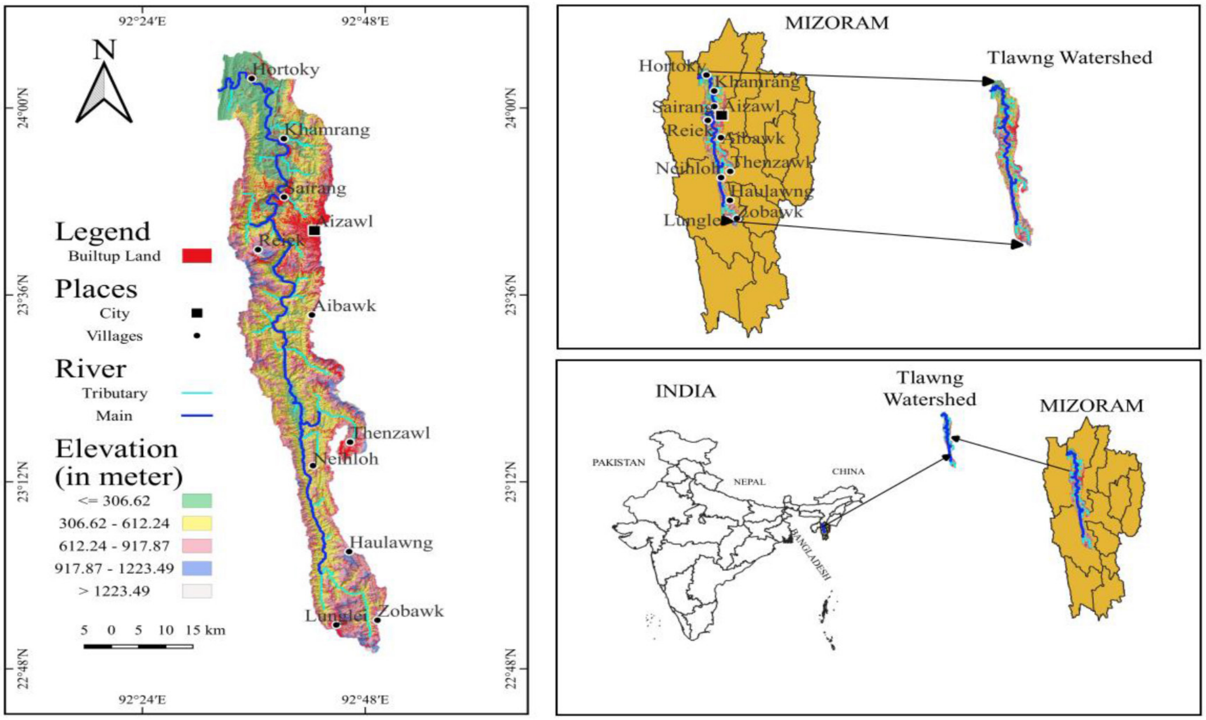

Fig. 1: Geographical location of Tlawng river basin

Table 1: Mann-Kendall trend and Sen's slope statistics of mean monthly, seasonal and annual rainfall

Months	Mean	Min	Max	SD	CV	Z	Tau	Q
January	6.3	0.0	67.1	11.8	186.5	0.1	1.2	0.0
February	16.4	0.0	60.3	16.3	99.2	0.0	0.0	-8.8
March	43.9	0.3	201.8	38.5	87.6	1.3	0.1	0.5
April	118.0	10.5	516.1	92.1	78.0	1.1	0.1	0.9
May	233.0	74.2	538.7	117.5	50.4	3.9	0.4	5.7
June	315.6	128.8	890.6	165.5	52.4	5.0	0.6	7.6
July	339.1	132.0	1162.3	212.6	62.7	2.79*	0.3	5.0
August	284.4	119.1	860.1	145.5	51.2	4.6	0.5	6.7
September	211.1	69.9	525.9	100.2	47.5	4.3	0.5	5.5
October	133.2	28.3	366.9	85.3	64.0	4.1	0.5	4.0
November	27.6	0.0	169.7	35.0	126.9	0.1	1.5	0.0
December	13.1	0.0	98.2	21.2	162.5	0.9	0.1	0.1
Winter season	15.8	1.4	54.1	11.4	72.2	1.40*	0.2	0.2
Summer season	131.6	59.8	348.4	58.6	44.5	4.1	0.5	2.7
Monsoon	256.7	130.8	695.9	113.7	44.3	5.5	0.6	5.9
Annual	1741.6	958.1	4645.7	739.1	42.4	5.7	0.6	26.9

*Statistically significant trends at the 95% significant level

The month wise spatial distribution pattern of rainfall at Tlawng watershed is illustrated in Fig. 2. The study reveals that the summer season (March – April) indicates higher the magnitude of slope ranges 0.2 mm yr^{-1} – 5.8 mm yr^{-1} in the northern part of the watershed. The analysis of time series rainfall data at Tlawng river basin reveals that the differentiation of rainfall pattern from station to station which indicates monsoonal regimes is controlled by geographical factors like, hill range, latitudinal, terrain characteristics and variation of temperature of the region. On the other hands, in winter season (November – February) and monsoon season (June – October) specified the increasing rate of rainfall is higher in the southern than northern part of watershed with a magnitude of slope 0.01 mm yr^{-1} – 0.1 mm yr^{-1} and 3.3 mm yr^{-1} – 9.8 mm yr^{-1}.

