DEEJ (2021) 10 (30) 65-80

University of Kashan

Desert Ecosystem Engineering Journal

Journal homepage: http://deej.kashanu.ac.ir

Investigating Changes in Some Climate Variables under the Future Climate Scenarios for a Semi-Arid Region

Arash Malekian[1]*, Parvin Mohamadi[2], Mehdi Ghorbani[3], Ali Akbar Nazari Samani[4]

Received: 28/09/2019 Accepted: 09/10/2020

Extended Abstract

Introduction: As proven by some researches, the atmosphere's general circulation models (GCMs) well predict the temporal and special variations in climatic variables such as temperature and precipitation at a global scale. However, although these models can simulate the global climate in a three-dimensional grid for the whole world, the resolution of their images cannot display the details of the climate changes at regional scale. Therefore, to predict climate changes at regional and regional scales, downscaling tools are needed to be developed. This study, thus, sought to investigate the variations of temperature and precipitation in future periods in a semi-arid region in Iran.

Materials and methods: To conduct this study, the Kermanshah province with average annual precipitation of 402.27 mm and mean temperature of 15.9° C was selected. To investigate the future climate change, we need a base period as an evidence or reference (1961-2005). The data used in this study were collected from station observations based on the required output and large-scale data NCEP and GCM gained from the nearest global network to the study area. To estimate the future periods' temperature and precipitation data, the GCM model of the CanESM2 was applied under three scenarios including RCP 2.6, RCP 4.5 and RCP 8.5, and SDSM 4.2.9 model was used in this regard for downscaling the output data. The SDSM is a multivariate regression model for the production of climatic data via statistical downscaling techniques, seeking to generate high-resolution climatic data from GCM's large- scale simulations data. This model is used when rapid and low-cost estimation of the climate is required.

Results: This study evaluated the model's performance in predicting climatic parameters based on R^2, RMSE, and NS. As confirmed by the results of RCP2.6, RCP4.5 and, RCP8.5, the values regarding the climatic parameters were modeled with acceptable accuracy. However, precipitation prediction was less accurate than temperature

1 Associate Professor, Faculty of Natural Resources, University of Tehran, Karaj; malekian@ut.ac.ir
2 PhD Student, Faculty of Natural Resources, University of Tehran, Karaj
3 Associate Professor, Faculty of Natural Resources, University of Tehran, Karaj
4 Associate Professor, Faculty of Natural Resources, University of Tehran, Karaj
DOI: 10.22052/deej.2021.10.30.41

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which could be attributed to the inaccuracy of the precipitation data and their unconditional nature.
The study's results showed that the annual mean temperature values in the period 2020-2049 under RCP2.6, RCP4.5 and RCP8.5 increased by 0.6, 0.7, and 0.9°C, respectively, compared to the base period. Moreover, the investigation of the prospective temperature changes in 2050-2069 period under the above-mentioned scenarios suggested that the temperature would increase throughout the year except in September, October, November, and December. The highest increase would occur in June by 6.6°C under RCP8.5, and the lowest increase would happen in October by 4°C under RCP2.6 scenario. Furthermore, the annual mean temperature values would increase by 0.8, 1.4 and 2.4°C in 2050-2069 under RCP2.6, RCP4.5 and RCP8.5 scenarios compared to the base period, respectively. It was also found that the temperature would increase in all season but autumn throughout 2070-2099, with the annual mean temperature values getting increased by 4, 1.9 and 4°C, respectively, under RCP2.6, RCP4.5, and, RCP8.5 scenarios.
Precipitation values and its variations in 2020-2049 period indicated that the highest decrease in precipitation value would occur in March by 38.2 mm under RCP2.6 scenario and the highest increase in this parameter would occur in October by 127.5 mm. Moreover, the annual mean precipitation rata would be 6.4 mm lower in 2020–2049 period than the observed value based on RCP2.6 scenario, and it would increase by 2.6 mm in the same period under the RCP4.5 scenario compared to the baseline period, and it would decrease by 2.6 mm under RCP8.5 scenario. Precipitation values for the period 2050-2069 show that the highest decrease in precipitation in March was 38.3 mm under RCP2.6 and the highest increase in October to 127.5 mm under RCP4.5. Furthermore, according to the annual mean precipitation values for 2050-2069 period, it was found that the highest decrease in precipitation rate would occur in March by 38.3 mm under the RCP2.6 scenario, and its highest increase would occur in October by 127.5 mm under RCP4.5 scenario.

Also, the annual precipitation rate in 2050-2069 period would increase by 2.6 mm and 4.2 mm under RCP8.5 and RCP4.5 scenarios, respectively, compared to the observation period, and it would decrease by 4.9 mm under the RCP2.6 scenario compared to the baseline period.
The results of the precipitation rate for 2070-2099 period showed that the highest decrease would occur in March by 48.1 mm under the RCP2.6 scenario, and the highest increase would occur in September by 129.5 mm under the RCP8.5 scenario. Moreover, in 2070-2099 period, the average annual precipitation values would decrease by 0.6 and 7.4 mm under RCP2.6 and RCP4.5 scenarios, respectively, and it would increase by 7.8 mm under the RCP8.5 scenario compared to the base period.

Discussion and Conclusion: The climate changes observed in the 20th and 21st centuries are incompatible with those of the past millennium. Arid and semi-arid regions are extremely vulnerable to climate changes. Therefore, identifying and comprehending the relationship between climate variables, and knowing their future changes are important for sustainable and efficient management of resources in such areas. According to studies conducted in this regard, climate change will inevitably occur in Iran. On the other hand, one of the most important issues in dealing with climate change in recent decades has been susceptibility to the climate changes. The investigation of the trends of the climatic data recorded in last decades, and the outputs of all climate models that predict future climates indicate that undeniable changes would occur in global climate.

To conduct this study, the daily temperature and precipitation data of Kermanshah province's synoptic station were used. However, non-conditional data presented more acceptable results. The study's findings showed that in 2020-2049 period, the precipitation rate increased under RCP4.5 scenario compared to the observation period (1961-2005), and it increased in the same period under the RCP2.6 and RCP8.5 scenarios. It was also found that in 2050–2069 period, the precipitation rate decreased under RCP2.6 scenario compared to the observation period (1961–2005), and increased under RCP4.5 and RCP8.5 scenarios. Generally, it could be argued that the precipitation rate would increase in this period. Moreover, it could be said that the precipitation rate would be decreasing throughout the 2070-2099 period compared to the observation period, and temperature would experience an increasing trend during 2020 -2049, 2050-2069, and 2070- 2099 periods compared to the observed period.

As indicated by the results, the Kermanshah province's climatic conditions in the prediction period would considerably differ from the current situation, suggesting serious changes in the region's climate status. Therefore, getting aware of the direct and indirect negative effects of the climate on different parts of the region and developing long–term strategic plans are necessary for dealing with such conditions.

Keywords: General Circulation Model, Greenhouse Gases, HadCM3, SDSM.