Research Paper: Investigation of the Trend of Hydroclimatology Changes Using Non-Parametric Tests in the Kasilian Watershed of Mazandaran Province

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ABSTRACT

Purpose: Significant reductions in runoff have created severe challenges and complexities in water resources development projects. Protecting the rights of stakeholders and investments in dams and other water facilities requires recognizing hydro climatological changes. This study aimed to investigate the changes in precipitation and temperature on the 60-year discharge trend of the Kasilian watershed by non-parametric Mann-Kendall and Sen's Slope tests.

Methods: In these studies, the discharge of Kasilian station, rainfall and temperature of 16 stations have been analyzed. Using non-parametric Mann-Kendall and Sen's Slope tests, the increasing or decreasing trend was tested monthly, seasonally, and annually at 5%.

Results: The results show that the annual discharge has a significant negative trend. Also, all seasons are faced with a decrease in discharge, the trend of which is significant in spring, summer, and autumn. However, the precipitation of the Kasilian basin does not have a significant trend at the level of 5%. The average maximum temperature in three months of the year also the average annual maximum have a significant positive trend. The average minimum temperature of the basin in all months of the year has a significant upward trend. The highest temperature increase is also observed in autumn.

Conclusion: One of the most important reasons for the decrease in discharge, despite being almost safe from development factors and upstream compared to most of the country's watersheds, is the increase in the average minimum temperature, which is one of the essential factors in reducing discharge in this area.

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1. Introduction

River discharge as one of the essential parameters in hydrology and water resources is in interaction with climatic elements. Therefore, climate change can have a direct effect on the flow of rivers. This reduction has created serious concerns for water resources development projects, and finalizing the allocations requires recognizing hydro climatological changes. Therefore, the study of changes in river discharge over time can determine the possible effects of changes in the climatic conditions of a region (Sohrab-Nia et al., 2019). For this purpose, it is essential to investigate the presence or absence of time series of hydrological and climatic data. Climate change has potential effects on rainfall distribution, runoff, and groundwater aquifer nutrition, so the future pattern of hydrological phenomena cannot be assumed as in the past (Bougara et al., 2020; Mohseni et al., 2022). Increasing demand and consumption of water, multi-purpose use of water systems, such as water supply (agriculture, drinking, and industrial), flood control, hydropower generation, and environmental requirements have increased water stress and the optimal study of water resources is necessary. Hydrological and meteorological data and methods of analysis and study of their trends in the evaluation of current and future water resources have significant economic value because it affects the economic and social development plans of the country that are related to water. Many studies have been done on climate change based on temperature changes. Mohammadi & Taghavi (2005), studied the temperature and precipitation limit indices in Tehran and showed that the precipitation limit index has a decreasing trend with a shallow slope. Moreover, has a lower slope. Also, Ataei et al. (2013), identified statistical models for the phenomenon of climate change in the Kerman and Bam stations. The results of this study indicate that in Kerman station trends were observed in the months that followed trend patterns; the average bulb temperature of decrease trend, the mean absolute maximum temperature without trend and the other elements have been increased trend.

Feizi et al. (2010), studied climate change in Sistan and Baluchestan and the results of data analysis showed that in all stations except Zahedan station, temperature parameters have a negative trend during the year and a negative trend of precipitation in months. The warmth of the year from May to September, as well as the time and type of changes in temperature and precipitation parameters, indicate sudden increasing and decreasing changes. Jahanbakhsh et al. (2010), studied the changes in rainfall and temperature in the Karkheh basin. They concluded that the annual rainfall in most sub-basins of the region has a decreasing trend while the trend in temperature is at a significant level of 95% increase. Research by Ghil & Vautard (1991), North & Kim (1995), Hasselmann (1997) and Jones & Hegerl (1998) can also be mentioned. Several studies have given great attention to detecting the trend in climate variables (mainly rainfall and temperature) worldwide (e.g., Jain & Kumar, 2012; Yang et al., 2014; Kisi & Ay, 2014; Da Silva et al., 2015; Djellouli et al., 2016; Otmane et al., 2018; Kumar et al., 2019; Bahadur et al., 2017; Panda & Sahu, 2019).

