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Analysis of Precipitation and Temperature Trends in Sefid-Roud Basin

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***Abstract*—**Temperature, humidity and precipitation in an area, are parameters proved influential in the climate of that area, and one should recognize them so that he can determine the climate of that area. Climate changes are of primary importance in climatology, and in recent years, have been of great concern to researchers and even politicians and organizations, for they can play an important role in social, political and economic activities. Even though the real cause of climate changes or their stability is not yet fully recognized, they are a matter of concern to researchers and their importance for countries has prompted them to investigate climate changes in different levels, especially in regional, national and continental level. This issue has less been investigated in our country. However, in recent years, there have been some researches and conferences on climate changes. This study is also in line with such researches and tries to investigate and analyze the trends of climate changes (temperature and precipitation) in Sefid-roud (the name of a river) basin. Three parameters of mean annual precipitation, temperature, and maximum and minimum temperatures in 36 synoptic and climatology stations in a statistical period of 49 years (1956-2005) in the stations of Sefid-roud basin were analyzed by Mann-Kendall test. The results obtained by data analysis show that climate changes are short term and have a trend. The analysis of mean temperature revealed that changes have a significantly rising trend, besides the precipitation has a significantly falling trend.

***Keywords*—**Trend, Climate changes, Sefid-roud, Mann-Kendall

I. Introduction

In the last decade, climate changes have been a great environmental matter of concern to different world organizations. Issues such as water and air pollution, decrease in soil production rate, destruction of natural resources, reforestation and similar issues, especially global warming are of great importance because of their role in increasing the greenhouse gases. Such issues may have different effects on different aspects of human life on the earth, especially on human settlements, agricultural products, energy consumption, etc. These factors have motivated man to trace the history of evidences, causes and future of climate changes. [1]. Lots of studies have been conducted about the trend of climate changes. For instance, Buffoni et al. [2] have analyzed the precipitation trends in Italy. They collected the precipitation data of 32 dispersed stations across Italy. The stations were divided into two homogenous climate regions, to analyze the seasonal and annual precipitation trends in Italy in a 164-year period. They used Mann-Kendall test to analyze the trend. They came to this conclusion that different regions and seasons have different trends. Having collected data from 25 stations, Stafford et al. [3] obtained the trend of temperature and precipitation for a 50-year period in Alaska (1949-1998). For linear analysis, they used mean maximum and minimum temperature, daily temperature and overall precipitation, they concluded that mean seasonal and annual temperature across the state had risen and most of them are statistically in 95% or upper level. Tomzieu et al. [4] analyzed the variations in winter precipitation in 40 Precipitation stations from 1960 to1995. They used Mann-Kendall and Petit tests to analyze the variability of time series and to estimate trends and change points. They found that in this period, nearly all stations were manifesting a significant falling trend in the winter precipitation. Domonkos [5] analyzed precipitation trend in Hungary. He analyzed monthly time series in Hungary's stations in 1901 to 1998 to discover long term changes in the precipitation of 20th century. In his study, he particularly investigated the changes in recent decades and their relations with long scale climate changes in Europe and Atlantic Ocean. Furthermore, systematic changes were analyzed by linear trend and Mann-Kendall test. Long-term changes were explained by a 15 point Gaussian filter in time series. Gemmer et al. [6] analyzed monthly precipitation in 160 stations in China from 1951 to 2002, using Mann-Kendall test. They succeeded to determine the positive and negative monthly trends in 90%, 95% and 99% level of significance. Using single season index, Livida and Asimakopolous [7] studied seasonal precipitation trend in Greece and compared the linear co-relation of this index with mean single season index. In the following step, they used regression analysis of this index along with latitude and discovered a significant reverse co-relation. Eventually, the analysis of time series of this index showed that there has been no significant change in seasonal precipitation of this region. Using daily precipitation data of 494 stations from 1961 to 2000, Qian and Lin [8] analyzed regional trend of precipitation indexes in China. Of precipitation indexes, precipitation accumulation, enduring precipitation was used and their decimal differences were investigated. AminiNiya, Lashkari and Alijani [9] have analyzed heavy snowfall variations in northeast of Iran. The analysis showed that heavy snowfall in all stations and during the common statistical period has had many variations and falling trend. The use of ranked Mann-Kendall test in stations having long term statistics shows a falling trend in receiving heavy snowfall in Tabriz and Uremia stations and the absence

