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Investigating the Precipitation and Temperature Change Procedure in Zayanderood Watershed

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***Abstract*—**Global warming and continental changes have been one of the people's issues in the recent years and its consequences have appeared in the most parts of the earth planet or will appear in the future. Temperature and Precipitation are two main parameters in climatology. Any changes in these two parameters in this region cause widespread changes in the ecosystem and its natural and humanistic structure. One of the important consequences of this procedure is change in surface and underground water resources. Zayanderood watershed basin which is the main central river in Iran has faced water shortage in the recent years and also it has resulted in drought in Gavkhuni swamp and the river itself. Managers and experts in provinces which are the Zayanderood water consumers believe that global warming; raining decrease and continental changes are the main reason of water decrease. By statistical investigation of annual Precipitation and 46 years temperature of internal and external areas of Zayanderood watershed basin's stations and by using Kendal-man method, Precipitation and temperature procedure changes have been analyzed in this basin. According to obtained results, there was not any noticeable decrease or increase procedure in Precipitation and annual temperature in the basin during this period. However, regarding to Precipitation, a noticeable decrease and increase have been observed in small part of western and some parts of eastern and southern basin, respectively. Furthermore, the investigation of annual temperature procedure has shown that a noticeable increase has been observed in some parts of western and eastern basin, and also a noticeable increasing procedure of temperature in the central parts of metropolitan Esfahan can be observed.

***Keywords*—**Zayanderood, Man_Kendal, Climate Change

I. Introduction

One of the noticeable phenomena in continental change is change in the temperature degree and amount of Precipitation. Increase or decrease in rain and temperature has an effect on many other continental and environmental phenomena like runoff, floodwater, and humidity; and also it influences on many other mankind activities like agriculture and type of housing. Moreover, change in precipitation system like turning liquid Precipitation to the solid ones or gathering Precipitation in some special months can cause too many chances and threats. The purpose of this study is the investigation of annual temperature and Precipitation changes procedure in Zayanaderood watershed. Furthermore, place distribution of Precipitation and temperature in the basin will be investigated.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

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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 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.

II. Methodology

In order to investigate the Precipitation and temperature changes in Zayanderood watershed basin, the statistical analysis of internal and external basin weather stations has been used. 31 stations from provinces like Esfahan, Chahar Mahale Bakhtiyari, and Yazad have been analyzed and investigated (fig.1).

Firstly, two matrices from weather stations data have been prepared whose rows and columns included stations and statistical years, respectively. Then by the use of Kringing model, interpolation has been done and the current data turned to 10 km pixel in 10 km and the amount of temperature and annual Precipitation has been calculated per pixel. After that, by the use of Kendal-man model, annual temperature and Precipitation changes procedure in zaynaderood watershed has been investigated.

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.

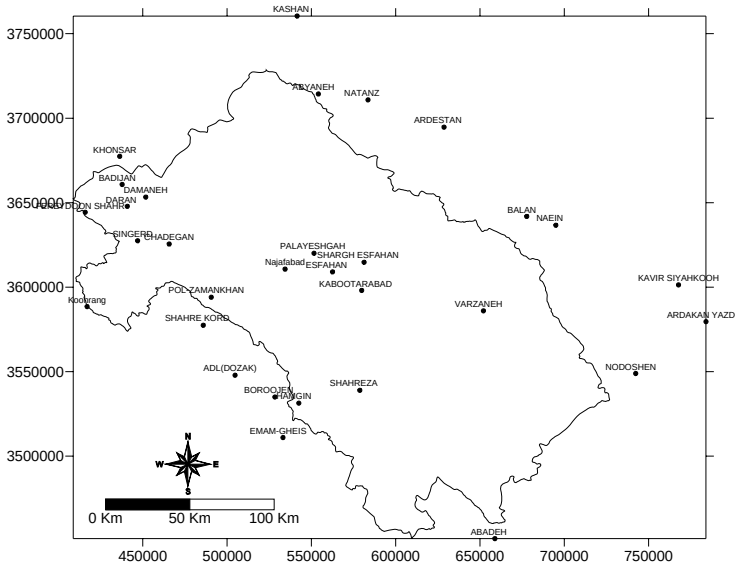

Fig. 1 Synoptic and climatologically stations inside and around Zayanderood watershed

III. Discussion

Zayanderood watershed is the most important watershed basin in central-Iran which is 41500 square kilometer in area. The highest parts of this basin are located in Chahar Mahal Bakhtiyari province, but the most parts of it are located in Esfahan and also a small part is located in Fars province (fig.2).

