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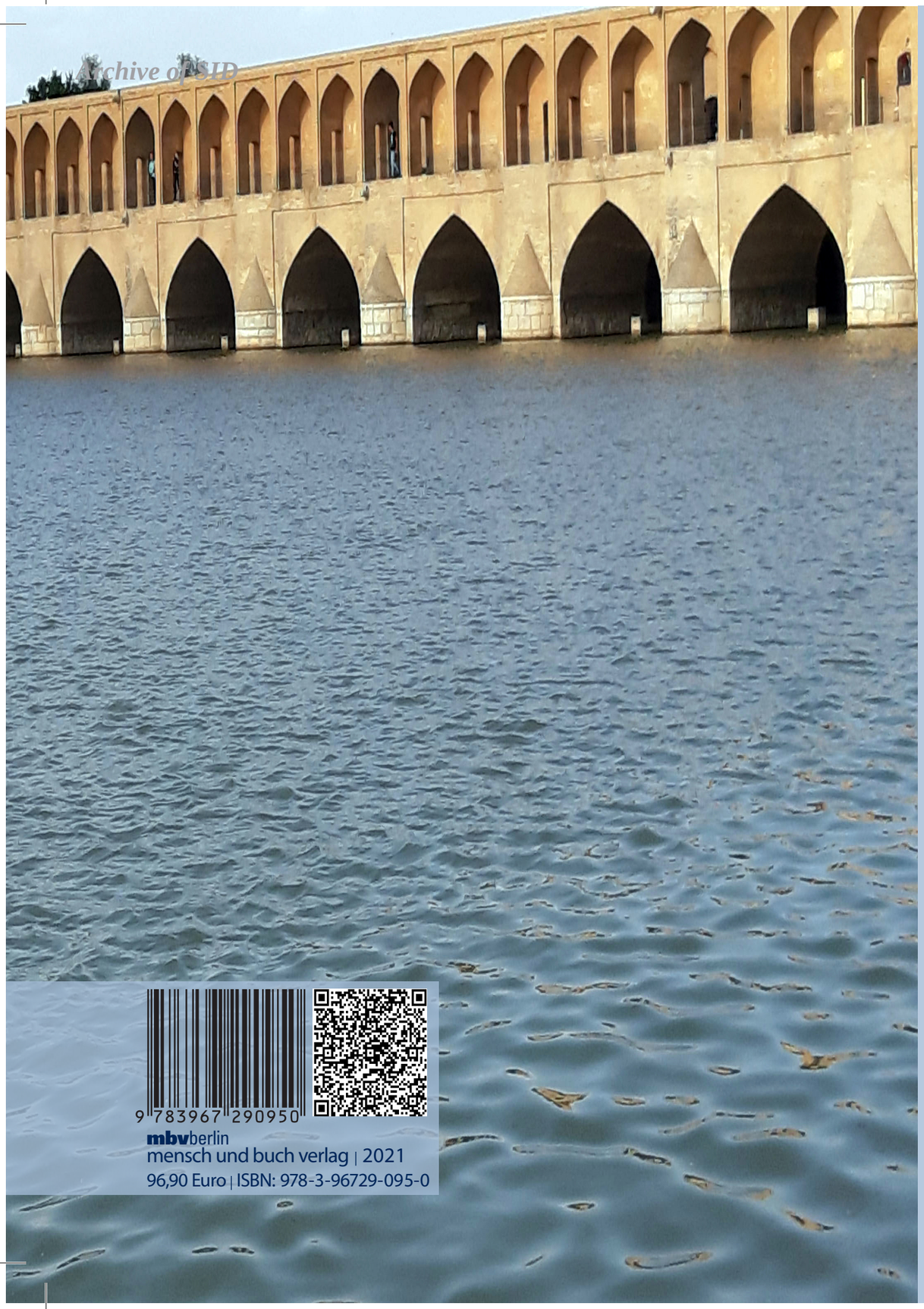

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Planning in Germany and Iran
Responding to Challenges of Climate Change through Intercultural Dialogue

Mais Jafari - Dietwald Gruehn
Hasan Sinemillioglu - Mathias Kaiser (Hrsg.)

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technische universität
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عنوان :

بررسی روند پارامترهای اقلیمی حوضه آبخیز زاینده رود

Investigation of Climatic Parameters Trend in Zayandehrud Watershed

گروه تخصصی: فنی مهندسی

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3.

