Modelling the influence of land use change on the hydrology of Mara River using USGS Geospatial Stream Flow Model

Simon Mulwa Mutie

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ABSTRACT

This study was carried out with the aim of assessing the effects of land use/ land cover change on the hydrology of River Mara. The study incorporated remote sensing and GIS tools and hydrologic models to prepare and analyze the data. The Mara River basin is a trans-boundary basin between Kenya and Tanzania. The basin is 13,835 km^2 and strands from the Mau forest in Kenya to Musoma in Tanzania. The basin receives bimodal rainfall with the mean values varying from 1400 mm/yr on the highlands to 600 mm/yr on the lowlands. The mean temperature is 25 ^oC.

Land cover change was analyzed from dry season LandSat MSS, TM and ETM images of 1973, 1986 and 2000 respectively. Digital image analysis showed that between 1973 and 2000, forests and shrubland have reduced by 32% and 34% respectively. Grassland, savannah and water bodies have also reduced by 45%, 26%, and 47% respectively. However agricultural land, tea and open forests, and wetlands all increased by over 100%.

The USGS Geo-SFM was evaluated as a streamflow generating tool for the Mara River basin. Calibration and validation were done with streamflow data from Nyang'ores, Amala and Mara mines gauging stations along the Mara River. The model was calibrated from 1983 to 1988 and validated from 1989 to 1991. After calibration the model was found to predict high streamflow

quite accurately but underestimated the low flows. The coefficient of determination (R^2) during validation varied between 0.69 and 0.87.

The calibrated USGS Geo SFM model was then used to investigate the effects of the derived land cover to the river flow. The hydrological response of 1973 and 2000 land cover classifications showed that over the 28 years, flow peaks have on average increased by 6% and occur 4 days earlier. The 2000 land cover dataset was more sensitive to rainfall runoff relationships and produced runoff even after small rainfalls which otherwise did not produce runoff when the 1973 land cover data set was used. In addition, the hydrograph generated with the 2000 land cover dataset was shifted to the left, the rise to peak was faster, peaks were higher and the recession phase was faster compared to the hydrograph generated with the 1973 land cover dataset.

Six land cover change scenarios describing different but plausible development pathways for the headwater forests in the basin were developed for the year 2025. The scenarios developed were business as usual scenario where forests were decreasing at 1.2%, forest conservation which had forests expanding at 5% and forest degradation scenario where forests were decreasing at 5%. The extreme of these scenarios; completely agricultural land, completely forested land and completely bare land were also analyzed. Comparing forest conservation and completely forested scenarios to the base scenario (current situation), stream flow peaks reduced by 8.7% and 17.1%