DESERT

Desert
Online at http://desert.ut.ac.ir

Desert 24-2 (2019) 171–182

Climatic elements, discharge and groundwater trends over time using Mann-Kendall Test in the Mighan Sub-basin of Arak

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Received: 12 October 2018; Received in revised form: 5 November 2019; Accepted: 25 November 2019

Abstract

This study was an analytical research across 84 meteorological stations, performed in the Mighan sub-basin over a fifty-year study period (1961–2011).This research seeks to answer the basic question of how declining streamflow, increasing temperatures, and fluctuation in precipitation have impacted water resource allocation in the Mighan sub-basin. The research method is analytical based on Mann-Kendall method. Analysis of independent flow measures (discharge and groundwater levels) using the Mann-Kendall trend test suggests evidence for climate change trends for many of the 84 stations. The results highlighted a mix of positive (increasing) and negative (decreasing) trends (monthly, seasonal, and annual) in the Mighan sub-basin. The results showed that during the 10-year period (1961-70), the minimum temperature occurrence in the first decade at -33.5 ° C (1973) and the maximum temperature event in the same decade at 57 ° C (1974) made this decade one of the most volatile decades in a fifty year period. Despite the inter-annual climatic fluctuations, results revealed that the Mighan Sub-basin has encountered many severe fluctuations of precipitation and average annual discharge during the five decades.

Keywords: Climate elements; Discharge; Groundwater; Mann-Kendall test; Mighan

1. Introduction

Climate change is one of the major challenges in the world that has been addressed by scientists and researchers.This phenomenon can affect human life, both directly and indirectly. Precipitation and air temperature are two important variables in the field of climate science and hydrology. Precipitation is an important component of rainfall-runoff relationships and affects flood / drought assessment as well as mitigation measures.Temperature plays a prominent role in evapotranspiration, transpiration, and water demand (both animal and human) and thus significantly impacts water requirements and strategies to assure its availability. The implications of changes in precipitation and temperature make it crucial for water resource planners to accurately assess their behavior and impacts on related hydrologic variables (Chattopadhyay and Edwards, 2016).

In the drought-prone area of central Iran, the intensity of cultivation has almost doubled since the late 1980s (since 1985) due to excessive use of groundwater irrigation.The long-term behavior of groundwater table in the drought-prone area has been studied using MAN-Kendal model following extensive installation of wells.The rigorous exploitation of groundwater for irrigation, rainfall reduction, and surface geological properties result in a downward trend in the groundwater table.This

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will hamper the country's food security and ultimately threatens its socio-economic sustainability. So the appropriate strategies for the management of groundwater resource on a sustainable basis should be the priority for maintaining agricultural productivity."(Rahman *et al*.,2016)

Scientific research has shown that global surface air temperature increased about 0.2 - 0.6°C during last century (Abaurrea and Cerian, 2001) and studies indicate that this parameter may increase about 1.5 to 4.5°C by 2100 (IPCC, 2013).

It should be considered that this rate may vary in different geographical regions(Colin *et al.* ,1999). Global warming can affect land ecosystems especially water cycle. Rainfall is a key input in the management of agriculture and irrigation projects and any change in this variable can influence the sustainable management of water resources, agriculture, and ecosystems. In particular, climate change science studies focus on potential changes in the annual series of variables such as rainfall or temperature.There are physical and empirical methods for climate change detection. Physical methods use a climate model for change detection. However, generally a statistical method uses empirical approaches.There are numerous studies using trend analysis for climate change. Climate data may be used directly (Van and Hughes, 1984); (Zhao and Dirmeyer, 2004); (Yue, S., and M. Hashino., 2003) or indirectly (Douglas and Kroll, 2000). Proedrou *et al*., 1997 in a study on winter air temperature in a creek found that this variable had a decreasing trend during 1951 to 1993 but showed an upward trend in the summer seasons.

Kampata *et al*., 2008 evaluated trend analysis for rainfall in the Zam bezi flow basin in Zambia using the Mann-Kendall test for five rain gauges. The results showed that there was less decrease of this variable which was not statistically significant.

Extreme events such as droughts and high flows have a profound effect on both the economy and ecology of a catchment, affecting both availability and distribution of water. Information about past changes in extreme events is important to determine trend and response tendencies in the catchment as a reference for future extreme event prediction. (Karlsson *et al*.,2014)

A study of the trends in rainfall for the central and western Sahel regime showed that drought intensity decreased in the central region compared with the past during the period 1990-2007. However, there is a negative trend in the rainfall in the western region and more droughts. Moreover, the variability of annual rainfall in the study area is related to large scale fluctuations of annual rainfall (Kumar and Jain, 2010).

The Mann Kendall test for trend detection in monthly, seasonal an annual scale of rainfall in the Kerala state of India during the period 1871 - 2005 showed that there was a significant decrease in Monsoon rainfall within the Northwest region but an upward trend was detected from 2005 till present. Also there was not any trend in the winter and summer seasons (Krishnakumar *et al*., 2009).