2. Literature Review

Also, many studies have been done on changes in climatic factors on river discharge and changes in river discharge over time, including the studies of Wahl & Tortorelli (1997), Lins & Slack (1999), Monlar & Ramirez (2001), Xu et al. (2004), Thodsen (2007), Jiang et al. (2007), Massah bavani & Morid (2006), Elahi gil & Hejam (2006), Ahmadi et al. (2013). Wahl & Tortorelli (1997), studied the possible trend of river flow in western Oklahoma. They concluded that river flow had a significant decreasing trend. Xu et al. (2004) studied the trend of temperature and precipitation changes and discharged in the Tarim watershed and showed that temperature time series have a significant increasing trend and precipitation data have also increased, however, discharge time series in the river mirage has an increasing trend. It was significant, but in most of the river routes, this trend has been decreasing. Thodsen (2007), studied the effects of climate change on river flows in Denmark from 1961 to 1990. The results showed that river discharge rates decreased from December to August and increased in September and October. Jiang et al. (2007) also analyzed the trend of changes in rainfall and river discharge in the Yangtze River Basin in the statistical period of 1961 to 2000, and their results showed a significant positive trend in summer rainfall data. Their results also showed that river discharge in most stations had increased significantly in 40 years. Valdes- abellan et al. (2017), examined the changes in rainfall in the western Mediterranean region. They collected daily rainfall data from the last 75 to 80 years in Spain and evaluated the studied data using the Mann-Kendall nonparametric test, and came to this conclusion. There have been evident changes in the rainfall pattern over the last 20 years, so the annual rainfall has decreased, and about 15% has been added to the dry periods.

Ataei & Fanaei (2014), Identified, relative maximum humidity changes during the recent half-century using the Mann-Kendall test in Isfahan province. Based on the findings resulting from this survey, the decreased trends of relative humidity have predominated the increased trends during the studied statistical period so that it has devoted more than 66.8% of the province area to itself. In addition, the highest rate of decreased relative humidity occurred in February and the lowest in June. Massah Bavani & Morid (2006), by studying the effects of climate change on temperature, rainfall, and runoff in the Zayandehrood river basin, concluded that the number of rainfall decreases and the temperature increases, and also the flow decreases to 5.8% in the future periods. Elahi Gil and Hejam (2006), studied the effect of temperature changes on runoff in the Imameh watershed during 32 years 1352-82. They showed a rule of thumb in all the days, the days and the days, the days, the days, and the days in the period. Mirabbasi Najaf-Abadi & Dinpajouh (2010), studied the trend of changes in river discharge in northwestern Iran in the last three decades and showed the trend of changes in the predominant river runoff in the northwestern region of Iran in general in the last three decades is significant and at 10%. Karmeshu (2012), in a study, diagnosed annual temperature and rainfall trends using the Mann-Kendall test to assess climate change in selected countries in the northeastern United States. The statistical results of the Mann- Kendall test showed how much the temperature and precipitation trends increased, or decreased. For temperature, all states showed a significant increase, except Pennsylvania and Maine, which did not show a statistically significant trend. In terms of rainfall, New Hampshire and Maine did not show statistically significant results, while other states showed significant increases.

