NANGARHAR UNIVERSITY
INTERNATIONAL JOURNAL OF BIOSCIENCES
ORIGINAL ARTICLE
NUIJB
e-ISSN: 2957-9988
Special

Received: 25 Dec 2023 Accepted After Revision: 22 Jan 2024 Published Online: 10 Feb 2024

Climatic Data Trend Analysis by Mann Kendal Test and Innovative Trend Analysis: A Case Study of Taloqan River at Takhar, Afghanistan.

Shujahuddin Rasooly Sayed[1*], and Alem Azimi Sayed[2]
[1]Department of Civil Engineering, Faculty of Engineering, Takhar University, Takhar, Afghanistan
[2]Department of Electrical Engineering, Faculty of Engineering, Takhar University, Takhar, Afghanistan
*Corresponding author email: rasooly.1368@gmail.com

ABSTRACT

Climate change is taking place due to increased population and anthropogenic activities. The impacts of climate change have increased the demand for sustainable management of water resources. The semi-arid climatic zone is widely affected by climate change. Afghanistan is vulnerable to climate change because of its climate and variable precipitation. This research has studied the trend analysis of climatic data in the Taloqan River, which is being utilized for drinking and irrigation. The recorded data of the Tangi-Farkhar hydro meteorological station from 2008 to 2021 is used in this work. The non-parametric Mann-Kendall (MK) trend test and the Innovative Trend Analysis (ITA) method are utilized in this investigation. This study has found an increasing trend in the mean value of temperature in May across the period of study but no trend in annual temperature data according to the MK test with a 95 percent confidence level. The ITA shows an increasing trend in the annual temperature data, a decreasing trend in precipitation, and a non-monotonic negative increasing trend in discharge. The MK test has presented no trend in the annual data of precipitation and discharge and showed an increasing trend in the mean discharge value in October and November across the study period.

Keywords: Climate change, Discharge, Precipitation, Trend analysis, Temperature

INTRODUCTION

The impacts of climate change have increased the demand for sustainable management of water resources. It was reported that an overall linear global warming increase from 0.65°C to 1.06°C occurred between 1880 and 2012 (Saade *et al*., 2021). The main challenges associated with climate change are floods and droughts, but they are not affecting only water availability; however, the quality of water is deteriorated by them as well (Delpla et al., 2009). Water quality is a key factor for human health, and a huge number of diseases are associated with unsafe drinking water (Rasooly *et al*., 2023). Drought is a natural hazard that causes a reduction in water availability. Drought is likely to happen in semi-arid regions (Alam *et al*., 2023). The impacts of climate change will be more extensive in places with low water resources. The detection of climate change impacts on water resources is complicated due to natural variations in precipitation and stream flows. Hydrological models are needed to simulate the trend of climate change impacts on water resources (Estrela *et al*., 2012). Afghanistan is located in a semi-arid climatic zone; the precipitation in this country occurs with high variability. The impacts of climate change are not investigated widely in Afghanistan, and hence a restricted volume of literature is available regarding climate change in this country. Previous studies illustrate an increased trend of warming in Afghanistan. The first systematic study of climate change in Afghanistan was published in 2017 by Aich et al. The study reports a 1.8°C increase in temperature from 1951 to 2020, which is higher than the average of global climate change (Akhundzadah *et al*., 2020). The impacts of climate change on water quality in Afghanistan has not been studied properly, comprehensive research works on the mentioned area is highly recommended, and precautions from a water quality preservation point of view must be taken into account in developing a water resources management plan. This study focused on the trend analysis of climatic data of the Taloqan River. The Taloqan River is one of the tributaries of the Amu Darya River Basin. To achieve the mentioned objective, the data of discharge, precipitation, and temperature were collected from records of a hydrometerological station installed beside the Taloqan River at a place named Tangi-Frakhar. Trend analysis has been carried out using two statistical methods of the Mann-Kendall (MK) test and Innovative

Trend Analysis (ITA). This study has concluded that there is an increased trend in temperature, but the two remaining data series of discharge and precipitation show a decreasing trend.

