

Assessment of the Flow Regime of Roanoke River due to Climatic and Anthropogenic Activities

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The natural flow regime of many rivers around the world has been significantly altered due to climatic and anthropogenic modifications such as the construction of dams and reservoirs. The natural flow regime plays an important role in the development of the riverine ecosystem. Therefore, quantification of the extent of the alterations in the natural flow regime would be helpful in the river's ecological assessment. The Roanoke River in southeastern United States had one of the biggest and least disturbed forest ecosystems but due to climatic changes and anthropogenic actions such as construction of dam, artificial regulations of the natural flow regime, the overall riverine ecosystem has severely impacted. In this study, SWAT (Soil Water Assessment Tool) has been used to reconstruct the long-term unaltered streamflow for a hypothetical no-dam scenario condition, in order to assess the impact of climate change as well as due to construction of the John H Kerr reservoir on Roanoke River streamflow from 1956-2012. In order to simulate the unaltered streamflow series post construction of John H Kerr reservoir, 32 years (1916-1948) of observed gauge inflow prior to anthropogenic disturbance (due to construction of John H Kerr Reservoir) was used for calibration and validation of the parameters of the SWAT model. Historical land use and land cover backcasting data for the year 1938 has been used in the hydrological model to simulate the flow regime prior to construction of the dam and it was kept same during the whole simulation period. The SWAT model simulated observed gauge data with Nash-Sutcliffe efficiency coefficient (NSE) = 0.70, Percent bias (PBIAS) = 0.00 and the determination coefficient (R^2) = 0.73 during the calibration period (1916 - 1936), and performed equally better during the validation period (1937-1948) with NSE = 0.72, PBIAS = 0.00 and R^2 = 0.74. The indicators of hydrologic alteration (IHA) methodology has been used to assess the natural flow regime (no dam or reservoir moderated flow regime) characteristics under a simulated no-reservoir scenario (scenario1) and compare with the IHA results obtained based on the gauged streamflow downstream of the dam (scenario2). Hence, in case of scenario 1, the post-impact period has been taken as the simulated flow series using SWAT model from 1956-2012 and in case of scenario 2 the post-impact period has been taken as the gauged observed streamflow from 1956-2012 at Roanoke Rapids gauging station downstream of the reservoir. The pre-impact period for both the scenario was kept the same i.e. from 1912 to 1949. The results reveal that in case of the IHA assessment based on scenario 1, significant alterations have been observed in 5 out of 32 indicators compared to 13 out 32 indicators in case of scenario 2. The overall hydrologic alteration in case of scenario 1 was 45.65% and it was 55.17% in the case of scenario 2. The alteration during the scenario 1 could be attributed to the overall natural climatic variability. The results also indicate that flow variability in terms of high and low flows were better in scenario 1 compared to scenario 2 where the high flows were completely absorbed including the low pulse count and duration due to regulation in the flow. However, the reservoir operations enhanced the monthly flows including the multiday minima low flows. Thus, the present method can be treated as an easy-to-implement comprehensive approach for designing natural flow regimes to mimic the pre-impact flow condition in order to restore the ecosystem of modified rivers due to anthropogenic interventions.

Keywords: SWAT, IHA, Streamflow, Hydrologic Alteration, Ecosystem