Tropentag, September 16-18, 2026, hybrid conference

"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

Blue and green water resources: Projected changes under climate change in the Upper Nile basin, Ethiopia

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Abstract

Future climate change is a critical issue for the Nile River Basin; however, its impact on water resources has been insufficiently studied despite the basin's substantial water potential. This study evaluated the impact of climate change on blue and green water in the Upper Nile, focusing on the Kessie watershed (~65,000 km^2) in Ethiopia, using the Soil and Water Assessment Tool (SWAT+). Multisite model calibration and validation were performed using streamflow data from four gauging stations (the main outlet and three subbasin stations). The quality-managed and homogenised meteorological climate data were used to set up the model. The study used a statistically downscaled best-fitted ensemble of Global Circulation Models (GCMs) from the Coupled Model Intercomparison Project Phase 6 to simulate future blue and green water. The simulations were performed at the three time periods: 2030s (2015 to 2044), 2060s (2045 to 2074), and 2090s (2075 to 2100) under the Shared Socioeconomic Pathways (SSP) (SSP1–2.6, SSP2–4.5, and SSP4–8.5), using simulations based on observed climate data (1986–2014) as a reference to evaluate changes. The SWAT+ demonstrated sufficient-to-excellent performance at all gauging stations. For instance, at the main outlet, the model showed good performance with R^2 = 0.74 (0.74), NSE = 0.71 (0.70), KGE = 0.81 (0.80), and PBIAS = -12.7 (-11.9) for calibration (validation). Both blue and green water components are projected to increase in all future periods. By the end of the 21st century, water yield is expected to increase by 17.6 %, 38 %, and 65 % under SSP1–2.6, SSP2–4.5, and SSP4–8.5, respectively. Green water flow is projected to increase by 8.6 %, 13.5 %, and 17 %, while green water storage may increase by 14 %, 20 %, and 66 %. Increased water yield indicates potential for irrigation and hydropower development in the basin. However, increased water availability may also heighten the risk of flooding and soil erosion, underscoring the need for watershed management and climate adaptation measures.

Keywords: Blue and green waters, climate change, SSP scenarios, SWAT+ editor, SWAT+ Toolbox

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