MATERIALS AND METHODS

Study Area

This study has focused on the Taloqan River, which is located in the Taloqan Sub-River Basin (TSRB). The Taloqan sub-river basin has an area of 12919 km2. TSRB is a part of the Panj-Amu River Basin. There are two different seasons in TSRB according to precipitation and water demand. The first season includes October to mid-May, which has proper rainfall and no water demand for agricultural use. The second season starts in June and ends in September with lower or no precipitation and high water demand for irrigation and agricultural use. The stream flow increases in the second season due to the melting of the snow. (V. Thomas et al., 2011). This research has used the climatic data of the Taloqan River from 2008 to 2021, which is recorded at a hydrometeorology station named Nazdiki-Taloqan. It is located in Tangi-Farkhar, with a latitude of 36.63535833 and a longitude of 69.73739944. The station has collected data of discharge, precipitation, and temperature. The data is recorded daily for all water years, starting in October and ending in September. The Mann-Kendall (MK) test and Innovative Trend Analysis (ITA) are used to check the data trend in this study.

Mann-Kendall (MK) Trend Test

The Mann-Kendall no-parametric test is a well-known method for modifying the trend of a time series. This trend test is based on the ranks of the observations (Hamed, 2008). The Mann-Kendall test is done with the following formulas:

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

S is the Man-Kendall statistic, trend test is done to a time series of x_i ranked as i=1, 2, 3, …. , n-1 and x_j ranked as j=i+1,2,3…n. Each data point x_i is compared to the next data point x_j so that

$$sgn(x_j - x_i) = \begin{cases} +1 \; when \; x_j - x_i > 0 \\ 0 \; when \; x_j - x_i = 0 \\ -1 \; when \; x_j - x_i < 0 \end{cases} \qquad (2)$$

The variance of S is calculated using the following formula.

$$Var(S) \frac{n(n-1)(2n+5) - \sum_{i=1}^{n} t_i * i(i-1)(2i+5)}{18} \qquad (3)$$

Where t_i is considered as number of ties up to sample i, the test Z statistic is calculated as follows.

$$z_C = \begin{cases} \frac{S\_1}{\sqrt{Var(S)}}, S > 0 \\ 0, S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}, S < 0 \end{cases} \qquad (4)$$

Trend is detected concerning the value of Z_c, a positive value of Z_c indicates an increasing trend when it is greater than the critical Z value. The critical Z value is obtained based on a specific confidence level (Mondal et al, 2012, & Alam et al, 2023). In this study, the confidence level is used as 95% which offers a critical z value of 1.96.

Innovative Trend Analysis (ITA)

The ITA method is suggested by Sen (2012) for the first time for trend analysis of time series. In this method, the time series is divided into two equal parts concerning the number of data points. The first half and second half are placed on the X and Y axes, respectively. If the data is placed on the 1:1 ideal line, there is no trend; if the data is placed in the upper triangle, it shows an increasing trend; and the placement of the data in the lower triangle presents a decreased monotonic trend (Caloiero et al., 2018). The ITA method can represent the non-monotonic trend as well. The ITA indicative is calculated as below:

$$B = \frac{1}{n} \sum_{n}^{i=1} \frac{10(x_j - x_k)}{\bar{x}} \qquad (5)$$

Where x_j and x_k are the first and second half of the subseries, respectively, x is the mean of the first half, and B is the trend indicator. A positive value of B indicates an increasing trend, and vice versa (Alam et al., 2023).

RESULTS

The data taken from the concerned station of hydrometeorology is shown in **Figures 1**, **2**, and **3**. The data itself doesn't show any specific trend, so it is analyzed further using the MK trend test and ITA method. The results of ITA are illustrated in **Figures 4**,**5** and **6**.