Investigation of Climatic Parameters Trend in Zayandehrud Watershed

Razieh Saboohi, Mojgan Mirzaei, Morteza Khodagholi, Somayeh Salehpour, Amir Masoud Samani Majd,

Abstract

Given the importance of climate change on the structure of the earth's environment and its inhabitants, it is crucial to understand each and every aspect of how climate change occurs. In this study, statistical analysis of climatic parameters of precipitation and temperature in monthly and annual time scale was investigated to study climate change in Zayandehrud watershed, and also the variability of the mentioned parameters was performed in 16 synoptic stations using non-parametric Mann-Kendall test. The results show that precipitation trend in most of the stations in different months of the year has a negative trend in the Zayandehrud watershed and the trend of precipitation tends to increase in spring and autumn. Also, the trend of monthly and annual temperature parameters showed an increase, which was significant in the first months of summer at most stations, and it indicates warmer weather in early summer. Observations in late summer and early fall were not significant. Therefore, the increase in temperature and the tendency of precipitation to increase in spring and autumn indicate possible climate change in the Zayandehrud watershed in the future.

Keywords: Climate change, Climatic parameters, Mann-Kendall, Zayandehrud watershed

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1. Introduction

In the present age, climate change has become more and more popular, and values of climatic parameters are changing in different directions. For instance, increasing temperatures over time or decreasing rainfall are among the issues that are constantly raised (Saboohi et al., 2012; Soltani and Saboohi, 2011). Scientists have also shown that the Earth's climate has not been constant, but the cause of these changes in the past and present is different. Changeability in climates occurs both as a result of changes in climatic systems and external factors (Chung and Yoon 2000, Herath, and Ratnayake 2004; Yu, Yang. And Kuo 2006). Although all the causes of climate change in the world are not fully understood, the debate over climate change has certainly been and will be of interest to many researchers. Human concerns about future climate change in recent years have attracted more attention to this issue, as temperature and precipitation change have occurred mostly over the past 100 years and are expected to continue to do so (Lahmer 2002).

Over the past 100 years, air temperature has risen by about one degree Celsius, although the minimum temperature has risen more than the maximum (Vose, Wuertz and Peterson, 2005). The change in air temperature has caused major changes in the climatic behavior of the Earth's natural system and has caused significant changes in the amount and pattern of precipitation, the amount of direct sunlight, the amount of sunlight scattering (which is effective in photosynthesis) and cloudiness (Babaei Fini et al., 2014). The Intergovernmental Panel on Climate Change predicts that by 2100 the global average temperature will rise between 1.8 and 4 °C. With an increase of 1.5 to 2.5 °C, it is expected that approximately 20 to 30 percent of plant and animal species will become endangered, and it will have adverse effects on food security in developing countries as well (FAO, 2007). Climate change is also affecting floods, droughts, natural ecosystems, society and the economy (Oxoz and Bayazit 2003). The occurrence of water stress due to climate change, such as rising temperatures, drought, and declining snow cover, are major challenges in the world that can affect the flow of rivers in different parts, especially upstream (Hasheminasab et al., 2019). The most important effect of climate change is the impact on water resources in each region and its change over time. As the temperature increases, the plants need more water and the water behavior of the plant changes and the utilization of water resources increases (Kondori et al., 2019).

Given the importance of climate change on the structure of the planet's environment and its inhabitants, trying to understand how climate change is occurring is a vital matter. This

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necessity becomes apparent, especially at the present time when global warming has become a serious issue. In this regard, many studies have been conducted globally and nationally in connection with the study of past trends and forecasts, which at the national level we can mention the researches by Nazeri Tehroodi et al. 2016, Abtahi et al. 2014, Qareh Khani et al. 2013, Modarres and Khodaqoli 2009 and at the global level, Niguse Beyene 2016, Rauf, Rafi and Muhammad 2016, Mekonnen and Disse 2016, Sarkar, Chicholikar and Rathore 2015, Osman et al., 2014, Saboohi et al. 2012 and Soltani et al.2012, Nazeri Tehrani et al. 2016., Ahmadi et al., 2019., Mirzaei et al., 2019 examined the trend of stationary and regional precipitation changes in the country. The results of the trend on both stationary and regional scales confirmed a downward trend in the northwest. On a regional scale, a significant declining trend was observed in the northwestern, semi-central, and southwestern regions of the country, a not significant declining trend in the western regions of Iran and a not significant declining trend in the northern regions and the Caspian Sea margin.