Kumar and Jain (2010) studied the trend in seasonal and annual rainfall and rainy days using the Mann Kendall test in the Kashmir valley. They used three time periods of 41, 80, and 107 years, respectively. Results implied that there was an upward trend of rainfall and rainy days in one station but other stations showed a decreasing trend for both variables.The t-test method was used by Ghahreman, 2006 to detect the trend of mean annual air temperature in 34 stations of Iran, and found that 50% of stations showed a positive trend while 41% of stations had a negative trend.

The local and temporal variations of rainfall in Iran were examined by Asakerh, 2007. The results showed that 51.4% of the total area of Iran was experiencing rainfall changes, indicating a high rate of change in the mountains and western part of Iran.The minimum change was -15.7 mm in Sarab station and its maximum was 29.6 mm in the Kouhrang station. In a different study, the standard precipitation index with Mann-Kendall test was used for trend analysis of drought in the Caspian Sea basin.This study implied that there was not any significant trend in this region at the confidential level of 95% for January, May, and December months (Lebel, T. and A. Ali, 2009).

Rainfall in the central basin of Iran was evaluated using 48 stations during 1971 till 2000. The Mann-Kendall and Sense Estimator Slope tests were used for trend detection.Results showed that rainfall series had a significant negative trend. Also, these two methods have a similar capability for trend detection; however, the Sens method showed better results when a series includes zero amount (Hajam *et al*., 2008.), (Yazdani *et al*., 2011).

In this paper, we have used data from the period 1961 to 2011, recorded by 84 climate stations, for five decades. The Mann-Kendall test was used to find any trend of rainfall, temperature and evaporation, flow discharge, groundwater level, absolute maximum temperature, and absolute minimum temperature, showing significant differences in case of rainfall and temperature.

The purpose of this paper was to demonstrate the basic analysis of long-term water quality data for discharge and groundwater trends in Mighan Sub-basin of Arak.

2. Materials and Methods

2.1. Case study

Mighan sub-basin with an area of 5475 square kilometers extent and average of altitude about 1600 meters above sea level, is located in the central part of Iran and has an important role in the socio economic development of Iran. Geographically, it is located at latitudes 33°47´-34°44´ N, and longitudes 49°21´-50°25´ E (Ensafi Moghaddam,2014) In this sub-basin, the main seasonal rivers include Karahroud, Ashtian, Ebrahim Abad and Farmahan, which play significant roles in sediments in the marginal parts of the Mighan seasonal lake (Khanjani and Qadimi, 2008). Regarding the purpose of the research, this area, which is prone to drought, was considered. In other words, this region is facing water supply stress. Therefore, for better management and planning, appropriate studies on precipitation and temperature in this area are necessary.These results can be used for local and regional planning of water resources section and helps governors to select optimum water management strategies. In fact, the purpose of this study is to determine the trend of a time series in climatic elements that results in a suitable water supply for better water management in the Mighan sub-basin