Khoshravesh et al. (2015), studied the trend of river flow and rainfall characteristics at monthly, seasonal and annual time scales of the Nekarud watershed from 1979 to 2012. They concluded that the average monthly and annual flow, especially in winter, in all sub-basins, is decreasing. Moreover, the maximum annual flow from the upstream to downstream areas is increasing. Zohrabi et al. (2016), investigated the temporal and spatial variations of temperature and precipitation variables in the Karkheh watershed located in western Iran and used non-parametric tests of Mann-Kendall, Spearman, and time series estimators of temperature and precipitation variables of 22 stations during the period. Statistical statistics evaluated from 1971-2011 showed that the most significant decreasing changes are observed in the western and southern parts of the Karkheh basin. The latest findings from global studies are consistent. Also, Javari (2017), Evaluated, temperature and elevation controls on spatial variability of rainfall in Iran. In this study, to predict the relationship between temperature, topography and rainfall, a combination of statistics including spatial statistics and Geographical Information System (GIS) methods were employed. It was found that the distribution and rainfall variability in some parts of Iran was regarded to be based on topography and temperature. The spatial patterns showed that the variability based on spatial autocorrelation in rainfall severity gradually increased from west to east and north to south in Iran.

Seyed Ali et al. (2017) analyzed the trend of changes in hydro-climatological factors and land use on existing water resources in the Hableood watershed using the non-parametric Mann-Kendall test. They showed that the parameters of rainfall and the average temperature in the three decades of monthly, seasonal and annual, as well as runoff data after the removal of precipitation and the correlation of the chains between the data, had no significant trend. Also, climatic factors and land use change have not had a significant effect on the status of surface water resources in the watershed. Also, the snow line of the basin did not show a significant trend and the graph of the minimum and average height of the snow line of the basin showed many annual fluctuations and the selected period for data analysis. These factors can be considered the main reason for the insignificance of runoff flow rate and runoff height.

Koulaian et al. (2017), analyzed the flow trend of rivers in Mazandaran province using the non-parametric Mann-Kendall test in 30, 40, 50, and 60-year periods on three-time scales: monthly, seasonal and annual. Every month, in most months, especially in summer, hydrometric stations have a significant downward trend and in winter have a positive trend over several decades due to rising temperatures and melting snow. Also, due to changes in precipitation patterns, peak discharge has had a positive trend.

Farzin & Alizade Sanami (2017), also evaluated the changes in the hydro climatology regime of the Gorganrood River at the Tamr hydrometric station. Examining the 44-year statistics of the above station and modelling and analyzing it with three software Arc GIS, ILWIS 2.1, and SMADA, the results showed that the region's climate is changing to the hot and dry climate, the effects of which can reduce rainfall. Moreover, pointed out the increase in temperature, increase in rainfall intensity and increase in peak discharges in the region. The study of the average monthly and annual discharges shows a relatively weak upward trend of this parameter in the mentioned area, which is in line with the global climate change situation in the Northern Hemisphere and latitudes of 30 degrees, which have become chiefly drier. The purpose of this study is to investigate the reason for the decrease in discharge of the Kasilian watershed during the last 60 years and the role of precipitation and temperature changes on its trend.

Hormozi et al. (2021), used daily, monthly, and annual precipitation data to study selected synoptic stations over 30-year span (1987 – 2016). They selected precipitation indices from soft RClimDex software to estimate the upward and downward trend of changes in precipitation limit values using Mann-Kendall non-parametric test method and the rate of precipitation changes with Sen's slope estimator method. The results showed that all precipitation indices (except for the number of days with more than 25 mm of rain and very wet days) had significant changes at 5%. Zakwan & Ahmad (2021), analyzed the trend of hydrological parameters of the Ganga River in India. This trend analysis was performed by the Mann- Kendall method, age gradient, and innovative trend analysis at different points along the river for months with heavy rainfall (Manson). Their results showed that analyzing innovative trends offers a more accurate understanding of hydrological changes. At the same time, the maximum and minimum annual discharges, respectively, showed a negative trend at all points and a positive trend in the upstream measuring sites of the river.

3. Methodology

Study area

The study area is located in Mazandaran province and the geographical coordinates of ′44 ° 35 to ′47 ° 36 north latitude and ′36 ° 52 to ′24 ° 53 east longitude. It includes the Kasilian River watershed, which is below the Talar watershed. The length of the Kasilian River to the connection to the hall is about 56 km, and the area of its watershed is approximately 330 square kilometres. Kasilian River originates from the northern slopes of the Alborz Mountains and, after joining the Talar River in Shirgah and passing through the cities of Ghaemshahr and Kiakla, finally leads to the Caspian Sea. The average rainfall of the basin is 845 mm, with the highest rainfall occurring in October. Figure 1- shows the location of the study area and meteorological and hydrometric stations under study.