In general, the above studies show an increase in temperature parameters in the world, but the precipitation parameter is increasing in some parts of the world and decreasing in some others. Overall, the precipitation pattern is changing around the world.

Therefore, in this study, in order to investigate the past trend of climatic variables of temperature and precipitation, a study was conducted in the Zayandehrud watershed.

2. Materials and methods

2.1 Area under study

Zayandehrud watershed with geographical coordinates of 50° 2' to 53° 24' east longitude and 31° 11' to 33° 42' north latitude is located in the central region of Iran. The area of this region is about 41347 square kilometers and its perimeter is 1183 kilometers (Khodagholi, 2005). About 87.7% of Zayandehrud watershed is located in Esfahan province and the rest in Chaharmahal and Bakhtiari, Yazd and Fars provinces. The watershed is bounded on the north by the Namak Lake watershed (central watershed), on the south by Abadeh and Semirom counties, on the west by the Karun river watershed, and on the east by the Ardestan watershed (Aslani 2009).

The western part of the watershed is mainly mountainous (Daranshahr, Fereydunshahr and Farsan cities) and its eastern part is plain and includes the cities of Esfahan, Shahreza and Meymeh. The watershed has a main tributary called Zayandehrud and a number of sub-

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tributaries. Its main tributary originates from the eastern slopes of the Bakhtiari Mountains (Koohrang) located in the middle Zagros and flows in the west-east direction, which after about 350 km flows into Gavkhuni Wetland (Khodagholi 1384).

2.2 Climatic database

In order to form a climatic database, synoptic stations were used inside and adjacent to the Zayandehrud watershed. These stations have the least missing data while having a statistically reliable length (Figure 3-1 and Table 3-1). The studied climatic data include precipitation and the average temperature on a monthly and annual scale.

2.3 Method

In this study, using climatic data of precipitation and temperature of nearby stations located in the study area, the trend of climatic factors related to temperature and precipitation was investigated. Because the factors related to temperature and precipitation are among the most important meteorological factors in determining the role and distribution of other climatic elements and they are also one of the important indicators in climatic classifications (Alizadeh et al., 2011).

The analyses of the temperature and precipitation trend were examined as follows:

- Collection of climate data from stations with long-term meteorological (about 30 years) statistics
- Investigating the trend of climatic factors related to temperature and precipitation using modified non-parametric Mann-Kendall test. Because precipitation data are usually not normal

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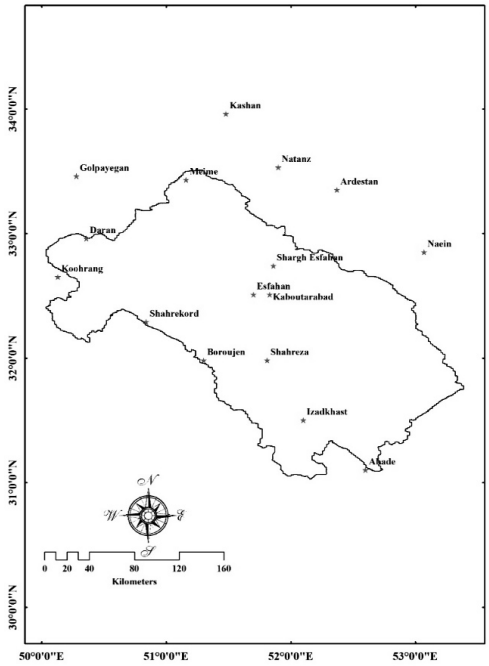

Figure 3-1 Location of synoptic stations inside and outside the province

Table 3-1 Location of selected stations inside and outside the Zayandehrud basin

Station	Elevation	Latitude	Longitude
Ardestan	1255.5	33.35	52.37
Esfahan	1550.4	32.51	51.70
Daran	2290	32.96	50.36
Kashan	955	33.96	51.48
Sharq esfahan	1551.9	32.74	51.86
Shahreza	1858	31.98	51.81
Kaboutarabad	1542.5	32.51	51.83
Golpayegan	1870	33.46	50.28
Meime	1980	33.43	51.16
Naein	1573.7	32.85	53.07
Natanz	1685	33.53	51.90
Boroujen	2260	51/30	31/98
Shahrekord	2050	50/84	32/29
Koohrang	2365	50/13	32/65
Abade	2030	31.1	52.6
Izadkhast	2188	31.5	52.1