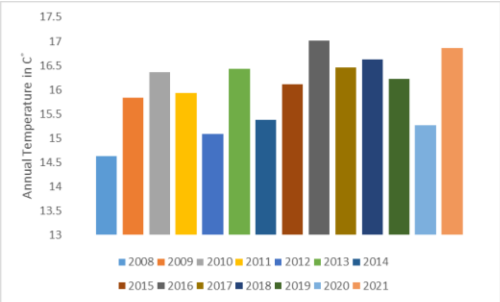

Fig. 1: Annual temperature data from 2008 to 2021

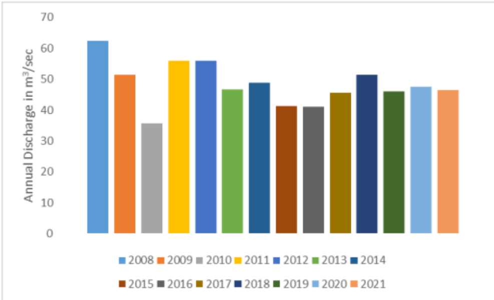

Fig. 2: Annual discharge data from 2008 to 202

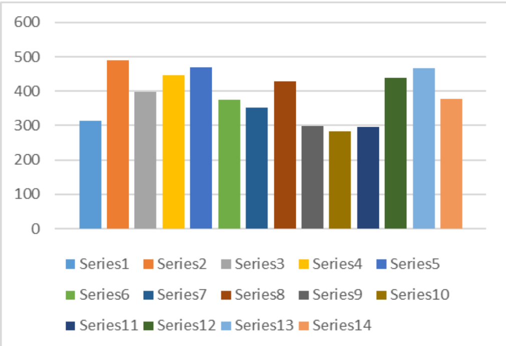

Fig. 3: Annual precipitation data from 2008 to 2021

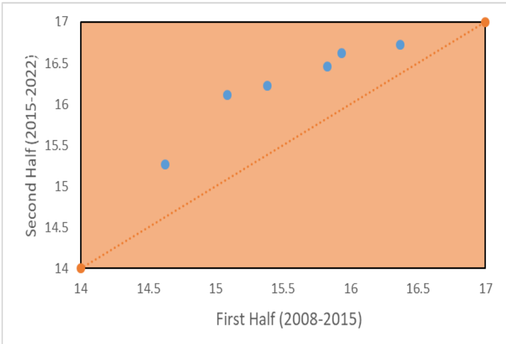

Fig. 4: ITA graph of annual temperature data

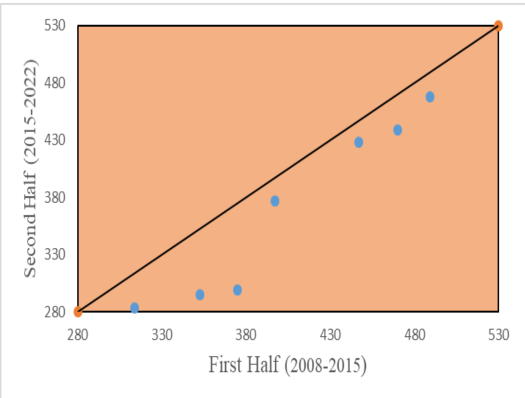

Fig. 5: ITA graph of annual precipitation data

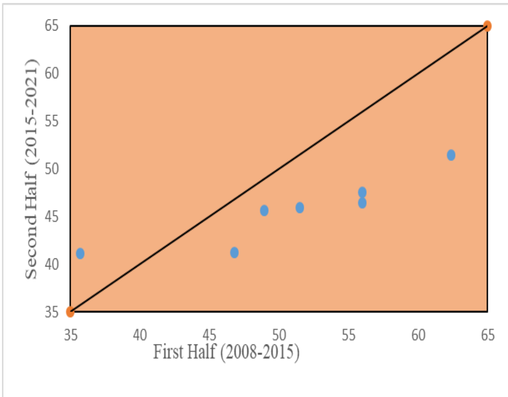

Fig. 6: ITA graph of annual discharge data

DISCUSSION

Trend analysis is important for determination of climate path and better water management. The climate scenario can't be developed without an accurate understanding of the concerned data trend. This study was aimed to determine the trend of climatic data in the fourteen years starting from 2008 and ending in 2021. The results of the study demonstrate that a strong warming potential existed in the Taloqan sub-river basin and the ice storages which are feeding the mentioned river, seems to be melting at a high speed. Comprehensive research works with a focus on climate change and its impacts on the Taloqan River are suggested to get done for better preparation to deal with warming subsequence in the future.