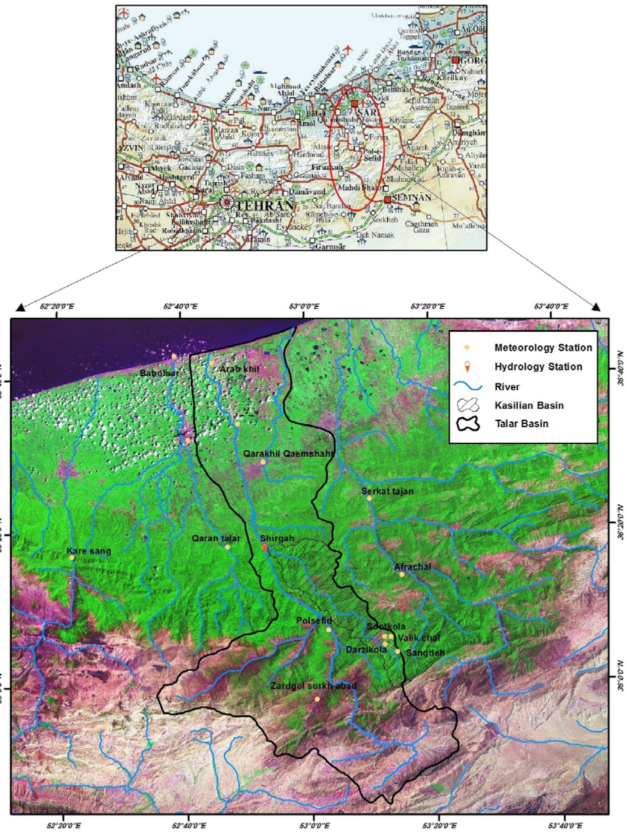

Figure 1. Location of study areas and stations in Talar and Kasilian watersheds

In order to investigate monthly, seasonal and annual rainfall trends in the Kasilian watershed, rainfall and temperature have been studied in 16 and 6 stations (synoptic, evaporative, and rainfall, respectively). Table 1, shows the characteristics of the studied stations.

To conduct studies, statistical data of selected stations were collected and analyzed by the Deputy of Regional Water Studies of Mazandaran Province as well as the Meteorological Organization and the normality of the data was checked. According to the obtained results, the above data are abnormal, so to study and analyze the trend of the above parameters, the non-parametric Mann-Kendall test, and Sen's slope estimator have been used, which has been described in the above methods. It should be noted that to determine a period, the discharge time index of the Shirgah hydrometric station, along with the average of three or five-year mobiles is plotted and presented in Figure 2, which is according to the observed wet season and drought periods. 60 years (1955- 2015) has been selected and studied.

Table 1. Details of the studied stations in the Kasilian watershed

Row	Station name	Geographical attributes		
		Latitude	Longitude	Height (meters)
1	Babolsar	36.72	52.65	-21
2	Afrachal	36.23	53.25	1300
3	Zardgol sorkh abad	35.97	53.02	1500
4	Shekat tajan	36.40	53.17	300
5	Qara kheyl Qaem Shahr	36.48	52.88	50
6	Qoran Talar	36.30	52.78	190
7	Babol	36.53	52.68	0
8	Darzikola	36.08	53.20	1300
9	Sang Deh	36.07	53.23	1320
10	Koreh sang	36.28	52.37	200
11	Pol sefid	36.12	53.05	620
12	Sud Kola	36.10	53.20	1200
13	Shirgah	36.30	52.88	250
14	Arab Kheyl	36.70	52.75	23-
15	Kia Kola	36.57	52.82	-7
16	Valik chal	36.10	53.22	1440
17	Shirgah kasilian	36.30	52.88	270