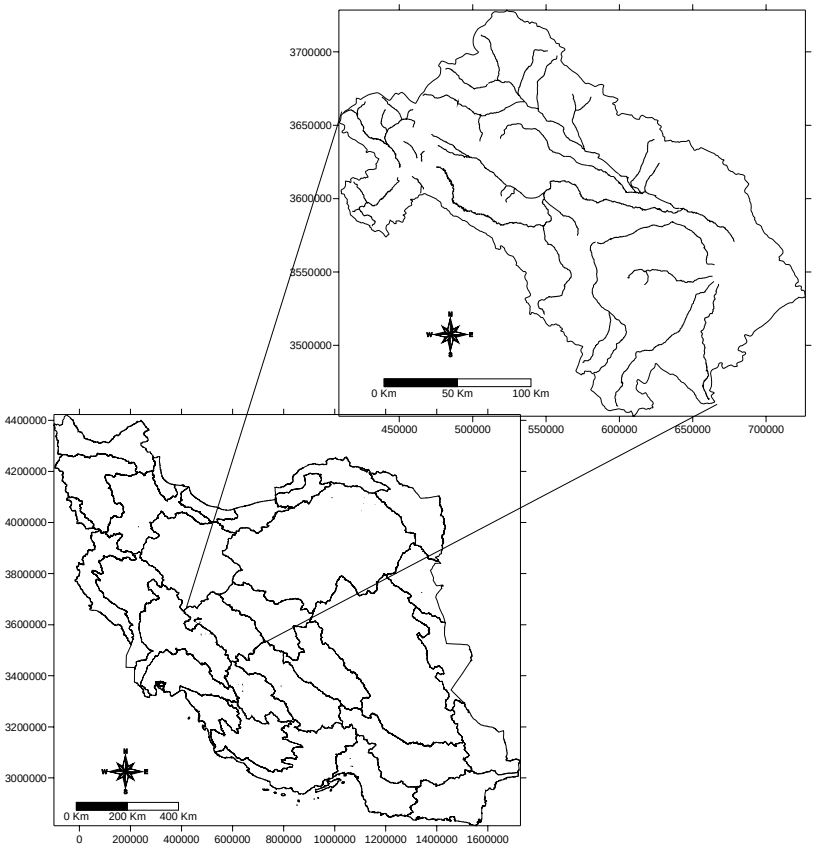

Fig. 2 Situation of Zayanderood watershed in Iran

Zayanderood River which is the only permanent river in central Iran conducts the obtained water of Precipitation in this basin to Gavkhuni swamp and consumes it for drinking, industry and agriculture. The decreasing water has caused some problems for cities, industry, agriculture and environment in recent years in Esfahan province. In order to investigate why the river's water has decreased, Precipitation and temperature changes procedure have been investigated in this study. The longitudinal series investigation of basin annual Precipitation does not show any special procedure. So, one can say Precipitation in Zayanderood basin has not had any noticeable decrease or increase (fig.3).