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of any trend in Ardebil and Khoy. Nader [10] has studied climate changes in the last 50 years, with particular emphasis on northwest region of Iran. To analyze and discover trends in time series, he had used Mann-Kendall t-test and Mann-Kendall statistical-graphic method. The study results showed that hypothesis of "accidental data" was utterly rejected, and a trend was dominating the data. Furthermore, graphic figure analysis show changes in U and U', mean minimum temperature and precipitation in the last 50 years are quite significant. Azizi and Roshani [11] have also used Mann-Kendall method to analyze climate changes in southern shore of Caspian Sea. The study results reveal that elements of climate change from 1950 to 1990. These changes were short term weather variations and trends, which are found in some monthly, seasonal and annual time series.

Using Mann-Kendall, Feizi et al. [12] have analyzed climate changes in Sistan and Baluchistan. The study results show that in all stations, except for Zahedan, temperatures have had a falling trend during the year.

Using Mann-Kendall method, Omidvar and Khosravi [13] have investigated the changes of some climate factors in northern shore of Persian Gulf. The study results show that changes in mean temperature in all stations are similar to changes in minimum temperature trend. Furthermore, minimum temperature was the factor which has raised the mean temperature of the stations in the study area. Besides, relative temperature had either significant falling trend or had no significant trend. As of precipitation frequency in the study area, there has been a significant falling trend and there was no significant rising trend.

Using none-parametric Mann-Kendall test, Hojam et al. [14] have investigated seasonal and annual precipitation trends. The study results show a significant falling trend in some of the time series of the study which was verified by both tests, but no rising trend was mutually verified by the two test methods.

Khordadi et al. [15] have analyzed metrological parameters of several regions in Iran.

Jahan Bakhsh et al. [16] have also investigated precipitation and temperature trends in Karkheh basin. The study results show that there has been a falling trend in annual precipitation in most sub-basins of the study area; meanwhile, the temperature has had a rising trend.

Taking the above factors into account, this study has tried to analyze the significance of climate changes and their effects on regional and local variables of temperature and precipitation trend in Sefid-rud basin, which at the same time play a greater role in climate changes.

II. Methodology

In this study, we have tried to investigate changes in temperature and precipitation trend of the Sefid-rud basin which is selected as the study area (Fig. 1).