* Hydrometric station

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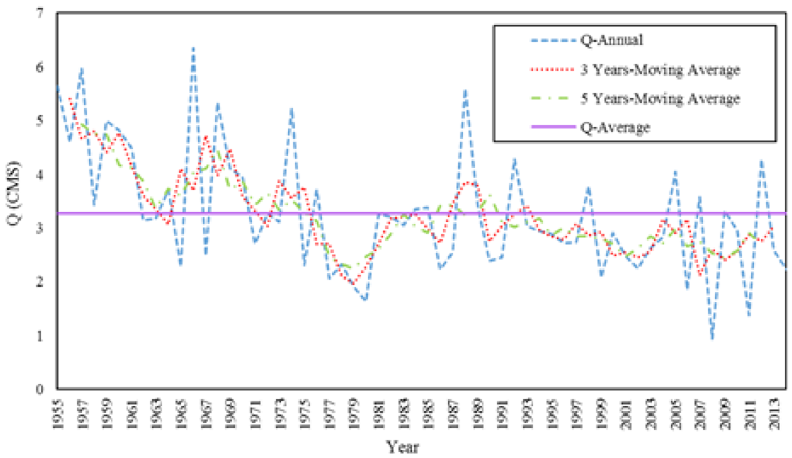

Figure 2. Flow time series of Shirgah hydrometric station with a moving average of three years and five years

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Research Techniques and Tools

Mann-Kendall nonparametric test method

The Mann-Kendall method was first proposed by Mann (1945) and developed by Kendall (1970). The null hypothesis of the Mann-Kendall test indicates that the trend in the data series is random, and the acceptance of hypothesis one (rejection of the null hypothesis) indicates a trend in the data series. In this method, first, the difference between each observation and all subsequent observations is calculated, and the parameter S is obtained according to the following equation:

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

Where n is the number of series observations, and xj and xk are the data of the j and k series, respectively. The function of the sgn symbol can also be calculated as follows:

for (xj-xk)>0 $\operatorname{sgn}(x_j - x_k) = +1$

for (xj-xk) =0 $\operatorname{sgn}(x_j - x_k) = 0$

for (xj-xk) <0 $\operatorname{sgn}(x_j - x_k) = -1$

In the next step, the calculation of variance S was calculated by one of the following equations:

forn>10 $$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t(t-1)(2t+5)}{18}$$

for n< 10 $$Var(S) = \frac{n(n-1)(2n+5)}{18}$$

Where n and m represent the number of sequences in which there is at least one duplicate data. Also, t indicates the frequency of data with the same value in a sequence (number of nodes). Finally, the Z statistic is extracted using one of the following equations:

for S>0 $$z = \frac{S-1}{\sqrt{Var(S)}}$$

for S=0 $$z = 0$$

for S<0 $$z = \frac{S+1}{\sqrt{Var(S)}}$$

Assuming two trend test domains, the null hypothesis is accepted if the following condition is met:

$$|Z| < Z_{\alpha/2}$$

Which is the significant level that is considered for the test, and Zα is the standard average distribution statistic at the significant level which has been used due to the two amplitudes of the test. In the present study, this test has been used for 95% confidence levels. If the Z statistic is positive, the trend of the data series is considered ascending, and if it is negative, it is considered descending (Mann, 1945; Kendall, 1970).

If the ZMK values are between +1.96 to -1.96, there is no trend at the 5% level; otherwise, it has a positive or negative trend.

Sen's Slope test

Sen (1968) proposed a nonparametric method for time series analysis based on the development of a series of statistical studies conducted by Thiel (1950). This method, like the Mann-Kendall method, uses the analysis of differences between observations of a time series. This method is based on calculating a median slope for time series and judging the significance of the slope obtained at different levels. The general steps of this test are as follows:

Calculate the slope between each pair of observational data using the following equation:

$$T_i = \frac{X_i - X_k}{J - K} \quad for \quad i = 1,2,3,\ldots,N$$

Where Xj and Xk are considered as data values at times J and K (J> K).