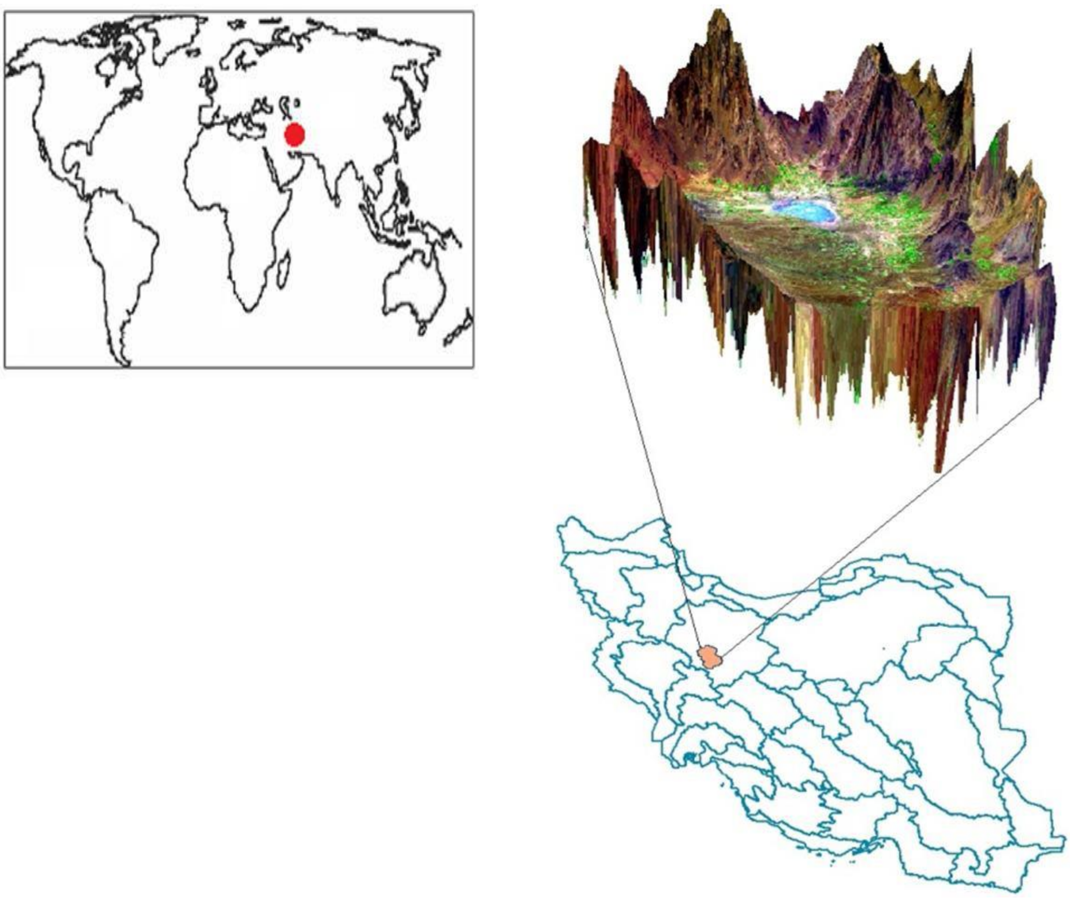

Fig. 1. Location and Geomorphic map of the Mighan sub-basin (Mohammadi and Seif, 2014)

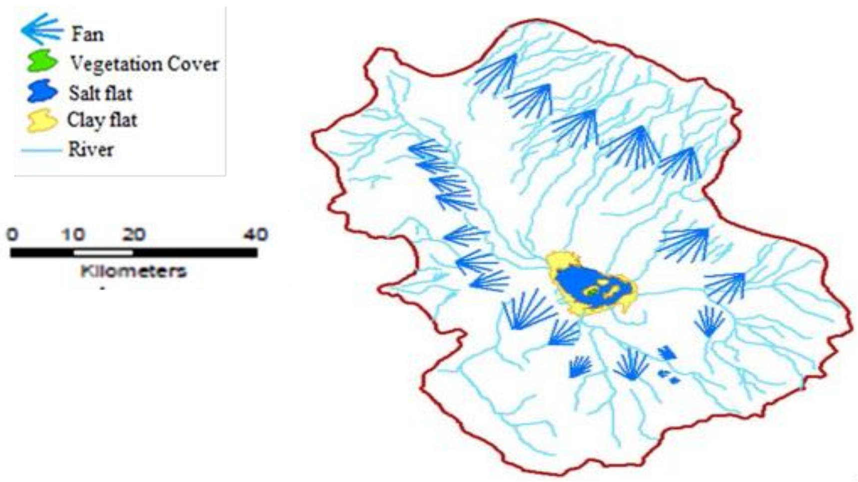

Fig. 2. Main seasonal rivers map of the Mighan sub-basin(Mohammadi and Seif, 2014)

2.2 Mann Kendall test

"The Mann-Kendall test is a nonparametric test for monotonic trends, such as concentrations that are either consistently increasing or decreasing over time. Therefore, the test is not appropriate when there are cyclic trends (where concentrations are alternatively increasing and then decreasing). The Mann-Kendall statistic provides an indication of whether a trend exists and whether the trend is positive or negative. Subsequent calculation of Kendall's Tau permits a comparison of the strength of correlation between two data series. The Mann-Kendall test can be used to evaluate the following: The Mann Kendall statistic (S) is calculated through pair-wise comparisons of each data point with all preceding data points, and determining the number of increases, decreases, and ties. Pairs of nondetects limit are "ties" that do not increase or decrease the value of S. A positive value for S implies an upward or increasing temporal trend, whereas a negative value implies a downward or decreasing trend. A value of S near zero suggests there is no significant upward or downward trend. The magnitude of S measures the "strength" of the trend. A statistically significant trend is reported if the absolute value of S is greater than the "critical value" of S. The nonparametric correlation coefficient Kendall's tau (τ) can be calculated to evaluate the nonparametric correlation between two data series. It is essentially a scaled measure of S; $\tau = S/[n(n-1)/2]$, where n denotes the number of concentration measurements. Therefore, a statistical trend is equivalently demonstrated when τ is significantly different from zero. However, it is more convenient to evaluate trends using Kendall's tau, because like the parametric linear correlation coefficient r, τ ranges from -1 to 1. A trend is "strong" if the absolute value of τ is near one. Trend tests may be used to determine if the mean of the population is stationary, which is a requirement for the use of many statistical tests. This test assumes independent concentration measurements„ (ITRC, 2011). "For trend-persistence calculation, we extend the Mann-Kendall test for trends to include arbitrary temporal weights„ (Maor and Keshet, 2016).

