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Spatio-temporal Analysis of Temperature and Precipitation Trends in Tashk-Bakhtegan Watershed

S. Imani [1, 2*], A.Farokhnia[3], S.Morid[4], R.Roozbahani[5]

[1]Research Fellow, Department of Water resource, Water Research Institute (WRI), Ministry of Energy, Tehran, Iran.
[2]PhD Student, Environmental Engineering-Water resource Group, Faculty of Environment, University of Tehran, Tehran, Iran.
[3]Head of Group, Department of Water resource, Water Research Institute (WRI), Ministry of Energy, Tehran, Iran.
[4]Professor, Water Resource Engineering Group, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran.
[5]Head of Department, Department of Water resource, Water Research Institute (WRI), Ministry of Energy, Tehran, Iran.

ABSTRACT: In the present era, climate change and its impact on available water resources are one of the main challenges. In this regard, temporal and spatial analysis of temperature and precipitation, which are important parameters in determining the status of water resources, can be used to assess the hydro-climatological conditions of the watershed and appropriate management policies. In this research, the trend in precipitation and temperature distribution over 30 years testing period of 1981-2010 was investigated using non-parametric tests such as Man-Kendal, Spearman, Sen's Slope, and Pettit. Afterward, interpolation techniques, such as IDW, LPI, GPI and RBF were used to detect spatially trends at the watershed. The results showed that precipitation decreased by 14.3% during the period 1981-2010 and the temperature increased by 3.5%, with changes in precipitation and temperature occurring in 2004 and 1985, respectively. However, the negative trend in precipitation was not significant in contrast to the positive temperature trend during the study period. A comparative analysis of interpolation techniques shows that Ordinary Kriging and Radial Basis Functions with least error are the best methods for spatial analysis of precipitation and temperature, respectively.

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1. INTRODUCTION

In arid and semi-arid regions like Iran, water availability is thoroughly reliant on the variations of precipitation and air temperature [1]. Therefore, analyzing the trends of these parameters is essential for water resource management. It can also provide required data to indicate how climate change may affect the water resources [2]. However, these parameters are not monitored in all places at every time in Iran, which may increase the related uncertainties. Therefore, to estimate locally distributed trends of these parameters must be investigated through proper interpolation techniques for detecting spatial trends in watersheds [3].

This research intends to identify the spatial and temporal trends of precipitation and temperature, as two main parameters in climate change assessment, in a watershed. For this purpose, Tashk-Bakhtegan basin, southern Iran, is chosen as the study area. 4 statistical indices are also used and compared for outlining the spatial and temporal trends of the two parameters. It should be noted that the study area currently encounters severe loss of water resources where the climate change is claimed to be the main factor.

2. METHODOLOGY

This research has three steps. First, the precipitation and temperature data of Tashk-Bakhtegan basin in the period of 1981-2010 were obtained and verified with respect to their homogeneity. Here, 30 precipitation and 10 temperature stations with proper spatial distribution and adequate data were chosen in watershed. In this step, some data required modifications and the gap data were completed by standard methods.

Second, the non-parametric tests such as Man-Kendal (MK), Spearman (SR), Sen's Slope (SS), and Pettit (PT) were used for the examination of the trends of parameters. Here, SS is a non-parametric test derived from Man-Whitney to recognize the statistical variations in time series. PT is also used in hydro-climatological studies to detect abrupt changes in the time series of the variable of interest. This method uses some statistical analysis that changes the mean of data to find the most compatible slope in time series with the slope of the coupled observed data. If the slop is positive, the trend is ascending and vice versa. Third, this research uses different deterministic and geo-statistical interpolation techniques, like IDW ،RBF ،LPI, and Kriging. In order to verify and compare the outcomes of these interpolation techniques, we used cross-validation methods like Leave One in which the criteria are Root Mean Square Error (RMSE), Mean Error (ME), and Mean Absolute Error (MAE).