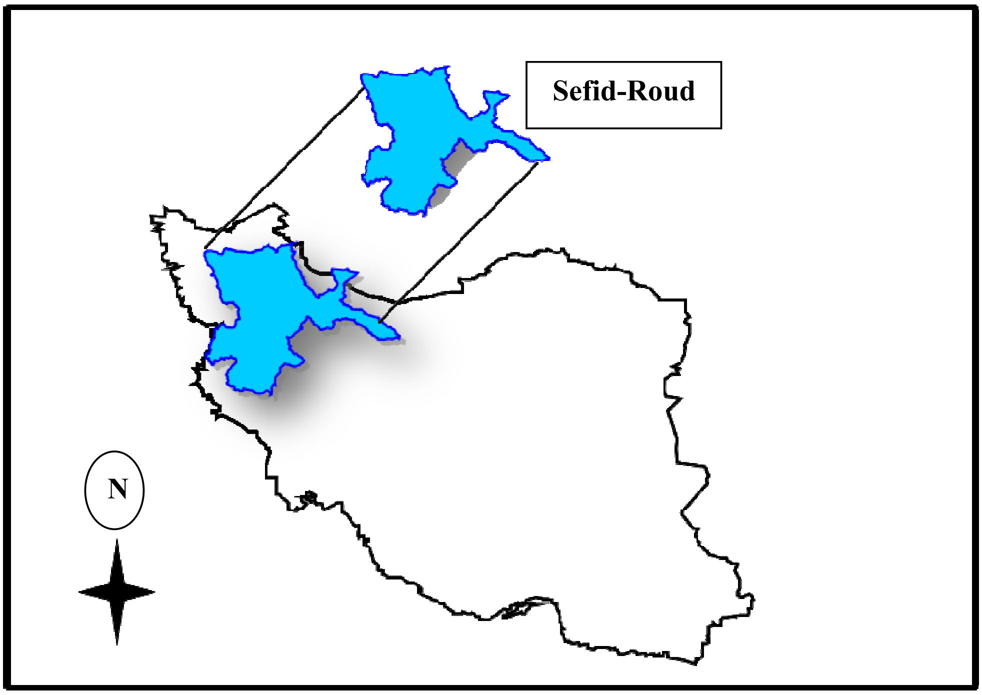

Fig. 1 Geographical characteristics of Sefid-roud basin

Sefid-roud basin has two major branches: Shah-roud and Gizil-Uzun. Shah-rud branch has a drainage basin of 5070 square kilometers, which rises in Talegan region and advancing eastward, enters Sefid-roud dam.

Gizil-Uzun branch with an area of 500 square kilometers rises from mountains of Kurdistan province. Sefid-roud basin has an area of 49300 square kilometers. The altitude of the basin is between -15 to 2971. It has a stream flow of 137.29

cubic meters. Sefid-roud delta is formed by Sefid-roud flowing into the Caspian Sea. This delta has a line shore of 110 kilometers and river plain of 3600 square meters. The river basin is more than 67000 square kilometers. The mean depth of the river in the delta is 2.5 meters, and the mean annual deposit carried in the river is 26 million tons. Sefid-roud dam, also known as Manjil dam, constructed in 1967 prevents a large amount of sediments from flowing into the delta.

The mean precipitation is about 519 mm, and varies between 299 to 1113 mm. The mean temperature change is between 5 to 19 degrees Celsius, with a mean of 14 Celsius. These data were collected from 36 synoptic and climatology stations. Four parameters of minimum temperatures, maximum temperatures, mean temperatures and precipitation of a 49-year period (1956-2005) were selected for analysis of general trend of climate changes. Having collected metrological data of the study area, we drew the map of temperatures and precipitation (maximum, minimum, and mean), then we calculated their annual mean. Mann-Kendall test was used for the analysis of significant trends in our data.

Mann-Kendall test was used for the analysis of significant trends in our data. This method is widely used for the analysis of trends in metrological and hydrological series [17]. One of the advantages of this method is its applicability for time series, which do not follow a typical statistical distribution.

This method is scarcely affected by temperature extreme values of time series. [18]

In a given series of data, the following formula is used to see whether data are accidental:

$$T=\frac{4p}{n(n-1)} -1$$

In which t is Mann-Kendall value, p is the total sum of ranks higher than n1, and is obtained by the following formula $P = \sum_{i=1}^{n} ni$ in which n is the representative of the total number of statistical years. For accidental series, the mathematical expectation of t is zero and variance is obtained by following formula:

$$Var(r)=\frac{2(2n+5)}{9n(n-1)}$$

Mann-Kendall test defines a standard normal variable of N, which is obtained by following formula; this formula is used for calculating the level of significance of t:

$$N=\frac{r}{var(r)^{5}}$$

If the total number of data increases, N (n) would quickly become homogenous by normal standard distribution. If absolute size of n is larger than na/2 (in 5% level, and, which has used normal distribution table of 1.96), data series would have a significant trend. If the value of n is negative, the distribution would have a falling trend; if n is between 1.96 and -1.96, data series would have no trend.