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3. Results

3.1 Investigating the variable trend of precipitation value

Table 3-2 shows that in January, the trend of precipitation in all stations except Ardestan is negative, and this trend is significant in Boroujen, Shahrekord and Meymeh stations at the level of 5%. In February, the trend was negative at all stations except Ardestan, Izadkhast and Boroujen, and no significant trend was observed at any of the stations. In March, all stations except Esfahan station have a negative trend and in Koohrang and Golpayegan stations, the trend is significant at the level of 5%. In April, unlike in previous months, the trend of precipitation in all stations except Abadeh and Naein is positive, and no significant trend is observed in any of the stations. In May, Golpayegan and Natanz stations have a negative trend and the rest of the stations show a positive trend and in Izadkhast, the trend is significant at the level of 5%. In June, July, and September, no significant trends were observed at any of the stations.

In October, the trends are positive in most stations except Boroujen and Shahreza, and in Shahrekord station, the trend is significant at the level of 5%. In November, the trend is positive in all stations, and in Ardestan, Shahrekord and Natanz stations, a significant trend is observed at the level of 5%. In December, which is the beginning of winter, the trends are negative in most stations, and in Izadkhavat, Abadeh and Meymeh stations, there is a significant trend at the level of 5% and in general, on an annual scale, most stations have a negative trend, and this trend is significant at the Koohrang station at the level of 5%. According to Figure 3-2, on this scale, the most negative trends are observed in the western and northeastern parts, and by moving towards the center of the watershed, we move towards positive trends.

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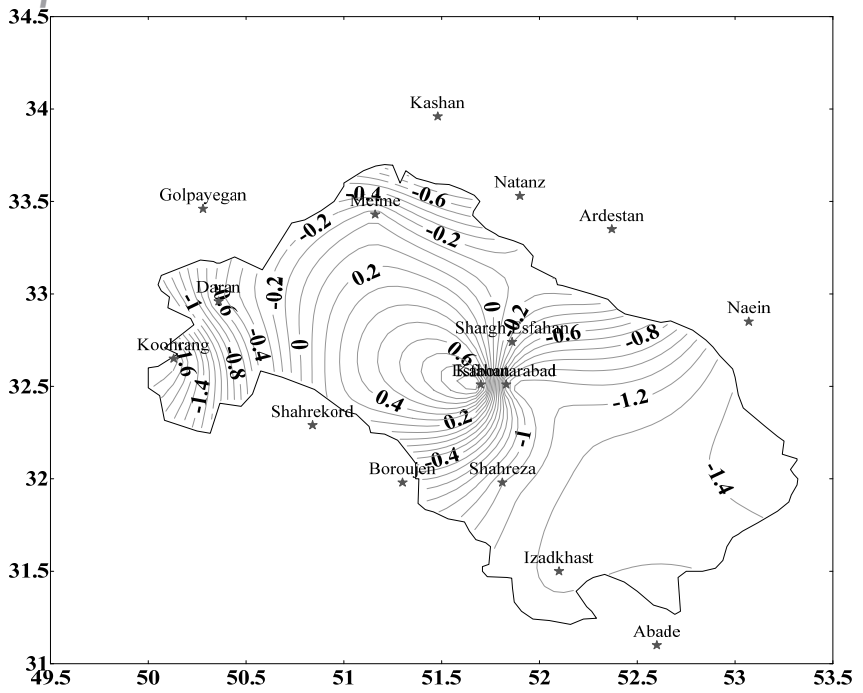

Figure 3-2 Trend of precipitation parameter in Zayandehrud watershed in about 30 years