3. Results

3.1. Land hydrosphere data

"The precipitation will be transformed in three ways after landing on the ground: to form surface runoff, to infiltrate underground and then form groundwater, and to land-evaporate via vegetation and ground surface. In these three ways, the slope surface has a short lag time that allows the precipitation to quickly import into the channel and flow away. Additionally, the temperature controls the land evaporation capacity to some extent. Thus, the precipitation amount and the temperature have important influences on the infiltration of groundwater in this area„(Jia *et al.* ,2017). Annual monthly and daily values of land hydrosphere data series included flow discharge (m3 s-1), and groundwater level (m), were extracted from Hydro-Climate Data Network for Survey and imported into EXCEL spreadsheets. In EXCEL, the observed flow data which were derived from five flows in the Mighan sub-basin, were modified and adjusted flow dataset. The observed flow series minus the irrigation depletion data (negative values) were recorded for each day of each month throughout the station.

3.2. Climatic elements and land hydrosphere data trends

For the Performance of Natural Attenuation program, we provided five decades worth of data. “This tests the data for both increasing and decreasing trends at 80% and 90% confidence levels. If an increasing or decreasing trend was not present, the additional coefficient of variation (CV) test is used for stable and unstable conditions, as proposed by Wiedemeier: Designing Monitoring Programs to Effectively Evaluate the Performance of Natural Attenuation, AFCEE, San Antonio, Texas, January 2000 (Wiedemeier, *et al.*,2000). Here it is especially noteworthy that negative or zero values cannot be plotted correctly on log charts. Only positive values can be interpreted on a logarithmic scale. Using AFCEE software, calculation of interest was done and figures were drawn. Linear trends of the five stream flow metrics were computed for annual, seven-year and ten-year moving average time steps using Mann-Kendall trend test, suggesting evidence for climate change trends for all of the five study periods, which are defined as decades, starting in the 1960s to the first decade of the 2000s. Despite the inter-annual variability of climate, some climatic and hydrological trends were also compared. As in the case of the annual data, the daily temperature tended to rise based on a ≥ 80%, while there was no trend during (1961-1970) period based on a ≥90%. During this period and based on a ≥ 90%, the mean annual precipitation and flow discharge over this period clearly indicated a decreasing trend; however, an increasing trend was found for groundwater level(Fig. 2) & (Table 1).

Table 1. Classification of Man-Kendall test for trend (1961-1970)

Event Number	Date	Daily Temp/C	Precipitation/mm	Discharge/m3/s	Groundwater level/m	TempAbsu.Max /C	TempAbsu .Min /C
1	1961		288.3	82.0	25.0		
2	1962		321.4	67.3	33.9		
3	1963		254.8	53.0	21.9		
4	1964		222.3	68.4	30.0		
5	1965		228.3	49.5	25.8		
6	1966		192.2	21.6	40.2		
7	1967	10.5	208.6	15.4	17.0		
8	1968	13.3	401.3	29.1	30.4		
9	1969	15.5	192.5	23.4	30.5		
10	1970	14.3	155.8	13.7	32.1		
Mann Kendall Statistic S=		-23.0	-33.0	11.0	0.0	0.0	
Number of Rounds n		10.0	10.0	10.0	0.0	0.0	
Average		246.5	42.3	28.7	Not Applicable	Not Applicable	
Standard Deviation		72.9	24.8	6.5	Not Applicable	Not Applicable	
Coefficient of Variation (CV)		0.3	0.59	0.2	Not Applicable	Not Applicable	
Trend ≥ 80% Confidence Level		DECREASING	DECREASING	INCREASING	n<4	n<4	
Trend ≥ 90% Confidence Level		DECREASING	DECREASING	No Trend	n<4	n<4	
Stability Test, If No Trend Exists at					n<4	n<4	
80% Confidence Level		NA	NA	NA	n<4	n<4	
Error Check, Blank If no Errors Detected					n < 4	n < 4	

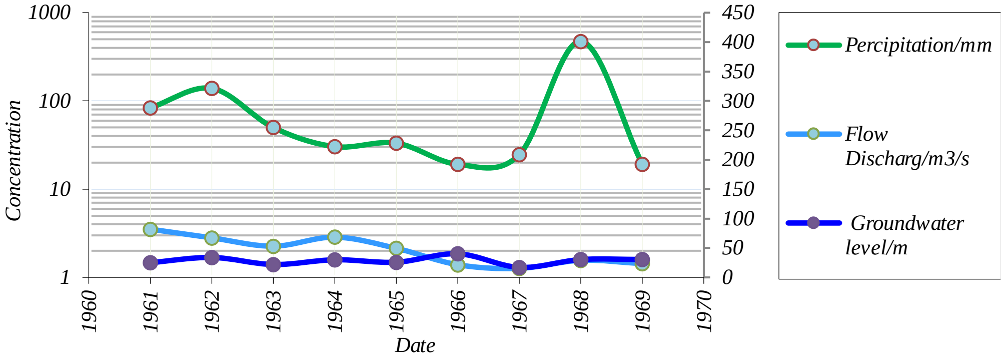

Fig. 2. Climatic elements and land hydrosphere data concentration trends (1961-1970)

During (1971-1980), the annual daily temperature, trends ≥80% and ≥ 90% was positive while rainfall showed positive trend based on a ≥ 80% and no trend based on a ≥90% of significance On the other hand, both annual trends, ≥80% and ≥ 90%, indicated an increasing rate for flow discharge and absolute minimum temperature during this period; however, no trend was found for groundwater level and absolute maximum temperature. (Fig. 3) & (Table 2.)