In the Sen method, the value of Ti is obtained from the middle of N data.

$$Q_i = \begin{cases} T_{\frac{N+1}{2}} & \text{N, if it is odd} \\ \frac{1}{2}\left(T_{\frac{N}{2}} + T_{\frac{N+2}{2}}\right) & \text{N, if it is even} \end{cases}$$

It should be noted that the age test is similar to the Mann-Kendall test, positive, and negative Qi value indicates the positive and negative trend. Equilibrium has been written in Excel software to facilitate the calculations of the above relations.

Using Mann-Kendall and Sen's Slope test methods, the trend of 60 years of discharge (at a 5% level) on a monthly, seasonal and annual basis at Kasilian-Shirgah station located in the watershed of Talar has been analyzed. This area, despite being almost safe from development factors and upstream perceptions, encountered a significantly reduced discharge, which shows that other factors have played a role in this reduction. Since precipitation and temperature parameters affect the flow rate, the trend of these parameters has also been studied. In the following, the trend status of each of the studied variables is presented separately.

4. Findings

Rainfall trend

Using the monthly rainfall of 16 stations located in Kasilian and adjacent areas, the rainfall was calculated according to the impact level of each station, and the rainfall time series. The results of Mann-Kendall and Sen's Slope test for the 60-year rainfall time series of the basin are presented in Table 2 and show that the monthly, seasonal and annual rainfall time series of the Kasilian basin are static. Therefore, rainfall can't cause a 45% reduction in discharge.

In the first step of this research, the rainfall trend was studied to determine the impact of rainfall reduction as one of the essential factors affecting river discharge. Examination of rainfall data showed that the total rainfall of the basin in monthly, seasonal and annual time series in 60 years (1955-2015), lacks a significant and static trend. In the monthly time series, only the decreasing trend of the Gondab station was observed in October and the increasing trend of Benkooh station in September. The results of this study are consistent with the results of the research of Abtahi et al. (2014), Jenifer and Jha (2021) and Karmeshu (2012), who found the precipitation trend to be constant. Figure 3, shows the precipitation trend in the Kasilian watershed.

The trend of flow rates (discharge)

Table 3, shows the results of the Mann-Kendall and Sen's Slope tests for the 60-year discharge time series of the Kasilian-Shirgah station. Considering the impact of precipitation and temperature parameters on the discharge rate (Table 3), it can be said that discharge trends have significantly decreased in all months (except in December and March). Among these, the greatest decrease in discharge is observed in April and October. Also, seasonal changes indicate a decrease in discharge in all four seasons of the year with a significant decrease trend in spring, summer, and autumn according to the Mann-Kendall method. The Mann-Kendall test shows that the annual discharge is not static and has a significant trend. According to Sen's Slope, this is a downward trend. It can be observed that the annual discharge of the Kasilian River has declined by 45% in the last 60 years and on average has lost one million cubic meters per year.

Table 2. Mann-Kendall and Sen's slope test results for precipitation in the Kasilian basin over 60 years

Row	Sen's slope	Mann-Kendall	Time	
1	-0.05	-3.55	July	Month
2	-0.02	-1.80	August	
3	0.00	-0.04	September	
4	-0.02	-2.14	October	
5	-0.01	-0.77	November	
6	0.00	-0.18	December	
7	-0.05	-2.28	January	
8	-0.03	-2.23	February	
9	-0.02	-3.45	March	
10	-0.02	-2.62	April	
11	-0.02	-3.08	May	
12	-0.03	-2.33	June	
13	-0.03	-2.26	Autumn	Season
14	-0.01	-0.99	Winter	
15	-0.04	-3.39	Spring	
16	-0.02	-3.37	Summer	
17	-0.03	-3.55	yearly	