3.2 Investigating the variable trend of average temperature

Table 3-3 shows that the average temperature in January in all stations except Abadeh station is positive and this trend is significant in Boroujen station at the level of 1% and in Kashan and Koohrang station at the level of 5%. In February, the trend is positive at all stations and Boroujen and Koohrang stations show a significant trend at the level of 1% and at the stations of Daran, East Esfahan, Kashan and Golpayegan at the level of 5%. At the end of winter (end of March), the average temperature trend is positive in all stations and there is a significant trend in most stations, as the trend in Ardestan, Esfahan, Boroujen, Daran, Shahreza, Kabutarabad, Koohrang, Golpayegan, Natanz and Naein stations at the level of 1% and at the East Esfahan station at the level of 5% is significant. In April, there was a negative trend in Shahrekord and Izadkhast stations, and this trend is significant in Esfahan and Shahrekord stations at the level of 1% and in Borujen and East Esfahan stations at the level of 5%. In May, there is a positive trend in all stations except Izadkhavat and Shahrekord, and the trend is significant at Esfahan and Shahrekord stations at 1% and at Borujen and East Esfahan stations at 5%. In June, the trend is positive in all months of the year, and in most stations the trend is significant at the level of 1%, as the trend in Ardestan, Esfahan, Borujen, Daran, East Esfahan, Shahreza, Kabutarabad, Golpayegan, Naein and Natanz stations is significant at the level of

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1%. In July, Shahrekord and Shahreza stations show a negative trend and the trend is significant at Esfahan station at the level of 1% and at Borujen, Daran and East Esfahan stations at the level of 5%. It is noteworthy that in August, which is one of the summer months, the trend is negative in many stations, and this negative trend is significant in Esfahan and Shahrekord stations at the level of 1%. In September, the trend is positive in all stations except Izadkhavat, Shahrekord and Meymeh, and the trend in Esfahan, Boroujen, East Esfahan, Shahrekord and Kabutarabad stations is significant at the level of 1%. In October, the stations of Izadkhast, Shahrekord and Meymeh show a negative trend, and in Boroujen and Koohrang stations, it is significant at the level of 5% and in Esfahan, East Esfahan, Shahrekord and Kabutarabad stations at the level of 1%. In November, the negative trend is observed in most stations and one of the notable points is the significant trend at the level of 1% in Shahrekord station. In December, most stations had a positive trend, except for Abadeh and Shahrekord stations, and the average temperature trend at Esfahan station is significant at the level of 5%. On an annual scale, the temperature is positive in all stations except Shahrekord, and this trend is significant in Esfahan, East Esfahan and Koohrang stations at the level of 1% and at the stations of Boroujen, Shahreza, Kabutarabad and Naein at the level of 5%. On an annual scale, the largest positive trends are observed around Esfahan, according to Figure 3-3, and the trend decreases as we move northwest.

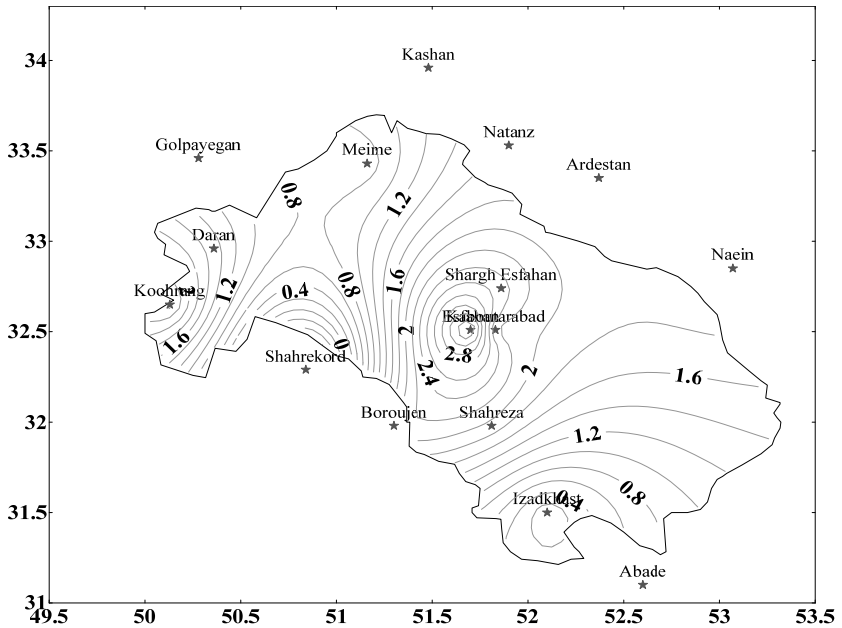

Figure 3-3 Trend of average temperature parameter in Zayandehrud watershed

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4. Discussion and conclusion