Table 2. Classification of Man-Kendall test for trend (1971-1980)

Event Number	Date	Daily Temp/C	Precipitation /mm	Discharge/m3/s	Groundwater level/m	TempAbsu .Max/C	TempAbsu.Min /C
1	1971	11.4	260.5	9.6	26.2	40.0	-30.5
2	1972	12.6	171.2	8.8	31.6	44.0	-26.0
3	1973	11.7	252.6	10.5	25.2	41.0	-33.5
4	1974	12.5	199.4	5.7	30.7	57.0	-27.5
5	1975	14.1	253.4	20.2	27.5	44.0	-20.0
6	1976	14.5	221.7	96.5	27.1	46.0	-30.5
7	1977	14.6	217.5	26.1	25.0	44.0	-15.0
8	1978	13.8	226.6	15.1	28.9	45.0	-13.5
9	1979	10.5	281.5	57.5	26.4	39.0	-18.5
10	1980	14.6	277.8	35.6	26.9	49.0	-17.5
Mann Kendall Statistic= S		17.0	13.0	23.0	-7.0	10.0	24.0
Number of Rounds= n		10.0	10.0	10.0	10.0	10.0	10.0
Average		13.0	236.2	28.6	27.6	44.9	-23.3
Standard Deviation		1.5	35.2	28.6	2.2	5.2	7.2
Coefficient of Variation (CV)		0.1	0.2	1.0	0.1	0.1	-0.3
Trend ≥ 80% Confidence Level		INCREASING	INCREASING	INCREASING	No Trend	No Trend	INCREASING
Trend ≥ 90% Confidence Level		INCREASING	No Trend	INCREASING	No Trend	No Trend	INCREASING
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	CV <= 1 STABLE	CV <= 1 STABLE	NA

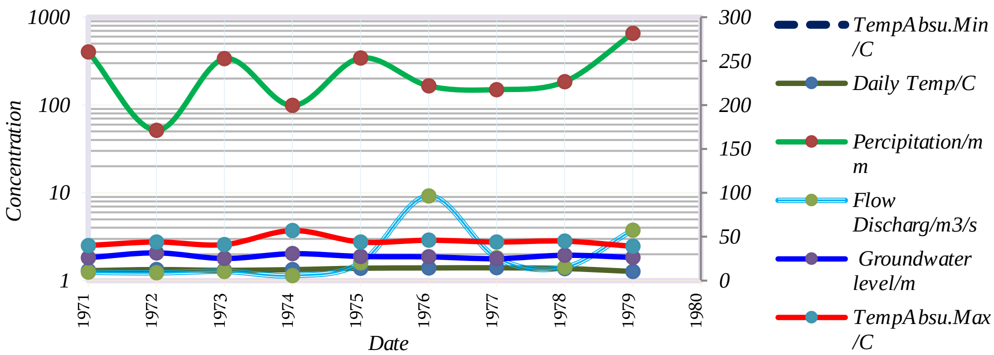

Fig. 3. Climatic elements and land hydrosphere data concentration trends (1971-1980)

Figure 4 and Table3 present an increasing (non-statistically significant) trend for daily temperature, based on a ≥ 80% and a ≥90% during (1981-1990) period. For precipitation and flow discharge, based on a ≥ 80% and a ≥90%, there were no trend; However, the results of Mann–Kendall test for groundwater represents the statistically significant trends at the 5% significance level (95% confidence level) and 10% significance level (90% confidence level). No trend was found for maximum and minimum absolute temperatures, based on a ≥ 80% and a ≥90%.(Fig. 4) &(Table 3).

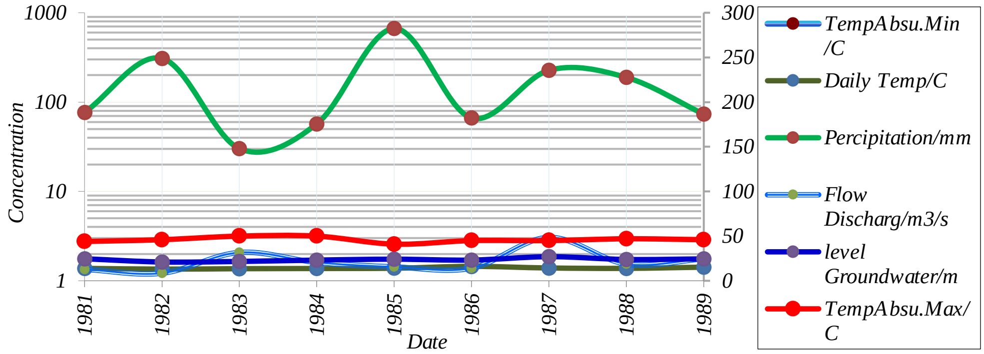

Fig. 4. Climatic elements and land hydrosphere data concentration trends (1981-1990)

