ASSESSING FUTURE LOW-FLOW VARIATIONS IN A DRY ZONE RIVER BASIN UNDER CHANGING CLIMATE CONDITIONS

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Climate change significantly alters the low-flow regimes of river basins worldwide and presents significant challenges to water-scarce regions, especially in dry regions. This current study investigates the impact of climate change on projected low-flow variations in the Maduru Oya River Basin in Sri Lanka, focusing on the reach to the Padiyathalawa stream-gauge station. The study utilizes a lumped hydrological modeling framework, which used the HEC-HMS rainfall-runoff model to simulate streamflow behavior considering anticipated climate scenarios. Projections for future precipitation were obtained from the CNRM-CM6-1 Global Climate Model (GCM), which is part of the Coupled Model Intercomparison Project Phase 6 (CMIP6), and subsequently downscaled through the Long Ashton Research Station Weather Generator (LARS-WG) according to two Shared Socioeconomic Pathways (SSPs): SSP2-4.5 and SSP5-8.5. The precipitation data, downscaled to the local scale, were integrated into the HEC-HMS model to forecast future river discharge and investigate possible changes in low-flow characteristics.

The 7Q10 low-flow index, which is defined as the minimum average flow in a continuous seven-day period with a recurrence interval of ten years was used for estimating and comparing low-flow characteristics. The model parameters were calibrated and validated using historical data from 1997 to 2019. Three objective functions namely: Nash-Sutcliffe Efficiency (NSE), Mean Relative Absolute Error (MRAE), and Percent Error in Peak Flow (PEPF) were used for optimizing model parameters. Future precipitation was projected for short-term (2021-2040), medium-term (2041-2060), and long-term (2061-2080) durations. The projected precipitation data was subsequently input into the developed HEC-HMS model to obtain future streamflow projections for the specified periods.

The results of the climate change scenario analysis showed that precipitation may vary due to climate change within the range of -16 % to -5 % for the 2021-2040 period, - 4 % to 1 % for the 2041-2060 period, and 1 % to 21 % for the 2061-2080 period. The results indicated a likely increase in low-flow values across both SSP scenarios. The flow-duration analysis showed that the Q_{90} flow, representing the flow level that exceeds 90% of the time, is expected to increase, reflecting an upward change in streamflow for low-flow conditions. These findings are important for water resource managers working in the area to plan for and adapt to the impacts of altered low-flow regimes that can impact water supply, agriculture, and overall ecosystem health. Further studies should consider incorporating the use of hydrological models coupled with diverse climate scenarios to better capture the uncertainties related to climate predictions and land-use changes. These would provide a better understanding of the impacts of climate change on river basin hydrology in dry regions like the Maduru Oya River Basin.