3. DISCUSSION AND RESULTS

The results of statistical investigations show that the trend

*Corresponding author's email: s.imani@ut.ac.ir

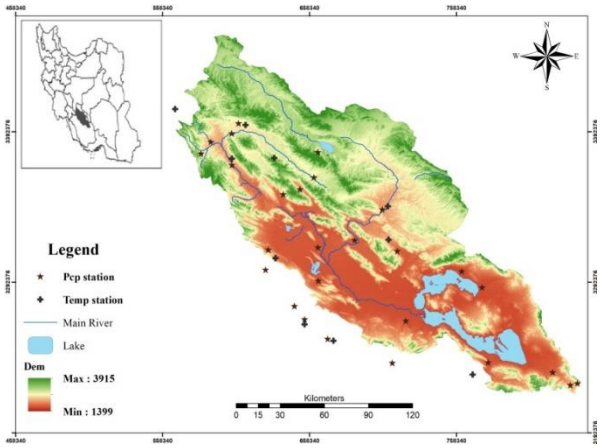

Fig. 1. Tashk-Bakhtegan basin with selected stations

of annual precipitation in 27 stations is decreasing regarding MK and SR tests. However, this decrease is only significant (>95%) in Kharameh station. The ratio of precipitation variation reduction (%) in comparison with the average precipitation in the study period (SS test) showed that the maximum and minimum variations are 22.8% and -55.6%, respectively. The average of variations in the selected stations is a 14.3% reduction in the annual precipitation. PT test also showed that most stations have abrupt changes in precipitation since 2004.

For temperature, MK and SR tests also show a significant increase in annual temperature in most of the selected stations in the study area. The slop of their variations (SS test) illustrates the maximum and minimum values of 12.5% and -11.3%, respectively. This equals a 3.5% increase in the annual average temperature. PT test also shows that abrupt changes have taken place from 1985.

MK and SR tests could lead to similar statistical results for the two parameters. Therefore, this research uses spatial distribution with the data of the MK test as recommended by the pieces of literature [3, 4]. The results of spatial distribution showed that Kriging has the least error in comparison with other interpolation techniques for precipitation distribution. The northwestern part of the basin has the lowest precipitation reduction rate, while the southwestern part of basin has the highest rate of precipitation reduction. Generally, the southern regions were mostly covered by farmlands and the lake itself has higher rates of precipitation reduction. Kriging is also determined as an interpolation technique with the least error for temperature distribution. In southern parts of the basin, the temperature increase is significant, while in northern parts where it is mostly mountainous, the temperature increase is not significant (Fig. 2).

4. CONCLUSIONS

Regarding the statistical analysis of precipitation and temperature data in the Tashk-Bakhtegan basin, it can be concluded that the trend of precipitation is decreasing in most stations, while it is increasing for temperature. In the period of 1981-2010, the annual average precipitation is reduced by 14.3%, while the annual average temperature is increased by 3.5%. However, it should be noted that the precipitation

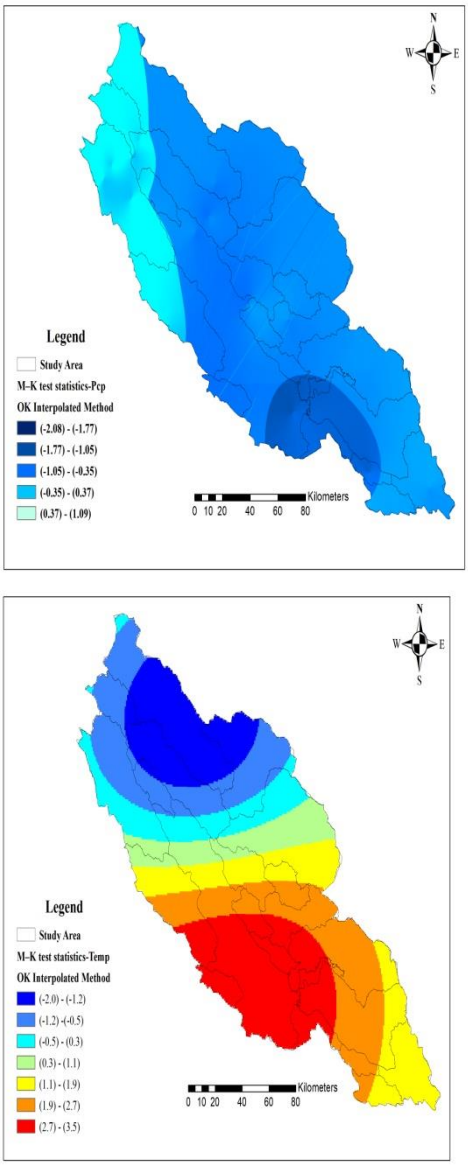

Fig. 2. Spatial distribution of precipitation (top) and temperature (down) with kriging

variations are not significant. PT test also showed that these trends have started in 2004 and 1985 for the two parameters, respectively. Among different interpolation techniques, Kriging is introduced as the least error technique. By this method, it is realized that the northern parts of the basin has encountered less precipitation and temperature variation but these variations are higher and significant in southern parts of the basin.

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