Table 3. Classification of Man-Kendall test for trend (1981-1990)

Event Number	Date	Daily Temp/C	Precipitation/ mm	Discharge/m3/s	Groundwater level/m	TempAbsu.Max/C	TempAbsu. Min /C
1	1981	13.9	188.5	12.8	24.6	44.0	-19.0
2	1982	13.1	248.8	8.5	21.0	46.0	-27.0
3	1983	13.5	147.9	31.7	21.7	50.0	-16.5
4	1984	13.8	175.6	20.6	23.2	50.0	-20.0
5	1985	14.1	282.4	15.6	24.2	41.0	-15.0
6	1986	16.1	182.2	14.2	23.2	45.0	-11.5
7	1987	14.3	235.6	48.5	27.0	45.0	-18.0
8	1988	13.9	227.6	18.7	23.9	47.0	-22.0
9	1989	15.3	186.5	24.6	24.5	46.0	-20.0
10	1990	14.8	179.0	14.9	28.1	45.0	-20.6
Mann Kendall Statistic= S		25.0	-3.0	9.0	23.0	0.0	-4.0
Number of Rounds= n		10.0	10.0	10.0	10.0	10.0	10.0
Average		14.3	205.4	21.0	24.1	45.9	-19.0
Standard Deviation		0.9	41.2	11.7	2.2	2.7	4.2
Coefficient of Variation (CV)		0.1	0.2	0.6	0.1	0.1	-0.2
Trend ≥ 80% Confidence Level		INCREASING	No Trend	No Trend	INCREASING	No Trend	No Trend
Trend ≥ 90% Confidence Level		INCREASING	No Trend	No Trend	INCREASING	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	CV <= 1 STABLE	CV <= 1 STABLE	NA	CV <= 1 STABLE	CV <= 1 STABLE

The analysis showed that a statistically significant trend was found in daily temperature for (1991-2000) at 95% confidence level (α = 5%) based on ≥ 80%; however, no trend was observed based on ≥ 90% confidence level. The results for precipitation, based on a ≥ 80% and a ≥90%, showed no trend during the study period. According to the result of the analysis, a negative increasing trend was found for the groundwater level during 1991 to 2000 and there was a small increasing trend for flow discharge based on a ≥ 80% and a ≥90%. A decreasing trend was observed in absolute maximum temperature based on ≥ 80%; however, no trend was found for absolute annual temperature with 90% confidence interval. No consistent pattern of change in extremes was found for absolute minimum temperature based on ≥ 80% and ≥ 90% confidence level. (Fig. 5) & (Table 4).

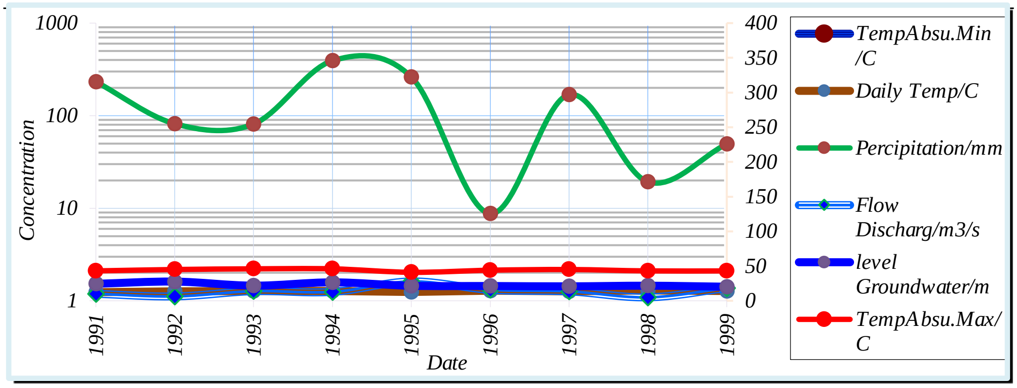

Fig. 5. Climatic elements and land hydrosphere data concentration trends (1991-2000)

Table 4. Classification of Man-Kendall test for trend (1991-2000)