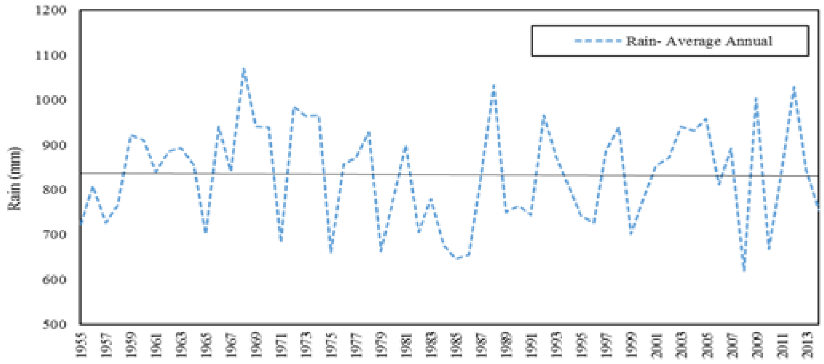

Figure 3. Rainfall time series of Kasilian watershed during the 60-year statistical period with a significant trend line

Table 3. Mann-Kendall and Sen's slope test results for discharge variable (Kasilian-Shirgah) in 60 years

Row	Sen's slope	Mann-Kendall	Time	
1	-0.18	-0.63	July	
2	0.24	-0.98	August	
3	0.12	0.54	September	
4	0.07	0.55	October	
5	0.16	0.85	November	
6	-0.18	-1.70	December	
7	-0.08	-0.48	January	Month
8	0.07	0.54	February	
9	-0.19	-1.95	March	
10	0.19	1.90	April	
11	-0.16	-0.68	May	
12	0.02	0.06	June	
13	-0.05	-0.22	Autumn	
14	-0.03	-0.06	Winter	Season
15	-0.38	-1.19	Spring	
16	-0.16	-0.44	Summer	
17	-0.32	-0.49	yearly	

The flow of rivers in the country has decreased significantly in recent years. Most of these changes are due to upstream harvests, especially development in the agricultural sector and the increase of area under cultivation. However, rivers such as Kasilian, which are almost safe from the above factors, face a significant trend of declining discharge, which shows that other factors have played a role in this reduction. The results of this study are consistent with the research of Kazemzadeh et al. (2013), Shrestha et al. (2016), and Zakwan and Ahmad (2021), on the reduction of river discharge for seasonal and annual series. Figure 4, shows the annual discharge trend in the watershed.

Temperature trend (average maximum and minimum temperature)

Using the statistics of 6 stations located in the Kasilian area and adjacent to this area, the 60-year time series, the average maximum, and the average minimum temperature have been calculated. The results of the 60-year time series analysis of the average maximum and average minimum temperatures of the Kasilian watershed are presented in Table 4.

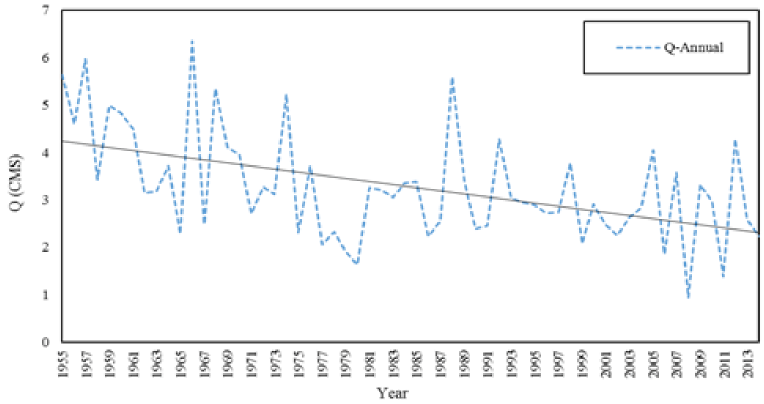

Figure 4. Time series of discharge of Kasilian watershed during the 60-year period with significant trend line. JSRD

Table 4. Mann-Kendall and Sen's slope test results for Tmax (maximum) and Tmin (minimum average) variables of the Kasilian domain during a 60-year span