The increasing trend of rainfall in summer season and winter season in Tlawng river basin is directly influenced by the occurrences of cyclonic turbulences with the thunderstorms and tropical storms arising from the Bay of Bengal. Similarly, the study performed in Bangladesh found out that the increasing rainfall pattern on summer and winter season due to thunderstorms, cyclonic

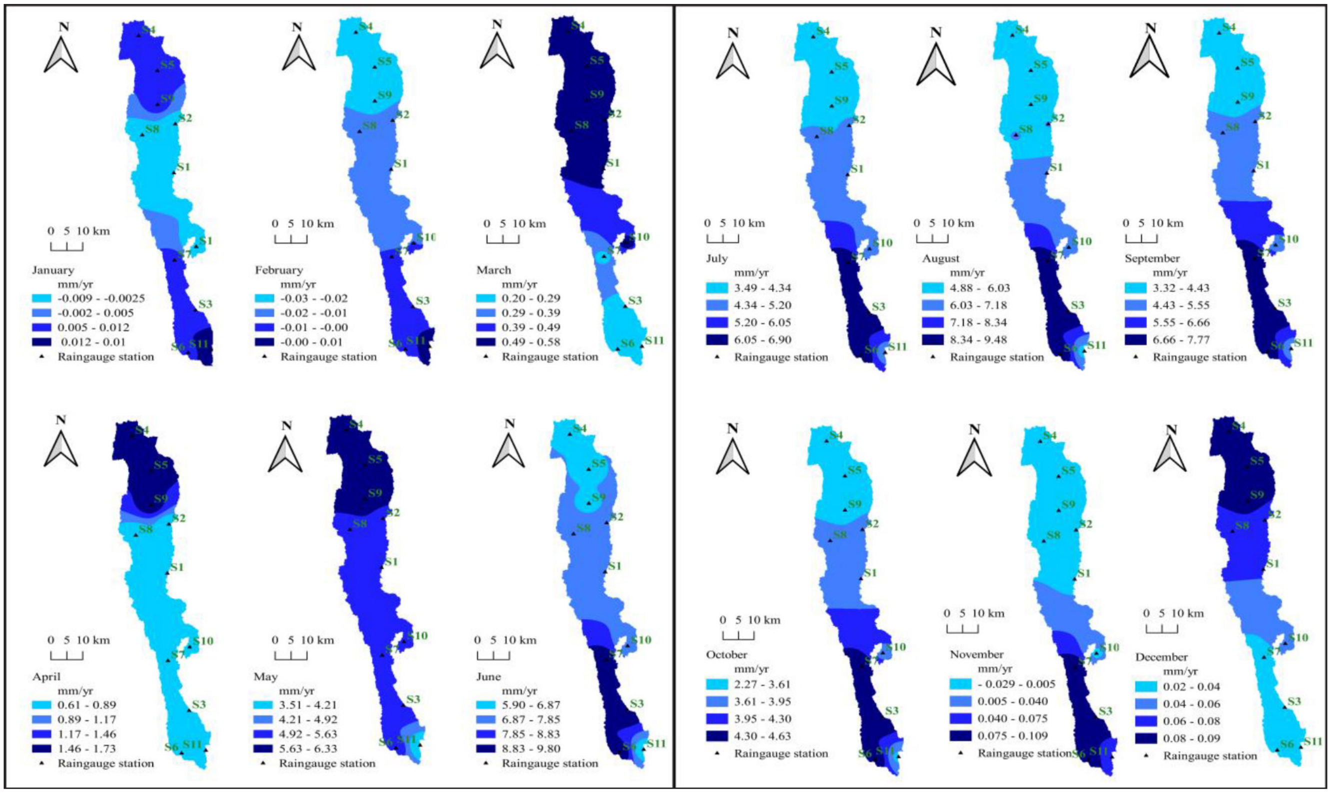

Fig. 2: Monthly rainfall magnitude of slope (Q) in Tlawng watershed

disturbances and sea surface temperature (SST). However, the gradual increase in sea surface temperature (SST) because of global warming is expected to be one of the reasons for such significant increasing trend of rainfall in these parts. Mizoram cropping system is greatly reliant on monsoonal rains, cropping on summer and winter seasons are difficult due to hilly and rugged terrain control with lack of irrigation system. However, this study reveals that the increasing rainfall trend in winter season likely to give longer duration of cultivation in this watershed. The study suggests that to stabilize water level in Tlawng river during the winter and pre-monsoon seasons bythe construction of check dams at tributaries of the river. Similarly, the watershed management authority and government intervention are highly required for immediate action to minimize the soil loss with further consequences of extreme rainfall during the monsoon season.

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***Data availability*:** All the datasets used in this research is available at https://power.larc.nasa.gov/data-access-viewer/

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***Authors certificate*:** The author's certificate of originality duly signed by all authors is submitted with the manuscript.

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