Temperature Trend Analysis in Urmia Lake Basin Compared with Water Level Fluctuations of the Lake

Shadi Hatami Majoumerd[1], Alireza Borhani Dariane[2]

***Abstract*—** This paper presents trend analysis during a 40-year period for temperature data obtained from 19 stations over Urmia Lake Basin. The results of this research indicate a significant positive trend of annual temperature throughout the basin. Moreover, temperature trends in monthly scale also shows a positive direction, although, in some stations no trend is observed in certain months. Comparing these results with the water level fluctuations of Lake Urmia indicates that the decline of water level can be only partially related to the significant positive trend in temperature throughout the basin. Temperature rise and the corresponding increase in the agricultural water demand cannot be fully attributed for the fluctuations of water level in Urmia Lake. Hence, some other causes such as extensive water related project developments throughout the basin could be considered as other important factors for the lake level deterioration. A comprehensive and integrated study is needed to determine the impact of various factors on the lake level fluctuations which could be used for determining the short-term as well as long-term actions and plans to save the lake from further shrinkage and to establish a sustainable socio-ecosystem in the area.

***Key Words*—** Climate Change, Trend Analysis, non-parametric Mann-Kendall, Uremia Lake

I. Introduction

CLIMATE changes and its impacts on basins has been the subject of various studies in recent years. Many of these investigations use trend analysis methods to simulate ahead climatological conditions. Mann-Kendall nonparametric (MKnp) method is among the commonly used trend analysis methods. Lins and Slack, 1999, evaluated trends in discharge of 395 stations over conterminous United States using MKnp method. Brunetti et al., 2001, also used Mann-Kendall nonparametric test to study the trend in daily precipitation of single station records and the mean of some areas in Italy.

Other studies, in order to achieve more comprehensive results simultaneously applied Mann-Kendall method to several hydrologic parameters. For instance, Burn and Elnur, 2002, studied hydrological variables such as rainfall, temperature and discharge at the same time, to determine the presence of any trend in Canada.

Some researchers also benefited from seasonal Mann-Kendall nonparametric test beside the usual MKnp in their studies. Lettemaier et al., 1994, studied monthly and annual trends for temperature, precipitation, and runoff in a basin in US. Kahya and Kalayci, 2004, also did a similar study in Turkey for monthly runoff trend analysis using the above mentioned methods.

Tabari et al., 2001, is among a few studies in Iran using MKnp method for examining different hydrometeorological variables. Kousari et al, 2014, applied the Reconnaissance Drought Index (RDI), MKnp and Sen's slope estimator for trend analysis in arid and semi-arid regions of Iran.

According to Wikipedia.org, Urmia Lake is one of 10 major lakes facing total deterioration. Desiccation and drought of lakes around the world has been considered in many studies (McBean, and Motiee, 2008; Razmara, et al., 2013). The recent water crisis in Urmia Lake basin has led to a sharp drop in water level of the Lake and a major lake's shoreline retreat, resulting in nearly 90% shrinkage in water surface area of the lake, as of 2014. Changes in lake's ecosystem have already begun to impact various social, economical and environmental problems in the basin. To slowdown the current trend of deterioration and solve these problems both long term and short term programming are needed. Identifying the share of hydrologic and management factors are the key points in finding such solutions. Among many other factors, temperature is believed to play a significant role in the health and wellbeing of any ecosystem.

Our study represents an initial stage in research designed to distinguish temperature trends in Urmia Lake basin using MKnp test and compare the results with observed water level elevation of Urmia Lake during the studied period. The results of this study may help to further clarify some of the reasons for the recent crisis in Lake Urmia. The study area, methods, main results according to the goals of our study and finally main conclusions are discussed in following sections.

II. Study Area And Data

Urmia Lake basin with area of 5750 Km2 is situating between 35◦ 40′–38◦ 30′ northern latitudes and 44◦ 07′–47◦ 53′ eastern longitudes and average altitude of 1276m (Figure 1).

