Modeling streamflow response to climate change in Wamkurumadzi River, Shire Basin in Malawi using the SWAT Model

L. Nkhoma[1], C. Ngongondo[2], Z. Dulanya[2], M. Monjerezi[3], C-Y. Xu[1], L.M. Tallasken[1]
[1]Department of Geosciences, University of Oslo, Oslo- Norway
Email: lusungunkhoma@gmail.com
[2]Department of Geography and Earth Sciences, University of Malawi
P.O Box 280, Zomba – Malawi
[3]Department of Chemistry and Chemical Engineering, University of Malawi
P.O Box 280, Zomba – Malawi

ABSTRACT

Climate change is expected to bring increased variability in future streamflow depending on the hydroclimate of the region and the specific characteristics of the catchment studied. Empirical evidence continues to show that Malawi is one of the countries that has experienced significant variations in hydrometeorological conditions, ranging from severe drought conditions to extreme flood events almost every year. However, there is still a gap in evaluating the long-term impact of climate change on streamflow mainly due to high rate of missing hydro-climatic data in most of the region. This study evaluates how climate change affects the flow of Wamkurumadzi River, a key tributary of Shire River in Malawi using the Soil and Water Assessment Tool (SWAT). Historical climate data from 1981 to 2015 and eight hypothetical climate change scenarios (e.g. combination of $\Delta T = +2^0C$ and $+4^0C$ and $\Delta P = \pm 10\%$ and $\pm 20\ \%$) were applied to simulate streamflow. Sequential Uncertainty Fitting 2 (SUFI-2) within SWAT-Calibration and Uncertainty Procedures (SWAT-CUP) was used for calibration from the year 1984 to 1999 and validation from the year 2000 to 2015. Model performance was acceptable according to evaluation criteria, with the Nash-Sutcliffe (NSE) coefficient of 0.78 and coefficient of determination (R^2) of 0.96 during calibration and NSE of 0.93 and R^2 of 0.98 during validation.

The results of historical trends showed a slight decrease in annual rainfall. On the other hand, there was no trend in annual temperature, whereas the trend in observed river flow suggests a predominance of increasing trends at monthly and annual timescales. The hypothetical climate change scenarios revealed that most prominent changes in river discharge were due to changes in precipitation (±10 and ±20%), whereas temperature had limited projected effect. For instance, scenario 8 ($\Delta P = +20\%$ and $\Delta T = 4^oC$) gave a relatively slight increase in simulated mean daily discharge of $2.13 m^3/s$ as compared to scenario 5 ($\Delta P = -20\%$ and $\Delta 4^oC$), which gave the lowest mean daily discharge of $1.77\ m^3/s$. Overall, the results indicate that the streamflow is sensitive to both precipitation and temperature but changes in precipitation gave a relatively higher effect on the magnitude of the mean daily, monthly and seasonal discharge compared to changes in temperature.

Keywords: Climate change; SWAT model; Streamflow; Wamkurumadzi River

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