The attention toward climate change over the past century has been marked by a warming process that began around the last decade of the nineteenth century. Climate change, which today is considered one of the most discussed scientific and even political-social issues, was not in fact, a process unique to our time. Based on the available evidence, the Earth has constantly undergone such changes in different periods of geology, during which warm periods were replaced by cold periods, and dry and wet periods were alternated with cold and dry periods (Azizi 2010, Kouchaki 1998). What distinguishes the climate change of the present century, and especially its second half, from the changes of the past, is its nature and rapidity, so that today these changes have accelerated to a greater extent, and the process is not so predictable (Kouchaki 1998). Therefore, in this study, the analysis of climatic elements of precipitation and temperature in monthly and annual time scales in 16 synoptic stations of Zayandehrud watershed was performed using the Mann-Kendall test. The results of annual precipitation show that the number of stations with significant trend is very low, so that in winter in December and January, respectively, 75.75 and 18.75% significant trend is observed, while Meymeh is the only station within the watershed that has a significant trend. While in the spring months, the trends are positive, but there is no significant trend in the watershed and the autumn trends are similar to the spring trends. But on an annual scale, most trends are negative, and only 6.25 percent of stations have significant trends. Soltani and Saboohi (2011) showed that although no significant trends have been observed in Iran over the past 50 years, the tendency towards reduced precipitation in April and its increase in December and July could indicate possible climate change in the future. Khalili and Bazrafshan (2004) analyzed the trend of annual, seasonal and monthly precipitation changes in five stations with long-term statistics in Iran. The results showed that in the monthly scale, the conditions that could prove the existence of a trend or climate change in precipitation are very limited and insufficient to conclude. At the annual scale, the tests do not confirm any component of climate change in the temporal trend of precipitation. Considering the average temperature parameter in winter, all stations located in the watershed have an increasing trend, and from these stations in December, January and February, 6.25, 6.25 and 18.75% of the stations have significant trends, respectively. Early in the spring, we see a significant increase in positive trends, with 37.5 percent of stations having significant trends in March. One of the highlights is the declining trend in August and November, with 31.25 percent of stations showing significant positive trends on an annual scale. The results of Saboohi et al. (2012) showed that until 2005, the

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temperature trend is heating up, especially in the summer. Masoudian (2004) studied the trend of temperature parameters in Iran in the last 5 decades. The results showed that the night, day and day-to-day temperature of Iran has increased by about three, one and two °C every hundred years, respectively. In the Zayandehrud watershed, according to this study, we are experiencing warming at the beginning of the summer season, while in the last months, there are declining trends. In general, on an annual scale, upward trends are observed in all stations, 31.25% of which is significant. In the highlands, the increase in average temperature, especially in early spring, late autumn, and winter, causes premature melting of snow in the region and due to reduced rainfall in mountainous areas, it causes many problems in water storage. In general, rising day and night temperatures along with reduced rainfall can have detrimental effects, including reduced snowfall and its premature melting, which causes more evaporation and transpiration and affects the water needs of plants.

Under such circumstances, rising winter temperatures will lead to declining snow reserves in the western part of the watershed, so in the future, we should expect more water shortage problems compared to the current situation. Therefore, the essence of the management of water resources in the Zayandehrud watershed based on climate scenarios should be on the agenda of managers and researchers in the future.

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Table 3-2 Statistical value of Mann-Kendall, precipitation parameter in stations inside and outside Zayandehrud watershed based on 1970-2019