Event Number	Date	Daily Temp/C	Precipitation /mm	Discharge/m3 /s	Groundwater level/m	TempAbsu.Max /C	TempAbsu .Min /C
1	1991	12.3	315.6	10.0	24.4	43.0	-28.0
2	1992	13.7	255.1	6.3	27.6	45.0	-22.0
3	1993	13.8	254.6	13.8	21.8	46.0	-21.0
4	1994	14.1	345.8	12.8	26.6	46.0	-18.0
5	1995	12.8	322.4	27.9	21.6	41.0	-22.4
6	1996	14.7	125.6	15.8	21.3	44.0	-17.0
7	1997	13.7	297.0	13.5	20.8	45.0	-20.5
8	1998	14.8	171.3	4.9	21.7	43.0	-18.0
9	1999	14.1	225.8	18.2	20.3	43.0	-26.0
10	2000	13.7	325.5	60.0	18.6	42.0	-28.5
Mann Kendall Statistic= S		11.0	-5.0	17.0	-33.0	-14.0	0.0
Number of Rounds= n		10.0	10.0	10.0	10.0	10.0	10.0
Average		13.8	263.9	18.3	22.5	43.8	-22.1
Standard Deviation		0.8	72.3	16.0	2.8	1.7	4.1
Coefficient of Variation (CV)		0.1	0.3	0.9	0.1	0.0	-0.2
Trend ≥ 80% Confidence Level		INCREASING	No Trend	INCREASING	DECREASING	DECREASING	No Trend
Trend ≥ 90% Confidence Level		No Trend	No Trend	INCREASING	DECREASING	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	CV <= 1 STABLE	NA	NA	NA	CV <= 1 STABLE

As can be seen from Figure 6 and Table 5, annual trends from Man-Kendall test indicate a decreasing rate of daily temperature, precipitation and flow discharge based on ≥ 80% confidence level during (2001-2011); however, no trend was found for the first two parameters based on ≥ 90%. A downward trend was also found for flow discharge. Moreover, a positive trend was observed for groundwater level and absolute maximum temperature based on ≥ 80% and for absolute minimum temperature based on ≥ 90% confidence levels. There was a negative trend for absolute minimum temperature based on two confidence levels. (Fig. 6) & (Table 5).

As previously mentioned, since the negative or zero values cannot be plotted correctly on log charts and only positive values can be interpreted on a logarithmic scale, the absolute minimum temperature diagram is not plotted in any figure. However, absolute minimum temperature values are available in the Designing Monitoring Programs tables.

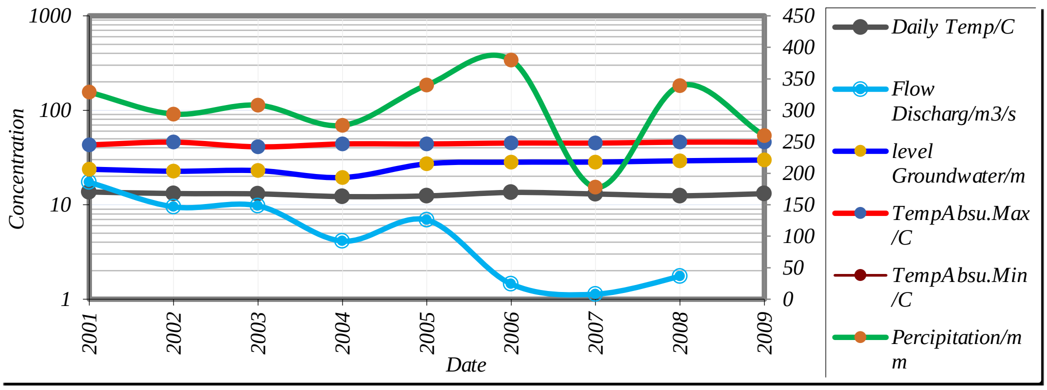

Fig. 6. Climatic elements and Land hydrosphere data Concentration Trends (2001-2011)

Table 5. Classification of Man-Kendall test for trend (from 2001-2011)

Event Number	Date	Daily Temp/C	Precipitation /mm	Discharge/m3/s	Groundwater level/m	TempAbsu. Max/C	TempAbsu.Min /C
1	2001	13.7	328.8	17.3	23.8	43.0	-21.4
2	2002	13.1	294.0	9.5	22.6	46.0	-21.0
3	2003	13.0	308.1	9.7	23.0	41.0	-21.0
4	2004	12.2	276.0	4.1	19.4	44.0	-21.6
5	2005	12.4	340.0	6.9	27.1	44.0	-21.5
6	2006	13.5	379.5	1.4	28.2	45.0	-20.5
7	2007	13.0	177.8	1.1	28.3	45.0	-22.0
8	2008	12.4	338.9	1.7	29.2	46.0	-32.0
9	2009	13.1	259.7		29.7	46.0	-32.0
10	2010	12.6	185.6		30.6	46.0	-32.0
Mann Kendall Statistic= S		-11.0	-11.0	-20.0	35.0	25.0	-25.0
Number of Rounds= n		10.0	10.0	8.0	10.0	10.0	10.0
Average		12.9	288.8	6.4	26.2	44.6	-24.5
Standard Deviation		0.5	66.1	5.6	3.7	1.7	5.2
Coefficient of Variation (CV)		0.0	0.2	0.9	0.1	0.0	-0.2
Trend ≥ 80% Confidence Level		DECREASING	DECREASING	DECREASING	INCREASING	INCREASING	DECREASING
Trend ≥ 90% Confidence Level		No Trend	No Trend	DECREASING	INCREASING	INCREASING	DECREASING
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	NA	NA	NA