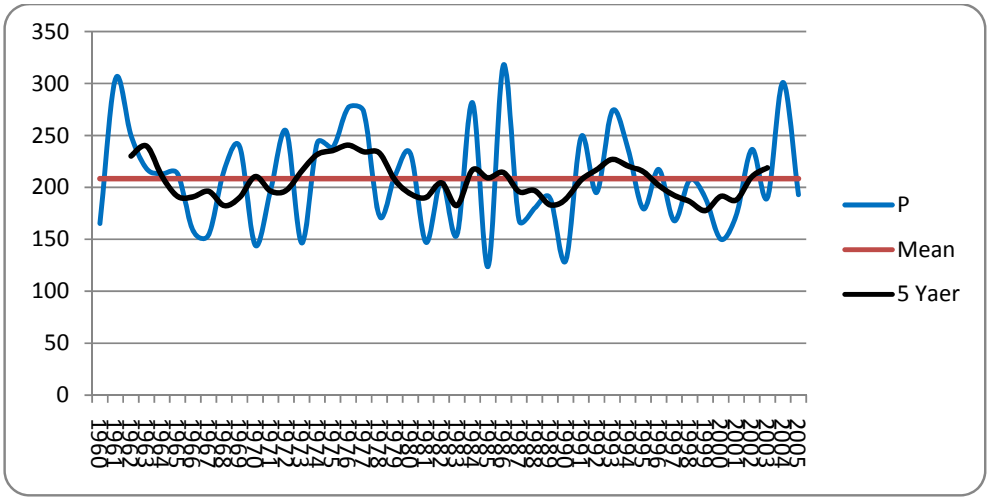

Fig.3 Annual precipitation and 5 years moving average in Zayanderood watershed

However, some fluctuations can be observed. 5 years dynamic average investigation of annual Precipitation shows that the basin has had two years period of rainy years and three year period of drought during these 46 years. The average annual Precipitation in this basin has been 208mm. The rainiest year with average Precipitation 318mm and the least rainy year with the average Precipitation 14 mm have been referred to 1986 and 1985, respectively. Although according to longitudinal series investigation of Precipitation, there has not been any decrease or increase procedure in the whole area observed, longitudinal series investigation of Precipitation on 20 pixel in 20 km basin showed that there has been some noticeable decrease of Precipitation in western parts of basin and also a noticeable increasing procedure in some parts of eastern and southern basin.(fig.4)

