PRECIPITATION TREND ANALYSIS USING THE MANN–KENDALL TEST IN THE UPPER KABUL RIVER BASIN, AFGHANISTAN

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1. INTRODUCTION

Precipitation (PPT) is an important factor affecting the natural resources of Afghanistan [1,2]. More than 80% of the country's surface and groundwater originates from the precipitation in the Hindukush Mountains [3]. In this study, we analyzed monthly, seasonal, and annual precipitation variations.

Inadequate spatiotemporal data coverage resulted in poor documentation of the precipitation variation in Afghanistan [1]. Most precipitation occurs as snow during winter; 75% of the country receives less than 400 mm of precipitation. However, regions that are above an altitude of 1000 m in the mountains receive a higher amount of precipitation [4]. Aliyar (2022) reported that the annual precipitation in the north and west is reduced; however, it increased in the other parts of Afghanistan [1].

This study aimed to assess the precipitation trend in the Upper Kabul River Basin (UKRB) in Afghanistan. In this study, the monthly, seasonal, and annual fluctuations in precipitation trends were evaluated. The Mann–Kendall test, which is mainly used for climatic studies, was used in this study.

2. STUDY AREA AND METHODOLOGY

The UKRB is located in the central part of Afghanistan; owing to the presence of the Himalayan Mountain ranges, it experiences highly variable precipitation [1,5]. According to Aliyar (2022), during the period 1979–2019, the mean annual rainfall was increased in six provinces in the central region, except for the Panjshir Province where it was decreased by -1.44 mm/year.

The data was obtained from the Ministry of Energy and Water of Afghanistan. It was recorded daily at weather stations (Stn) installed in the study area.

The Mann–Kendall test, a nonparametric test used for climatologic time-series data trend detection, was used in this study [5]. The *S* statistic for the Mann–Kendall test was calculated using Equation (1), where *n* represents the number of data points and x_j are the data values in the time series *i* and *j* ($j < i$), respectively. The variance was calculated using Equation (2), where *n* is the number of data points, *m* is the number of tied groups, and t_i denotes the number of ties of extent (Gocic et al., 2012). The test statistic Z_s was computed using Equation (3).

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn\left(x_j - x_i\right) \quad (1)$$

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i-1)(2t_i+5)}{18} \quad (2)$$

$$Zs = \left(\frac{S-1}{\sqrt{Var(S)}}, if\ S > 0\right) \ (0\ if\ S = 0) \ \left(\frac{S+1}{\sqrt{Var(S)}}\ if\ S < 0\right) \quad (3)$$

The positive and negative values of Z_s show increasing and decreasing trends, respectively; the trends were tested at a specific significance level. If $Z_s > Z_1 - \alpha/2$, the null hypothesis H_0 is rejected; therefore, at a 10% significance level, the "no trend" hypothesis is rejected if $Z_s > 1.64$ [5].

3. RESULTS

Trend analysis was conducted for monthly, seasonal, and annual precipitation data. The results showed significant negative trends for the monthly precipitation at stations Stn.2, Stn.3, Stn.4, Stn.7, Stn.8, and Stn.9 (Fig. 3). Meanwhile, no significant trend was detected for the seasonal and annual precipitation at stations Stn.1 to Stn.9 (Figs 4, and 5).

3.1. Monthly precipitation trend

Monthly precipitation data exhibit a significant negative trend (Fig. 3). The distribution of Z_s for the stations Stn.2, Stn.3, Stn.4, Stn.7, Stn.8, and Stn.9 is lower than -1.64. Therefore, the null hypothesis (H_0) of no trend was rejected and a significant negative trend was detected for the monthly precipitation.