4. Discussion

"Mann-Kendall test can be conducted in the presence of co-varieties. The non-parametric Mann-Kendall test is commonly employed to detect monotonic trends in series of environmental data, climate data or hydrological data."(Pohlert, 2018).This study employed the Mann-Kendall non-parametric test method to analyze the variation trend and mutation characteristic of the annual precipitation, evaporation, temperature, discharge/m3/s and groundwater recharge in the Mighan Sub-basin of Arak. In this research, it was assumed that there is a correlation between the concentration of climatic factors (s) and groundwater recharge and flow discharge of river streams.

By comparing the relationship between the change in precipitation and the discharge, the change in precipitation has a small contribution to the change in water level in the region. A total of 50 years of statistics reveal that the annual precipitation of the region generally follows an initial decreasing and then the subsequent increasing trend, and the most obvious declining trend occurred in 1996s, which was 276 mm less than that of the 1968s. Likewise, the variation trend of evaporation is similar to that of precipitation; however, the annual average temperature has maintained an increasing trend. The variation process of the groundwater recharge in the region is not generally consistent with that of the precipitation. Contrary to the flow discharge of river streams, the annual average of the flow discharge of river is generally consistent with that of the precipitation. Thus, all climate changes over the study period resulted in a reduction in the rate of recharge. The climatic change had the strongest influence in the 1996s, which caused the groundwater recharge amount in Mighan Sub-basin of Arak be reduced to 125.6 mm of annual precipitation, about 31.2% lower than that of the 1968s.The reduction of precipitation is one of main reasons disrupting the flow discharge of river streams. The results of the Mann-Kendall abrupt change test revealed that the groundwater recharge amount in the reservoirs zone of the region generally exhibited a declining tendency and the flow discharge of river streams had an initial decreasing trend. The flow discharge amount exhibited a rising trend before 1997. After that, a declining trend took place; however, a rising trend has been occurring since 2000. The calculated data from the period 1961 to 2011, recorded by 84 climate stations for five decades, were compared with 50-year observation data indicating that the model quality was satisfactory. This result was in consistent with the findings reported by of Jia *et al*., (2017) in the Jinci Spring Region, Northern China. They have compared the monthly simulation data of the observed groundwater flow and the river flow discharge, so that the statistical and graphical representation of their study has had similar satisfactory conclusions that could support the results of this study.

5. Conclusions

In this paper, the graphical Mann-Kendall test was used. According to the climatic and hydrological changes within a year and over five decades, the changes occurred were sudden. Most of these changes were observed in the average precipitation. The data indicate that while there is large year- to- year variability, daily temperature (annual) and the absolute maximum and minimum temperatures did not change over the study period. For climatic elements and the land hydrosphere data, the effects of long-term trends are great. As seen in the figures, there are many trends in climatic elements and streamflow timing. The greatest stream flow discharge occurred in 1976, while water shortage occurred in 2007. In the same year, precipitation values were quite low. In 1967, stream flow discharge and groundwater level values revealed water depletion. However, in other years, fluctuations in surface water discharge occurred separately. It is especially noteworthy that for the daily temperature, groundwater level and maximum and minimum temperature values, the trend has been remarkably slow and without any strong fluctuation between the two years over the five decades. For precipitation and especially flow discharge, the trends have been associated with larger fluctuations over five decades. This is the same feature found in arid regions of the world. Over time, most changes occurred in the first and fifth decades of the study period. According to the results obtained here, the daily temperature, maximum and minimum temperature and groundwater level trends have been slow or with no fluctuations for five decades, while precipitation and especially discharge have always been associated with severe fluctuations over five decades. Among the five time series extracted from the period, the first decade was the coldest decade with an average temperature of 12.96 ° C. The fifth decade was the hottest decade with an average temperature of 14.12 ° C over the fifty years in the Mighan sub-Basin. Based on the data distribution indices particularly the standard deviation and the coefficient of rainfall variability over the last two decades (2001-2001) and (2001-2001), the most irregular occurrences have been in the five decades of study period. Continued changes in precipitation and temperature trends may lead to water scarcity as well as drought and dust storms in Mighan sub-basin in the near future.

Acknowledgments

This paper is a part of Research Project under title: “ Influence of climate changes on ground and surface water using fifty years (Case study: Mighan watershed of Arak)” (2014)which is available in Research Institute of Forests and Rangelands, Tehran, Iran , by 2-09-09-89015 Cod. This work was partially supported by Research Institute of Forests and Rangelands (RIFR). The data used for Mighan sub-basin analysis during the past 50 years were provided through the careful and diligent work.

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