III. Discussion

To analyze the trend in precipitation and temperature data (Maximum, minimum and mean temperatures), first we identified the length of a 49 year-old period (1956-2005) in 36 major stations in Sefid-roud basin. To trace changes in the precipitation and annual temperature, the graph of temperature and precipitation time series for stations were drawn (Fig. 2).

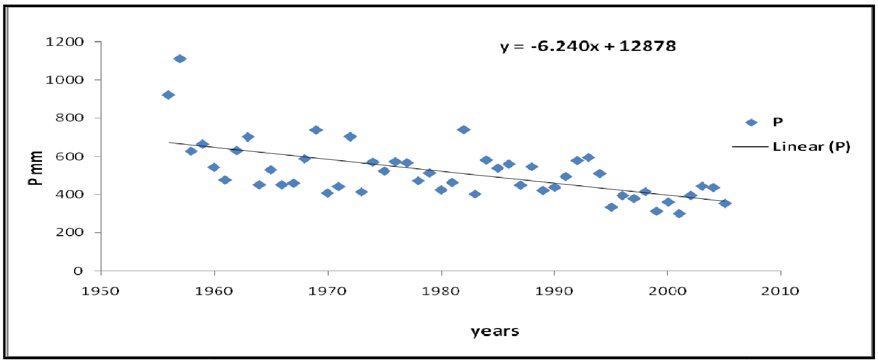

Fig. 2 Means annual precipitation in Sefid-roud basin

As the figure-1 shows, annual precipitation has a negative slope of -6. The analysis of precipitation time series in every station reveals that most of the stations have a negative precipitation trend. However, the slope of changes might vary, to some extent. There have been different time changes in temperature recorded in the stations during the statistical period. Mean annual temperature changes in the stations generally show a positive trend with a slope of 0. 102 C (Fig. 3). Therefore, compared to raising slope of temperature in the statistical period, precipitation has a more falling trend. Thus, it could be concluded that human activities in the in the study area have had an impact in decreasing the precipitation. Mann-Kendall test was used for more elaborate analyze of the trend in annual precipitation and temperature changes (maximum and minimum) in Sefid-roud basin. The Mann-Kendall test results, with a significant level of 95% shows, precipitation in the study area has a negative trend, and temperature has a positive trend. However, the results of this test also indicate that precipitation trend is greater than that of temperature. Therefore, according to figure-1 and 2, and Mann-Kendall test results in the study area, one can generally conclude that precipitation has a falling trend, and temperature has a rising trend. However, the precipitation trend is greater than that of temperature.

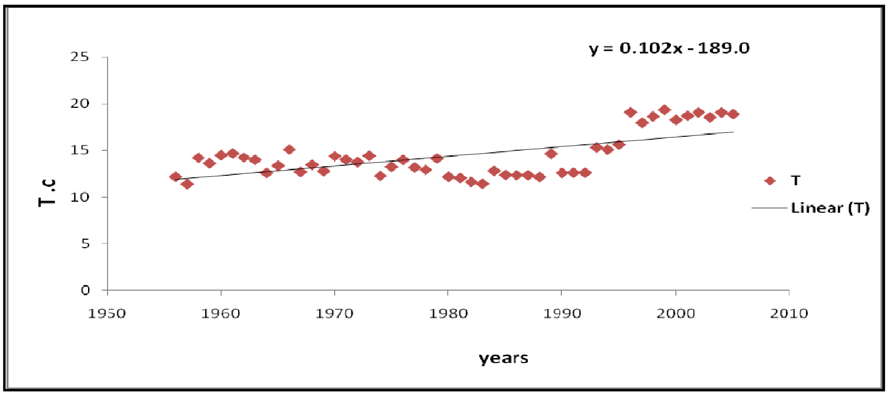

Fig. 3 Means annual temperature in Sefid-roud basin

Furthermore, considering rainfall maps (Fig. 4 and 5), it is evident that in the 49 year period of mean annual precipitation in 36 stations of Sefid-roud basin, in 1957 the maximum precipitation was 1113 mm, and in 2001, the minimum precipitation was 299 mm. According to rainfall maps, precipitation level in plains is higher than other parts. As one approach to higher altitudes, the amount of precipitation decreases and based on the rain type, it may turn to snowfall and change in the hydrological system.