3.2. Seasonal precipitation trend

The distribution of the Mann–Kendall Z_s value for the seasonal precipitation was determined to be $-1.64 < Z_s < 1.64$. Therefore,

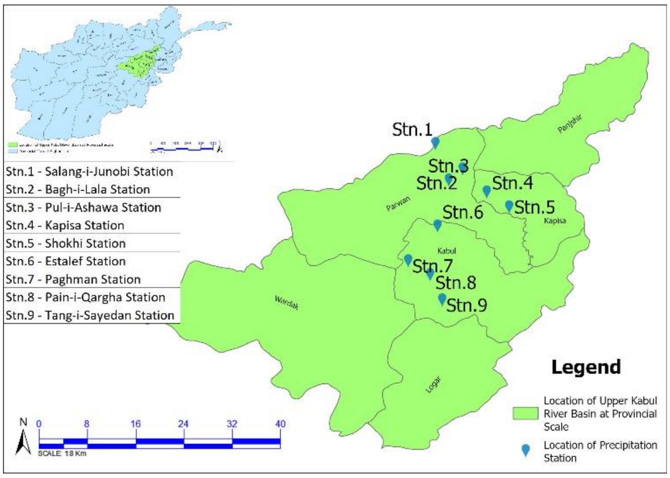

Fig. 1: Map of the UKRB at the provincial scale and locations of PPT stations

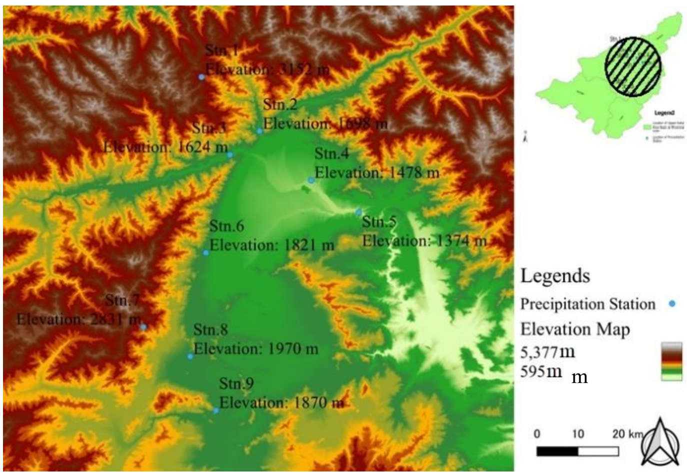

Fig. 2: Elevation map of precipitation stations in the UKRB

Keywords: trend analysis, precipitation data, weather station, significant trend, monthly precipitation, seasonal variation
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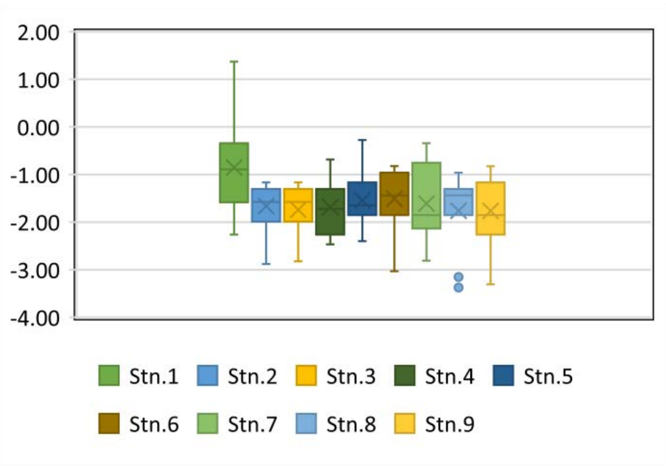

Fig. 3: Distribution of *Zs* for the monthly precipitation.

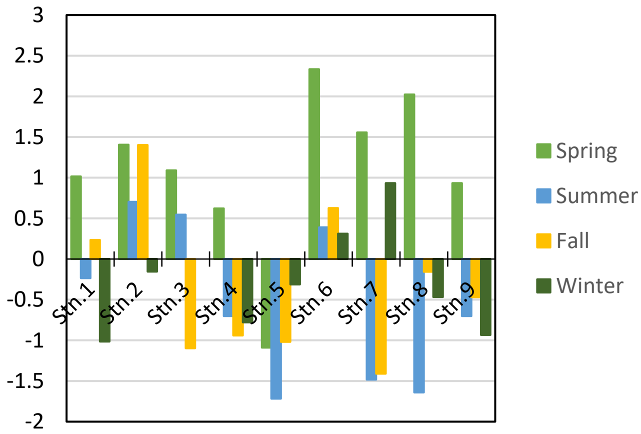

Fig. 4: Distribution of *Zs* for the seasonal precipitation.

