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The Effect of Climate Change on Surface Runoff Fluctuations in the Aras River Basin

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1-Introduction

Climate change is an essential issue of the current era (Jiang et al., 2019: 2). Impacts on water resources are considered an effect of climate change (Motamed Vaziri et al., 2020: 102). Understanding climatic changes, their behavior in future periods, and their effects in different fields, particularly in water resources, is specifically important in macro and strategic planning (Haji Mohammadi, 2018: 144). The volume of surface runoff is one of the main components in sustainable development; therefore, predicting the level and trend of its changes is important in the issue of water resources management (Goodarzi et al., 2015, 176). Due to the importance and necessity of the issue, therefore, the effects of climate change on surface water fluctuations were frequently studied in the Aras basin, northwest of Iran. Climate change and its effects on the basin runoff were investigated in several studies (Fatehi and Shahoui, 2020: 294; Zahbioun et al., 2011: 43). The use of general atmospheric models HadCm3 and LARS-WG on the microscale and using the SWAT method have been of interest in evaluating the climate change effect on the basin hydrology. In a study, Babaian et al. (2015: 907) observed climate change effects on water resource behavior in the basin. They reported that precipitation would decrease and temperature would increase in the basin by climate change effects on the hydro-climatic variables in part of the basin of the important Darghaz River. Moreover, Jahanbakhsh et al (2016: 107) investigated the climate change effect on temperature and precipitation in a study on the Shahr Chay River basin in Urmia and concluded that the precipitation in this basin would decrease by 9 mm in the coming period. Zhang et al. (2012: 2199) examined the climate change effect on water resources in North China using the SWAT model. They concluded that climate change increased blue and green water resources, and human activities did not significantly affect the change in these resources. Located in the northwest of Iran, the Aras basin is a common boundary basin with Turkey, Azerbaijan, and Armenia. In terms of the political divisions of Iran, it includes parts of

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the three provinces, West Azarbaijan, East Azarbaijan, and Ardabil. With an area of 39,534 km2, the basin is geographically located between 44° 1′ 42" to 48° 42′ 33" E and 37° 46′ 10" to 39° 47′ 7" N (Hafezparast, 2015: 63).

2-Methodology

The Aras River basin forms the northernmost hydrological area of Iran between 38° and 40° northern latitudes. From a macro-scale climatology point of view, this basin features the characteristics of the temperate regions of the earth's middle latitudes (Talabi, 2019: 2004).

1.2 Climate simulation and downscaling of data

The future climate was simulated using the statistical data of seven selected synoptic meteorological stations in the Aras basin in the 1985-2014 period. In this research, the output of the Hadcm3 model was extracted from the AOGCM model subset related to the fifth assessment report in 2021-2050 and 1985-2014 as the future and base periods, respectively, under the RCP8.5 emission scenario. In previous studies comparing the efficiency of atmospheric general circulation models, Hadley Center models, especially Hadcm3, are known to be appropriate for fitting temperature and precipitation in Iran and have the closest results to observational data compared to other models.

2.2 Introduction of the SWAT model

Developed by the United States Agricultural Research Service, SWAT is a comprehensive and complete model on the basin scale to predict the effect of different management methods on flow, sediment, nutrients, and chemical balance in basins with different soil, land use, and management conditions for long periods (Nich et al., 2002: 88). It is a time-continuous, semi-distributive, physically based hydrologic model developed by USDA-ARS (Arnold et al., 1998: 73).

3-Results and Discussion

1.3 Downscaling and simulation data generation

Simulated data were generated for the future period (2021-2050) after choosing the Hadcm3 climate model and determining the RCP8.5 scenario. Then, the model outputs for each climate change were averaged monthly to compare simulated and observational data.

2.3 Validation and calibration of the prediction model of climatic parameters

Based on the statistical evaluation criteria, namely root mean square error (RMSE), Nash-Sutcliffe efficiency (NSE) coefficient, bias coefficient, and coefficient of determination (R2) of base period climatic data and observations with simulation data, the RMSE value

is higher for precipitation, which can be attributed to the nature of the precipitation parameter. The error rate of the maximum, minimum, and average temperature data is more than 0.8, indicating the minimum error in the predicted data. The correlation coefficient of the data is close to 1, suggesting the appropriate correlation of the data.

3.3 Model validation results for runoff estimation

The distribution of observed and recorded discharges of the Aras basin hydrometric station is closer to 1, indicating the clustered distribution of discharge in stations. According to map 10 of Moran's analysis in the observational condition of the Aras River basin, the high-high cluster status of the clusters is high with a positive spatial correlation at the 99% confidence level in the estuaries of the main river sub-basins. A cluster with a low-high outlier critical status is not observed in the Aras River basin.

4-Conclusions

In this research, possible changes in average climatic parameters and surface runoff were evaluated as statistical indicators that are mostly relied on in water resources management. The scientific goals include forecasting changes in temperature and precipitation in this region and evaluating climate change effects on the status of surface water resources in the basin area. The practical goals of this research include the scientific development of the conceptual rainfall-runoff model framework (SWAT), the climate change effect on the fluctuations of surface water sources, evaluating changes in surface runoff at different periods using approved global parameters, using the LARS-WG model, downscaling the studied variables, and predicting climate changes and surface water changes in the long term. The results of this research demonstrate significant changes in climatic and hydrological variables of the Aras basin in the future forecast period. The comparison of the observed and simulated climate components by this climate model in the 2021-2050 period shows that the temperature of the region increases by 0.9 °C in different months compared to the base period. Precipitation also decreases by 7.9 mm, except in rain-free months. This increase in both temperature and evapotranspiration and, consequently, the decrease in precipitation can influence the available water level, peak time, and extreme events. According to the statistical analysis of the recorded and simulated climatology and hydrology data of the studied area, climate change and temperature increase have occurred in the studied area. Furthermore, although mountainous lands still provide the discharge of existing rivers up to the hillsides of the mountains, permanent rivers cannot be supplied and refilled in plain lands. However, the effects of drought are still slightly observed on the Ares river discharge due to the topographical and geopolitical features of its basin. The results of the research indicate an increase in the temperature of the basin in the future, which can lead to an increase in evaporation and transpiration, a decrease in snowfall, and a rise in torrential rains and

floods. This can, in turn, result in a decrease in the water reserve and supply of the basin, an increase in damages caused by torrential rains, and fertile soil washing.

Keywords: Climate Change, Surface Runoff, WG-LARS, SWAT, Aras Basin, Northwest of Iran.

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