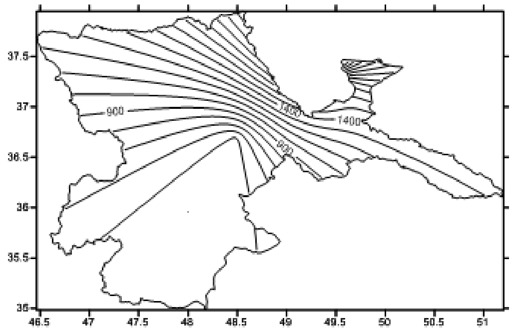

Fig. 4 Maximum precipitation in Sefid-roud basin in 1957

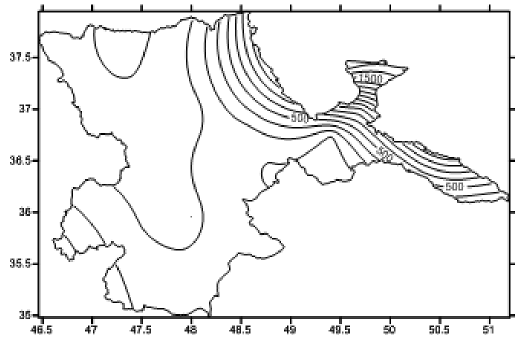

Fig. 5 Minimum precipitation in Sefid-roud basin in 2001

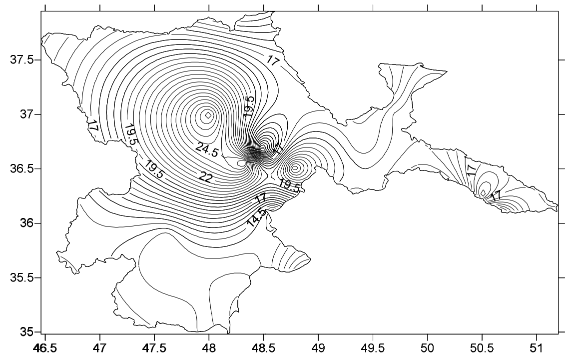

Fig. 6 Maximum means temperature in Sefid-roud basin in 1999

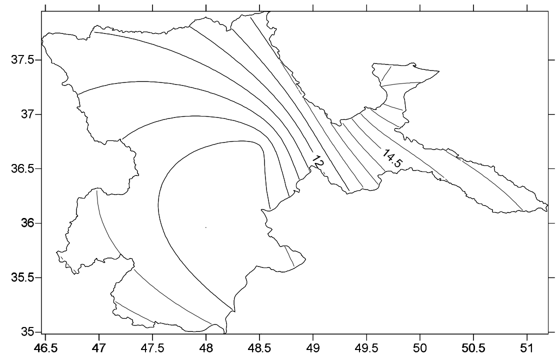

Fig. 7 Minimum means temperature in Sefid-roud basin in 1957

According to temperature maps (Fig. 6 and 7) of Sefid-roud basin, in 1999 the maximum temperature was 19 C and in 1957 the minimum temperature was 11C. Therefore, in plain areas, temperature goes up, and as one approaches higher altitudes, the level of temperature goes down.

IV. Conclusion

Eventually, the annual temperature and precipitation time series in Sefid-rud basin were analyzed by using regression and Mann-Kendall and the following results were obtained:

The analysis of mean precipitation factors, temperature (mean, maximum and minimum) in 36 stations in Sefid-roud basin revealed that the above factors have little climate changes. These changes were typical short-term variations in weather conditions and are trends which are found in some years.

The analysis of mean temperature revealed that changes have a significant falling trend and precipitation also has a falling trend.

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