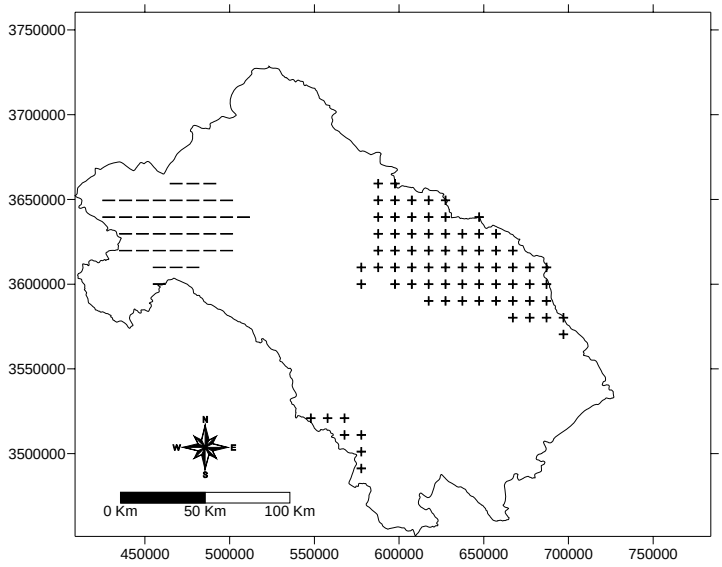

Fig.4 Precipitation changes in Zayanderood watershed

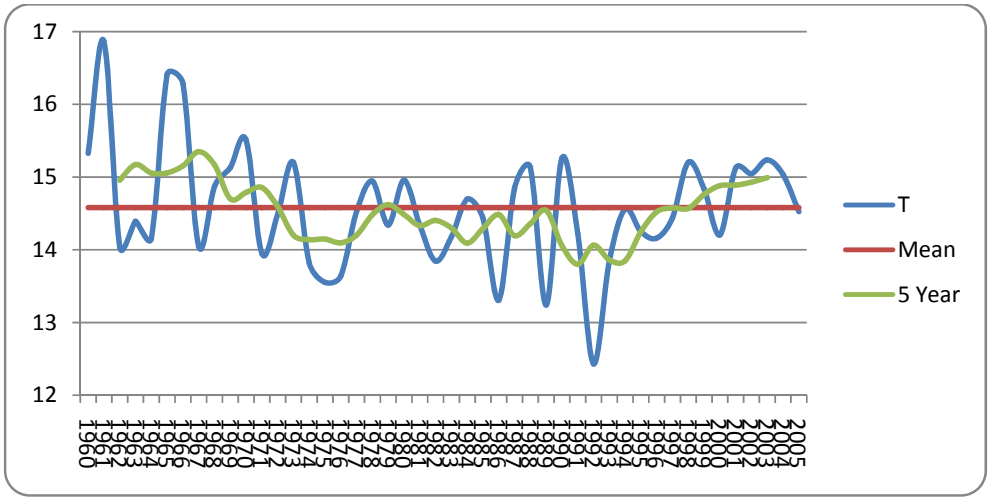

Fig.5 Annual temperature and 5 years moving average in Zayanderood watershed

Longitudinal series investigations of basin annual temperature (fig.5) do not show any decreasing or increasing procedure.

So regarding temperature, one can say it has not had any noticeable decrease or increase in Zayanderood basin for about 46 years. The average annual temperature in the basin has been (14/6c) in this period. The warmest and the coldest years have been 1961, 1992 with the temperature (16/9c&15/2c), respectively. Clearly, due to Pinatobo volcano, whole earth planet has passed a very cold year. The warmest year was 1988 with the temperature (15/2c) in the recent years. Naturally, due to special condition of SOI, it has been a warm year all over the earth planet. Although longitudinal series investigation of temperature has shown that there was not any decrease or increase regarding temperature in the whole area, longitudinal series investigation of temperature in 10 pixels in 10 km in the basin has shown that there has been a noticeable decrease in small parts of western and eastern basin and also a remarkable increase in some central parts of the basin and around the metropolitan Esfahan. (fig. 6).

The reason is the development of Esfahan and establishment of different industries around it, so the increase of temperature has been due to main activities in this region not the continental change.

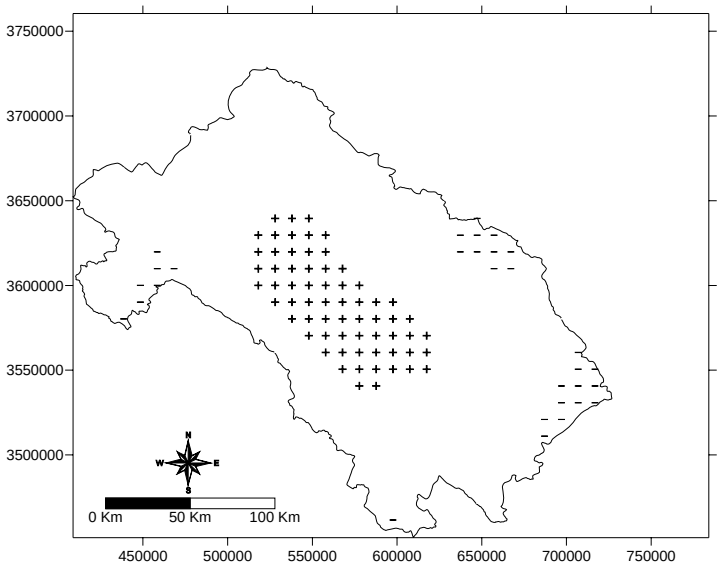

Fig.6 Temperature changes in Zayanderood watershed

IV. Conclusion

The amount of water in Zayanderood River has seriously decreased in recent years and has caused some problems for cities around the river, especially Esfahan itself. Furthermore, this decrease of water resources has caused some major problems to the environment, agriculture and industry too. Managers and experts in this field believe that this decrease in water resources has been due to continental change, rain decrease and temperature increase. 46 procedure investigations of Precipitation and temperature in Zayanderood basin has shown that there have not been any noticeable increase or decrease observed in the whole area in this period. However, there has been a noticeable decrease observed in small parts of western areas. Instead, a noticeable increase in Precipitation in some parts of eastern and southern basin has been observed. Moreover, regarding temperature investigation, any noticeable decrease or increase procedure has been observed in the whole area during this period and just in small part of western and eastern basin some remarkeable decrease has been observed and also a noticeable increasing procedure has been witnessed in the central parts of the basin around the metropolitan Esfahan. According to the obtained results, one can say decrease in Zayanderrood water resources has not been due to continental change, rain decrease and temperature increase. But the incorrect management in using of water resources and using incorrect plans in the use of these resources has created problems for Zayanderood basin and its environment.

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