Comparison of Land Use and Climate Change Impacts on Runoff in a Small Mountainous Catchment (Case Study: Garin Dam Catchment)

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Extended abstract

Introduction

Land use and climate change and its impacts on water resources and hydrological regime have always been the most important problems in recent decades in Iran. These environmental risks will have direct and indirect impacts on health, economy and society by accelerating the hydrological cycle, drought and flood. Some researchers have examined the impacts of climate and land use change on extreme rainfall, runoff and flood events. Water resources have been investigated in different basins using hydrological models and GIS in arid and semi-arid regions via different scenarios and strategies. They have identified a serious increasing trend of extreme rainfall and drought intensity and duration due to land use change and climate change. Western Iran has experienced an agriculture growth and land use change that can alter evaporation patterns and affect the more frequent occurrence of drought and flood extremes largely due to climate change in this mountainous region. Definitely, there is an increasingly notable challenge in management of water resources, prediction of future changes in land use and climate variabilities, and human activities. In a watershed, climate change and human activities both contribute to the hydrological cycle, and this result has been supported by many researches. In this study, climate change scenarios and land use change models are coupled with a hydrological model to study impacts of these changes on runoff in a mountain catchment in western Iran.

Materials and methods

Under the assumption that runoff is affected only by land use and climate changes, the effects of climate changes on runoff were studied using SWAT model. This hydrological model calibrated for the period of 2002 to 2007 and was then validated for the period of 2008 to 2010, and after

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that it is operated in base (2014) and future (2042) period. The required data are including a Digital Elevation Model (DEM), soil properties, vegetation, land use, climate observations, and discharge observations in Garin dam gauging station. Land use in the Garin Basin was extracted from the Natural Resources Department of Hamadan in 1986. These maps have been produced from Landsat 8 images in 2000 and 2014. Additionally, Land use map has been predicted for 2042 using Markov and CA Markov models based on transition probabilities. Curve number can reflect the capacity of runoff yield for the land cover with a continuous spatial distribution. Based on land use maps of two periods and soil type data of Garin catchment, CN distribution maps in the same periods were obtained with spatial interpolation. To predict the future climate, the HADCM3 model was used and its outputs were scaled up with SDSM model. SDSM Model used for down scaling of rainfall and temperature data obtained in Hadcm3 output for prediction of Garin future climate.

Results and discussion

The SWAT model is performed well in both the calibration and validation periods, accurately simulating the outlet flows according to the model performance criteria after the sensitive parameters were optimized. The simulation coefficients for calibration and validation are presented in Table 1 and 2. The results show that the forest area will be increased and rangeland will be decreased until 2042 (table3). The Result of Markov chain and CA Markov Chain analysis indicate that land use change will make less the runoff rate under A2 and B2 scenarios in 2042. The results reveal that climate change impacts on reduction of runoff is more than land use change during 2042 to 2050 compared with 2000 to 2010.

Table1. The model criteria in Calibration and validation for discharge simulation in Garin catchment

br2	MSE	P-factor	R-factor	R^2	NS
0.36	0.39	0.47	0.03	0.60	0.59
0.51	0.16	0.39	0.04	0.67	0.66

Table2. The comparison of the land uses areas in 2014 compared with 2042

Rockland	Rangeland	Cultivated Forest	Natural Forest	Year
3.24	14.63	0.82	2.35	2014
3.20	14.19	1.05	2.59	2042

Conclusion

The results of NC, br^2, R^2, MSE, P-factor and R-factor coefficients show that validation was better than calibration and both reveal that performance of the model is reasonable. It was obvious that climate change with increased precipitation and decreased evaporation caused an increase in runoff in the study area. The results show that if the trend remain stable during 1986 to 2014, the forest area will be increased by 2.28 percent and rangeland will be decreased by 2.07 percent until 2042 and also, mean precipitation will be reduced but mean temperature will be increased. The results indicate that decrease in rangeland and rock land area and increase in forest area result in a reduction in runoff under A2 and B2 scenarios in the future. The output of the SWAT model show that the monthly runoff has decreased in January, February, March, April, May and December and has increased in July, August and September due to the rainfall decrease and increase compared with the base period. Overall, the results show that the effects

of climate change on runoff reduction is more than the effects of land use change from 2014 to 2042. The results can be used to improve management of Garin watershed and to focus on soil and vegetation cover damage. Besides, the amount of runoff altered by land use change (6.5%) is lower than the climate change effect (10.7%) in this mountainous catchment. Further research is required to acquire the regional future climate scenarios coupled with the hydrological model of a basin under GCMs (general circulation models) with the downscaling technique, so as to further quantify the relations between runoff and climatic variables. In addition, the space-time distribution of floods and droughts resulted from the runoff change should also be examined to provide scientific framework for basin-scale water resource management.

Keywords: climate change, Garin Catchment, runoff, land use, SWAT model.