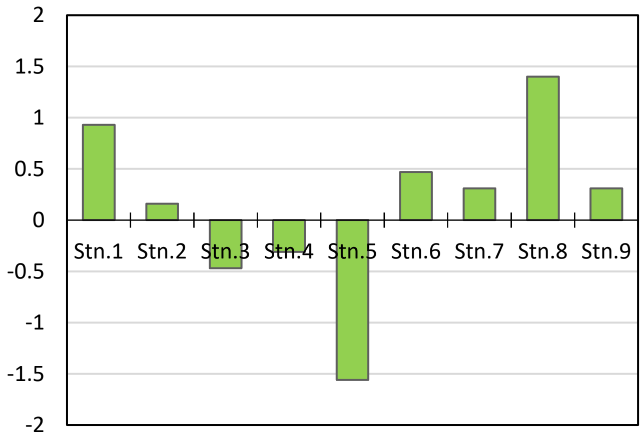

Fig. 5: Distribution of *Zs* for the annual precipitation.

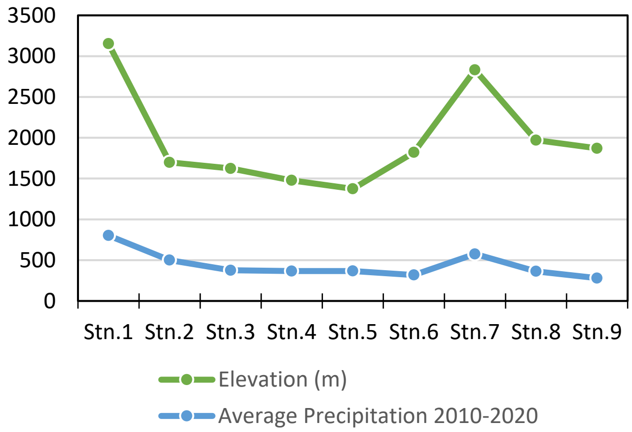

Fig. 6: Distribution of the elevation and average precipitation.

the null hypothesis (H_0) was accepted, where no significant trend was observed at any of the stations (Fig. 4). However, on some special occasions, at four points in Stn.6 and Stn.8 in spring with Z_s values of 2.34 and 2.02, and at stations Stn.5 and Stn.8 in summer with *Zs* values of -1.72 and -1.64, significant positive and negative trends were detected, respectively; however, this did not affect the overall results.

3.3. Annual precipitation trend and distribution of the precipitation

The annual precipitation analysis did not show any significant trends (Fig. 5). The Mann–Kendall *Zs* values were $-1.64 < Zs < 1.64$, where the null hypothesis was accepted; there was no significant trend.

The average precipitation for each station during the study period, 2010–2020, was highly variable. Stations with higher elevations and proximity to mountainous regions tended to have higher precipitation than those located at lower altitudes (Figs.2, and 6).

4. CONCLUSION

Trend analysis was performed for evaluating the monthly, seasonal, and yearly variations in precipitation from 2010 to 2020, in the Upper Kabul River Basin in Afghanistan. There was a significant decreasing trend in the monthly precipitation in Stn.2, Stn.3, Stn.4, Stn.7, Stn.8, and Stn.9; no significant increasing trend was observed. The seasonal precipitation showed a significant increasing trend in some special cases: Stn.6 and Stn.8 in the spring season, and a significant decreasing trend: in Stn.5 and Stn.8 in the summer season. However, no significant positive or negative trends were detected for annual precipitation. The results of this study provide insights into precipitation in the study area and thus benefit future research on the effects of climate change and global warming.

5. REFERENCES

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