Row	Medium Min Sen's slope	Medium Max Sen's slope	Mann-Kendall	time	
1	0.06	0.02	1.64	July	
2	0.07	0.00	0.00	August	
3	0.07	0.00	-0.31	September	
4	0.07	0.00	0.17	October	
5	0.06	-0.004	-0.24	November	
6	0.07	0.04	1.98	December	Month
7	0.06	0.03	2.23	January	
8	0.06	0.02	1.55	February	
9	0.06	0.01	1.29	March	
10	0.05	0.01	0.76	April	
11	0.04	0.03	2.20	May	
12	0.05	0.02	1.78	June	
13	0.07	0.00	0.21	Autumn	
14	0.07	0.02	1.27	Winter	Season
15	0.06	0.03	2.54	Spring	
16	0.04	0.01	1.70	Summer	
17	0.06	0.01		yearly	

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5. Discussion

The results show that the average maximum temperature in March, April and August has a positive trend at the level of 5%. In addition, spring and the average maximum annual temperature have a significant trend. The average minimum temperature has a significant trend on a monthly and annual scale. On a seasonal scale, in all seasons (except summer), there is a significant trend at the level of 5%, and in all cases, this trend is upward. According to the results of the Mann-Kendall test, the average minimum temperature of autumn shows the highest increase, followed by spring and winter. In different seasons, the average minimum temperature has a more significant increase than the average maximum temperature, especially in autumn. Only in summer, the increase is more homogeneous and has the same ratio. The increasing trend of temperature, especially the average minimum temperature, can be one of the essential factors in reducing discharge in this area. The temperature of the basin has changed during these 60-year periods. This change is a type of short-term climate fluctuation and trend observed in most monthly, seasonal and annual series, especially for moderate temperatures. This is a significant upward trend. These results agree with the research of researchers such as Karmeshu (2012), Moors et al. (2011), Shrestha et al. (2016), and Zakwan and Ahmad (2021). They reported a trend of increasing temperature in the study areas which led to an increased evaporation rate and decreased discharge rate.

In this research, in order to detect and know the presence or absence of changes in the parameters, the statistical series of climatic and hydrological variables of rainfall, temperature and average discharge of the hydrometric station and spatial distribution were subjected to a trend test to prove the existence of a trend. It is possible to find the reasons for these changes (climate effects or direct human and management effects) and involve them in the statistical analysis related to determining the flow rates of infrastructure structures (dams, bridges, aqueducts and walls). floodwaters) reduced the possibility of failure of construction projects and water resource planning.

In this research, in order to detect and know the presence or absence of changes in the parameters, the statistical series of climatic and hydrological variables of precipitation, temperature and average discharge of the hydrometric station and spatial distribution were subjected to a trend test. Because if the existence of a trend is proven, it can be possible by finding the reasons for these changes (climatic effects or direct human and management effects) and involving them in the statistical analyzes related to determining the discharge of infrastructure structures (dams, bridges, culverts and flood walls), reduced the probability of failure of construction projects and water resource planning. The results obtained from the analysis of data from the Kasilian River watershed for 60 years show significant changes in some hydro-climatic parameters. The most important parameters are as folows:

• Watering 8 months of the year has a significant decrease trend. All four season of the year show a discharge decrease with a significant decreas trend in with spring, summer, and autumn with

• The time series of monthly, seasonal and annual rainfall in the Kasilian area.is static.

• The average maximum temperature in March, April, and August has a positive trend at the level of 5%. In addition, the average maximum annual temperature in spring has a significant trend.

• The average minimum temperature also has a significant trend on a monthly and annual scale. On a seasonal scale, in all seasons (except summer), , there is a significant trend at the level of 5%, and this trend is upward. in all cases.

• Due to the static rainfall, the factor of 45% discharge reduction can't be related to this parameter. However, the moderate increase in minimum temperature, is one of the essential factors in discharge reduction the in this area.

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Conflict of Interest

The authors declared no conflicts of interest.

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