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ardestan	0.23	0.71	-0.98	1.50	0.92	0.12	0.11	-1.66	0.14	0.64	2.41*	-0.29	0.71
Esfahan	-1.02	-0.08	1.69	0.30	0.47	1.56	0.51	-0.09	-0.39	0.01	1.72	-0.89	1.07
Izadkhast	-1.85	0.36	-0.75	0.52	2.38*	-0.14	-1.49	0.95	-0.25	1.29	0.75	-2.04*	-1.33
Abade	-1.95	-0.57	-0.98	-0.05	0.16	-0.70	-0.13	-0.89	1.35	0.47	1.47	-1.97*	-1.12
Boroujen	-2.29*	0.10	-1.36	0.82	0.50	0.33	-0.11	0.56	0.82	-0.60	0.87	-0.95	-0.65
Daran	-1.40	-1.08	-1.50	0.58	0.48	-0.57	0.34	-1.58	0.47	1.68	1.15	0.50	-0.54
Shargh esfahan	-1.63	-0.75	-0.79	1.71	0.60	0.80	-0.07	-0.20	0.54	0.40	0.74	-1.77	-0.38
Shahreza	-1.15	-0.18	-1.72	0.84	1.56	-0.19	-1.11	-0.36	0.52	-0.28	0.20	-0.77	-1.10
Shahrekord	-2.02*	-0.11	-0.15	0.24	0.24	1.17	1.60	-0.93	2.43	2.02*	2.08*	0.22	0.12
Kashan	-0.90	-1.12	-0.46	0.56	0.28	0.19	0.38	-1.21	1.49	0.79	0.87	-1.36	-1.88
Kaboutarabad	-1.77	-0.86	-1.71	0.92	0.00	-0.41	-0.89	-0.92	0.31	0.21	1.52	-1.21	-1.13
Koohrang	-1.35	-1.25	-2.12*	0.47	0.86	-0.14	-1.65	-0.14	-0.52	0.65	0.50	-1.57	-1.99*
Golpayegan	-1.81	-1.17	-2.33*	0.63	-0.60	-0.71	0.26	-0.21	0.75	1.38	1.33	-0.42	-0.79
Meime	-2.47*	-0.36	-0.88	0.62	1.30	0.64	-1.50	-1.15	-0.52	0.95	1.78	-2.34*	-0.03
Naein	-1.73	-0.25	-0.83	-0.31	0.04	-0.82	0.23	-0.38	-0.78	0.48	1.81	-1.42	-1.44
Natanz	-0.25	-0.33	-1.33	0.29	-0.63	-0.19	0.08	-1.04	0.23	1.01	1.94*	-0.90	-0.75

*Significance at the level of 5%

** Significance at the level of 1%

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Table 3-3 Statistical value of Mann-Kendall, average temperature parameter in stations inside and outside Zayandehrud watershed based on 1970-2019

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ardestan	1.88	1.25	2.67**	1.21	1.41	3.13**	1.81	-0.92	0.58	1.42	-0.79	0.92	1.41
Esfahan	1.45	1.68	2.54**	3.72**	3.13**	3.69**	4.32**	2.63**	3.81**	3.25**	1.52	2.19*	3.72**
Izadkhast	1.78	0.23	0.62	-0.94	-0.75	1.33	0.03	-0.81	-0.81	-1.59	-1.07	0.55	0.03
Abade	-0.03	0.74	1.84	-0.53	0.46	0.52	0.92	-1.11	-0.91	1.18	-1.34	-0.20	0.75
Boroujen	2.86**	3.50**	2.68**	2.40*	2.00*	4.01**	2.41*	0.75	3.03**	2.25*	-0.20	0.95	2.14*
Daran	1.63	2.00*	3.13**	1.15	1.46	2.86**	2.16*	-0.83	1.42	1.58	-0.25	1.13	1.50
Shargh esfahan	1.26	2.36*	2.28*	1.41	2.10*	2.58**	2.21*	0.83	2.45**	3.00**	-1.11	0.63	2.50**
Shahreza	0.84	1.10	2.95**	0.40	1.90	2.60**	-0.63	-1.01	0.18	1.63	-1.15	0.09	1.94*
Shahrekord	1.67	1.10	0.14	-0.57	-2.47**	-1.51	-1.38	-2.49**	-2.59**	-2.51**	-2.50**	-0.04	-1.71
Kashan	2.09*	2.20*	1.52	0.99	0.65	0.45	1.03	-0.13	0.97	0.32	-1.14	0.56	1.28
Kaboutarabad	1.25	2.25	3.46**	2.13*	1.19	4.17**	1.71	1.21	2.59**	2.75**	0.33	0.96	2.16*
Koohrang	2.14*	3.81**	2.58**	2.97**	0.94	1.44	1.43	-0.21	1.05	2.42*	-0.70	1.15	2.48**
Golpayegan	1.71	2.00*	3.13**	1.25	0.79	3.00**	1.58	-0.38	1.63	1.63	-0.71	0.54	0.93
Meime	1.14	0.55	1.01	-0.21	0.16	1.46	0.98	-0.88	-0.10	-0.75	0.42	0.49	0.68
Naein	1.79	0.96	3.34**	1.54	1.63	3.29**	0.75	-0.58	0.63	2.13*	-0.79	1.13	2.07*
Natanz	1.92	1.83	2.84**	1.21	1.54	3.00**	1.79	-0.42	1.13	1.42	0.00	0.96	1.63

*Significance at the level of 5%

** Significance at the level of 1%

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