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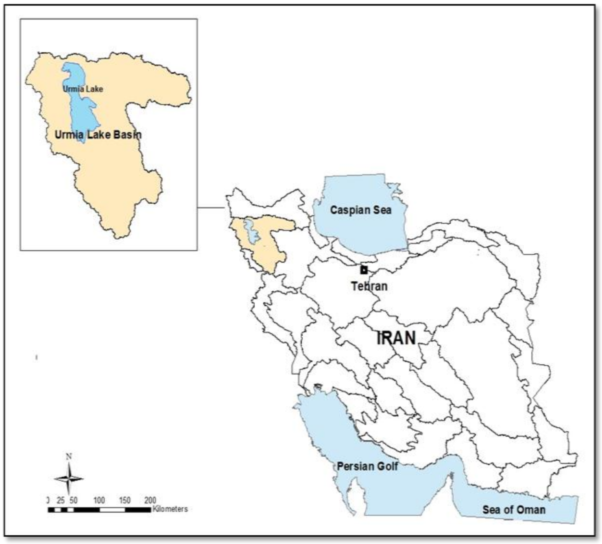

Fig.1. Location of Urmia Lake and its basin in Iran

The Lake Urmia region has a semi-arid climate with a mean annual precipitation of 340 mm and a mean annual temperature of 11.2° C.

Urmia Lake is a UNESCO designated Biosphere Reserve and among the most important aquatic ecosystems in the world. The Lake situated between latitudes 37° 4′–38° 17′N and longitudes 45°– 46°E has a semi-rectangular shape, with maximum length and width of 135 and 55 km, respectively. The surface area fluctuates between 5000 and 6000 km2. The average depth of the lake is around 5.4 meter.

The geographic situation of thermometry stations used in this study is listed in Table 1 in the appendix. Monthly and annual records for all 19 thermometry stations that were used for trend analysis covers a 40–year period expanding from 1966 to 2007.

III. Methods

In this study trend of annual and monthly temperature has been analyzed using the Mann–Kendall non-parametric method.

In the first step, the Mann-Kendall test static S, Variance of S and the test static Z is calculated. A positive value of S represents an increasing and a negative value indicates a decreasing trend. The test statistic Z is used as a measure of significance of the trend.

For checking out the presence of any trend and determining the its significance level, P-value probability is used. When P-value is less than a specific threshold value, chosen by the researcher, it shows that the trend is significant (Helsel and Hirsch, 1992). In this study, we assumed that a P-value less than 0.05 indicates a significant trend, between 0.05 and 0.1 a stable trend, from 0.1 to 0.2 a poor trend, and for values more than 0.2 no trend is detected.

IV. Discussion

In this section the results of applying the non-parametric Mann-Kendall test for temperature together with its impacts on the hydrologic conditions of the basin and the fluctuations of the lake's water level are presented. The study classifies trends in 7 different groups as mentioned below:

1.Significant Trend+, 2.Significant Trend-, 3.Stable Trend+, 4.Stable Trend-, 5.Poor Trend+, 6.Poor Trend - & 7.No Trend

Figure 2 represents an overview of trend changes for annual temperature for selected stations throughout the basin. As it can be seen from this figure, annual mean temperature in most of stations is significantly positive and this increase is uniformly distributed throughout the basin.

