Hydrologic analysis for river Nyando using SWAT

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Abstract

The Nyando River is one of the major Rivers in the Lake Victoria Basin. It drains parts of Nandi, Kericho and Nyando districts. It has a catchment area of about 3600 km² of Western Kenya and an average discharge of approximately 15 m³ s⁻¹, and has within it some of the most severe problems of environmental degradation and deepening poverty found anywhere in Kenya. The Nyando River drains into the Winam Gulf of Lake Victoria and is a major contributor of sediment.

The primary role of GIS in hydrological modeling is to integrate the ever increasing volumes of diverse spatial and non spatial data. This can be the model input or output. Recent advance in GIS (hardware and software) technology offer unprecedented capabilities for storing and manipulating large quantities of detailed, spatially-distributed watershed data (ASCE, 1999). SWAT, which is an interface of Arc View GIS, uses Arc View to prepare input data and display the model output as spatial maps, charts or time series data. This makes it easy to study and display the information for assimilation by SWAT.

SWAT is a continuous time model that operates on a daily/sub-daily time step. It is physically based and can operate on large basins for long periods of time (Arnold et al., 1998). The basic model inputs are rainfall, maximum and minimum temperature, radiation, wind speed, relative humidity, land cover, soil and elevation (DEM). The watershed is subdivided into sub-basins that are spatially related to one another. Routing in stream channel is divided in to Water, Sediment, nutrients and organic chemical routing (Neitsch et al., 2002a).

Stream flow data was available for two Stations 1GD03 and 1GD07. The stations had data ranging from 1950 to 1997, though they had missing gaps. Rainfall data were available for twelve rainfall recording stations in and around the basin. The collected data ranges between 1960 and 2000 though there were quite a number of missing data. The other weather data used were temperature data (maximum and minimum) for Kericho and Kisumu Meteorological stations.

During the study the available water capacity (SOL AWC) was varied within the range of ±0.05 mm of water/mm of soil. The result showed that SOL AWC affects the stream flow. SOLAWC affects both the surface flow and base flow. An increase in SOL AWC results in decrease on the stream flow because of increase in the ability of the soil to hold more water. An
increase in the initial curve number (CN2) increases the stream flow, but the effect is more pronounced on the effects on surface run off. The slightly increase in total stream flow could be as a result of ration of surface run off to base flow.

The amount of stream flow contributed by the base flow was more than 50% of the total stream flow as show by base flow separation. The goodness of fit between observed and simulated stream flow was assessed for the aforementioned (1GD03) station, the $R^2$ was found to be 0.24 while the NSE was 0.46 respectively. The low value of $R^2$ and NSE could be attributed to lots of data gaps in the station and also the effects of combined tributaries. The station is located about 10 km upstream of Ahero Bridge just before the flood plain. The model over estimated the low flows at this station while the high flows were well estimated.

The performance of the model varied depending on the available input data. The coefficient of determination $R^2$ varies for observed and simulated stream flow at River gauging Station. The relationship between land use/cover change and stream flow is very significant in Nyando basin. The observation made is that with decreased Forest Cover up to 0% there is increased stream flow mean and peak and increased forests cover i.e. 100% results in decreased mean and peak stream flow.