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Analysis of the combined and single effects of LULC and climate change on the streamflow of the Upper Blue Nile River Basin (UBNRB): Using statistical trend tests, remote sensing landcover maps and the SWAT model

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Understanding the response of land use/land cover (LULC) and climate change has become a priority issue for water management and water resource utilization of the Nile basin. This study assesses the long-term trends of rainfall and streamflow to analyse the response of LULC and climate changes on the hydrology of the UBNRB. Analysis of rainfall and streamflow data are done by Mann-Kendal statistical trend detection method while Landcover change assessment was done by classification analysis of Landsat satellite remote sensing based data. The Mann-Kendal (MK) trend test result showed no statistically significant changes in daily, monthly and annual rainfall. Tests for mean annual and seasonal streamflow showed a statistically significant and increasing trend. Landsat satellite images for 1973, 1985, 1995 and 2010 were used for LULC change detection. The LULC change detection findings indicate the conversion of forest land to cultivated land during the period 1973-2010. Natural forest decreased from 17.4% to 14.4%, 12.2% and 15.6% while cultivated land increased from 62.9% to 65.6%, 67.5% and 63.9% from 1973 to 1985, 1995 and 2010 respectively.

SWAT hydrological model was used further to analyse the combined and single impacts of climate and LULC change on the streamflow and water balance components. A baseline-altered method was used in which the simulation period 1971–2010 was divided into 4 equal periods to represent baseline conditions 1970s (1971–1980) and altered land use and climate conditions 1980s (1981-1990), 1990s (1991-2000) and 2000s (2001-2010). A SWAT model was calibrated for the baseline and altered periods separately. For the calibration period, the values of correlation coefficient (R2) , Nash–Sutcliffe efficiency (NSE) and relative volume error (RVE (%) from the four model is ranged from 0.78 to 0.91, 0.73 to 0.91 and 0.7% to 4%, and for the validation period it ranged from 0.84 to 0.94, 0.84 to 0.92 and -7.5% to 7.4% respectively. The simulation result showed that mean annual streamflow increased by 15.6% between the 1970s and the 2000s due to the combined effect of LULC and climate change. The single effect of LULC change on streamflow analysis suggested that LULC change significantly affects surface run-off and base flow. This could be attributed to the 5.1% reduction in forest coverage and 4.6% increase in cultivated land. Effects of climate change revealed that increased rainfall intensity and number of extreme rainfall events from 1971 to 2010 have greatly affected the surface run-off and base flow of UBNRB.