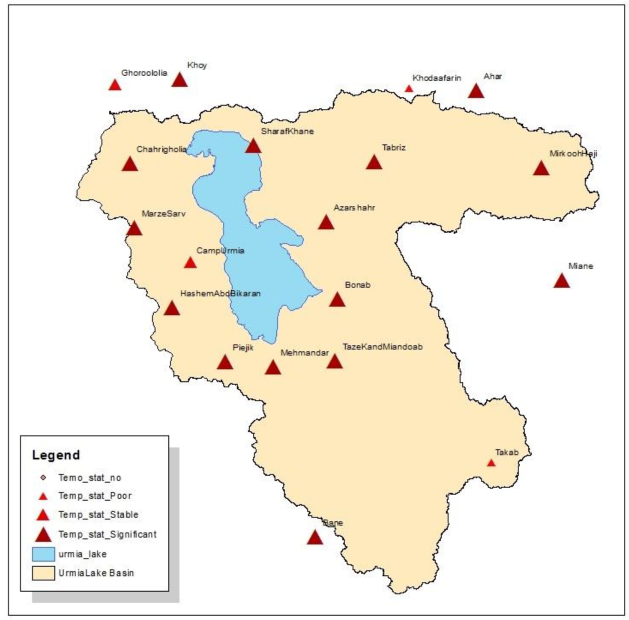

Fig.2 Annual temperature trends in selected stations of Urmia Lake Basin

Graph shown in Figure 3 depicts the relative number of temperature stations in different trend classes in the basin.. As it is illustrated by the graphs annual temperature is mostly enjoying a significant increase during the study period. As is obvious from this chart, none of stations experience No Trend conditions or negative trend in temperature, while about 80% of stations show "Significant Trend+" and the remaining 20% evenly are distributed among "stable" and "poor positive" trends both with allocating 10% of thermometry stations to their classes.

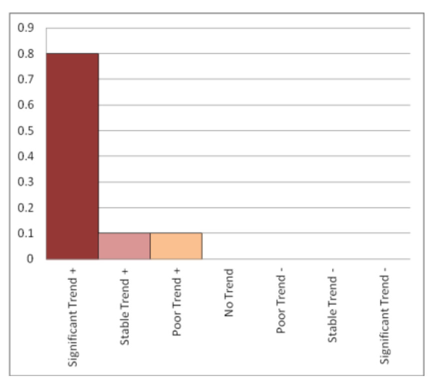

Fig. 3. Relative frequency of differen trends in temperature stations.

Monthly trends were also examined to reveal more details of long-term temperature variations throughout the basin. Figure 4 illustrates relative number of different trend classes of temperature for each month. As it can be seen from this figure, none of the months experience a decreasing trend. It also reveals that while there is no significant trend during cold months of the year, other months usually experience a considerable increasing trend. Positive trend is more remarkable in October, February, May, June, July, August and September. Increasing temperature in February can be considered as the most important one as it leads to premature snow melting in higher altitudes that would result in early depletion of snow water reserves in the region.

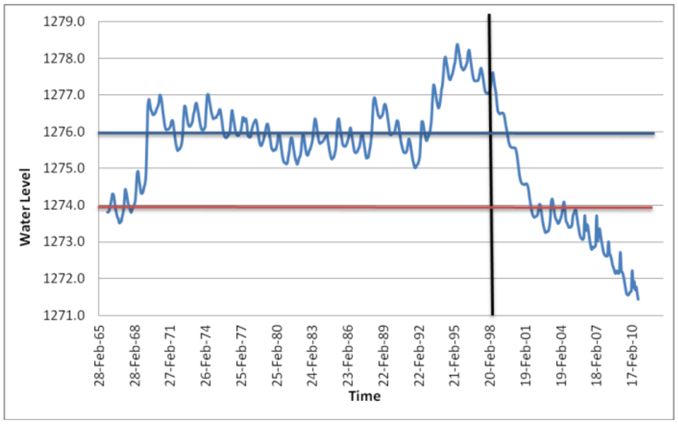

Fig. 5. Water level elevation fluctuations in recent years.

In Figure 5, the red horizontal line at 1274m elevation is the ecologic elevation water level of the basin and the blue line at 1276m shows the average water level through the normal period from 1965 to 1998. As it can be seen from this Figure, the water level elevation's decline which started in 1998 continued to the end of the studied period. This level passed the critical ecologic elevation in year 2001.

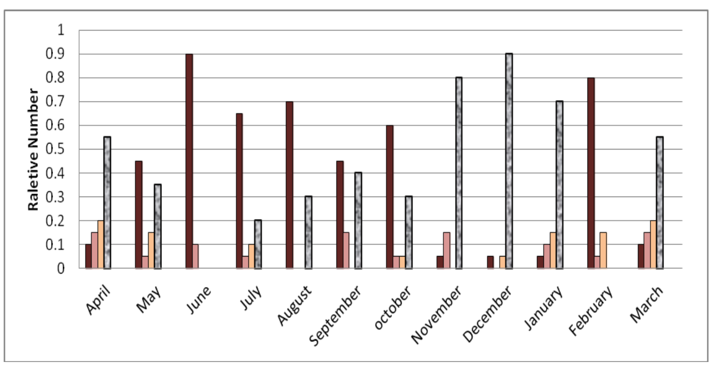

Fig. 4. Relative number of each trends' class in temprature for different months of year.