CONCLUSION

This research has used the MK test and ITA graph to assess the trend of three important climatic variations, temperature, precipitation, and discharge, in the Taloqan river at Takhar, Afghanistan. The MK test shows increase in mean value of temperature in May between 2008 and 2021, and no trend has been detected in the annual temperature value over the specified period of the study. The ITA graphs show an increased trend in annual temperature data from 2008 to 2021.

No trend has been detected in precipitation in annual and monthly data according to the MK test concerning a confidence level of 95%. The ITA method shows a decreased trend in precipitation in its annual data. The MK test has indicated an increasing trend in the mean value of discharge recorded in the October and November months from 2008 to 2021 and no trend in the other months with a 95 percent confidence level, while the annual discharge data from 2008 to 2021 show no trend. The ITA method has represented a non-monotonic negative increase in the annual discharge data.

Acknowledgment: We are grateful to the Takhar river basin directorate for providing the necessary data for this study.

Conflict of Interest: All authors express no conflict of interest in any part of the research.

Funding: This research received no external funding.

Authors Contributions: Rasooly S. S. has conceptualized, analyzed, and provided the original manuscript, and Azimi S. A. has provided figures and checked the manuscript for further corrections.

REFERENCES

Akhundzadah, N. A., Soltani, S., & Aich, V. (2020). Impacts of climate change on the water resources of the Kunduz River Basin, Afghanistan. *Climate*, *8*(10), 102..

Alam, J., Saha, P., Mitra, R., & Das, J. (2023). Investigation of spatio-temporal variability of meteorological drought in the Luni River Basin, Rajasthan, India. *Arabian Journal of Geosciences*, *16*(3), 201.

Caloiero, T., Coscarelli, R., & Ferrari, E. (2018). Application of the innovative trend analysis method for the trend analysis of rainfall anomalies in southern Italy. *Water Resources Management*, *32*, 4971-4983.

Delpla, I., Jung, A. V., Baures, E., Clement, M., & Thomas, O. (2009). Impacts of climate change on surface water quality in relation to drinking water production. *Environment international*, *35*(8), 1225-1233.

Estrela, T., Pérez-Martin, M. A., & Vargas, E. (2012). Impacts of climate change on water resources in Spain. *Hydrological Sciences Journal*, *57*(6), 1154-1167..

Hamed, K. H. (2008). Trend detection in hydrologic data: the Mann–Kendall trend test under the scaling hypothesis. *Journal of hydrology*, *349*(3-4), 350-363.

Mondal, A., Kundu, S., & Mukhopadhyay, A. (2012). Rainfall trend analysis by Mann-Kendall test: A case study of north-eastern part of Cuttack district, Orissa. *International Journal of Geology, Earth and Environmental Sciences*, *2*(1), 70-78.

Rasooly, S. S., & Anwer, M. (2023). Assessment of Drinking Water Quality and the Efficiency of the Two Water Treatment Plants in UP, India. *Journal of Mechanical, Civil and Industrial Engineering*, *4*(1), 01-08.

Saade, J., Atieh, M., Ghanimeh, S., & Golmohammadi, G. (2021). Modeling impact of climate change on surface water availability using SWAT model in a semi-arid basin: case of El Kalb River, Lebanon. *Hydrology*, *8*(3), 134.

Thomas, V., Osmani, A. and Abdi, S., 2009, Nahr-e-Said and Nahr-e-Zargar Canal Assessment. PMIS project report

Vincent Thomas, Abdullah Osmani & Kai Wegerich (2011) Local challenges for IWRM in Afghanistan, International Journal of Environmental Studies, 68:3, 313-331, DOI: 10.1080/00207233.2011.573963