The dark red bars indicate significant positive trends and pink and orange ones are indicatives of stable and poor positive trends respectively. At last the gray bars are signs for number of stations with No trends conditions.

By comparing the trend analysis results with lake's water levels as shown in Figure 5 and time series of total inflow to the lake together with average temperature of selected stations over the basin in Figure 6, the increase in the temperature data can be considered only as one of the factors for the decline in the lake's water level. In fact, the rate of temperature increase does not justify the amazingly sharp drop in lake's water level in recent years.

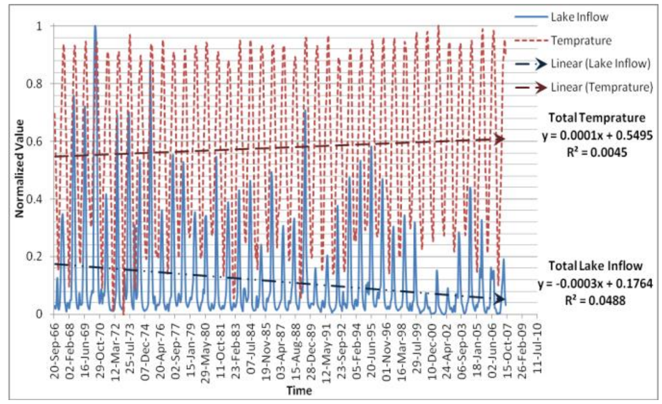

Fig. 6. Normalized lake inflow in comparison with normalized temperature time series

As it is can be seen from the trend lines of total inflow to the lake and average temperature in Figure 6, the negative slope of the trend line in inflow is about 3 times steeper than the positive slope of average temperature. In general, according to these findings, the inflow into the lake is reduced by a rate of 328 million cubic meters per each decade. Whereas, temperature enjoying only 0.3° C increase per decade experience much slighter changes.

V. Conclusion

This study presented a statistical analysis of trends in monthly temperature records from 19 thermometry stations in Urmia Lake Basin for the period expanding from 1966 to 2007. Trend analysis by Mann-Kendall non-parametric method indicated increases both in annual and monthly temperatures. Annual temperature trends analysis revealed that about 80% of stations have significant increasing trend and the remaining 20% evenly have stable and poor positive trends.

By comparing the trend analysis results with lake's water levels and time series of total inflow to the lake together with average temperature of selected stations over the basin, the increase in the temperature data can be considered only as one of the factors, among others, for the sharp decline in the lake's water level. The rate of temperature increase does not justify the amazingly sharp drop in lake's water level in recent years.

Appendix

Table 1 shows the geographic situation of thermometric stations used in this study.

TABLE I
THE GEOGRAPHIC LOCATION OF THERMOMETRY STATIONS

Name	Longitude	Latitude	Altitude(m)
Ahar	47-05-00	38-21-00	1350
AzarShahr	45-59-00	37-45-00	1425
Bane	45-50-00	36-00-00	1510
Bonab	46-03-00	37-19-00	1260
CampUrmia	45-02-00	37-32-00	1381
ChahrighOlia	44-06-00	38-05-00	1655
GhoroolOlia	44-33-00	38-32-00	1290
HashemAbadBikaran	44-54-00	37-17-00	1570
KhodaAfarin	46-32-00	38-28-00	1320
Khoy	44-56-00	38-31-00	1103
MarzeSary	44-38-00	37-43-00	1650
Mehmandar	45-36-00	36-57-00	1350
Miane	47-38-00	37-25-00	1100
MirKoohHaji	47-30-00	38-02-00	1830
PieJik	45-16-00	36-59-00	1375
Shafarkhane	45-28-00	38-11-00	1270
Tabriz	46-19-00	38-05-00	1370
Takab	47-06-00	36-24-00	1817
TazeKandMiandoab	46-02-00	36-59-00	1287

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