Keywords: 7Q10 Index, CMIP6, GCMs, HEC-HMS, LARS-WG, SSPs

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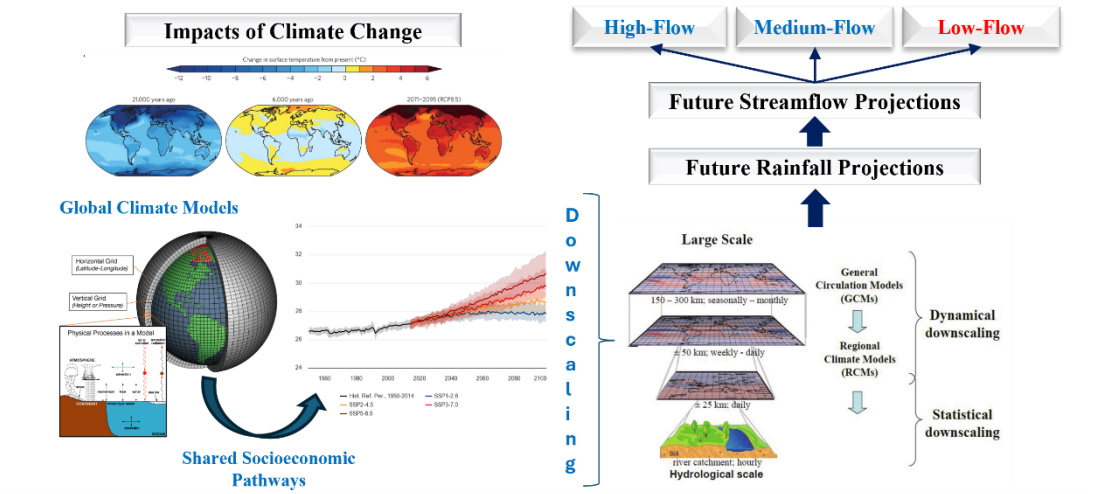
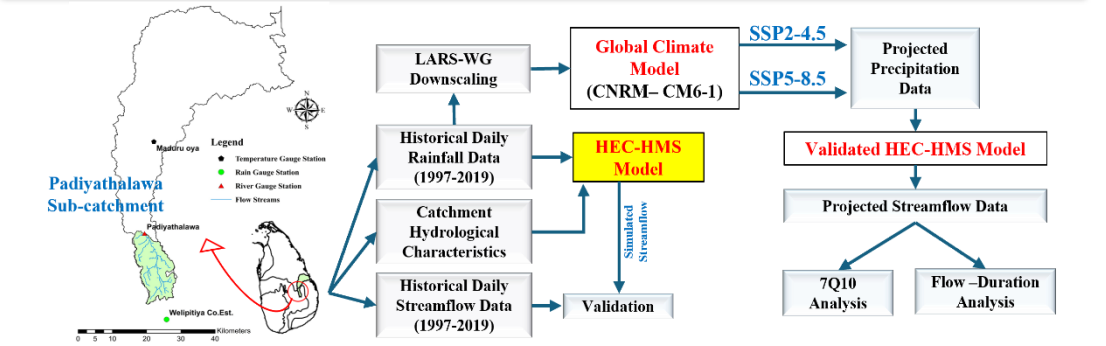
Background

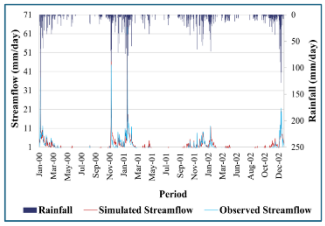


Research Methodology

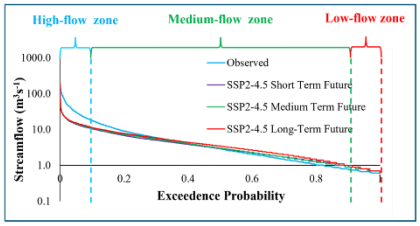


Results

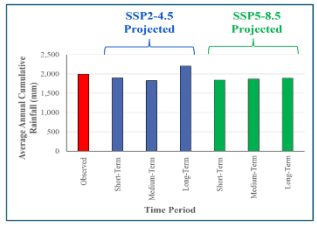
Rainfall-Runoff Hydrograph - Calibration Period



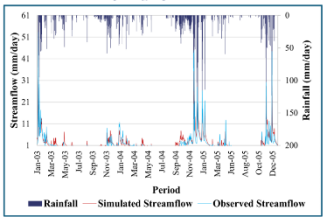
Flow-Duration Curves for the SSP2-4.5



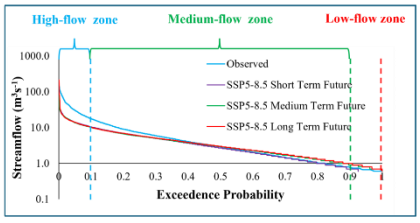
Change in Average Annual Precipitation



Rainfall-Runoff Hydrograph - Validation Period



Flow-Duration Curves for the SSP5-8.5



Model Step	NSE	MRAE	PEPF(%)
Calibration	0.667	4.04	6.18
Validation	0.755	1.99	5.29

-16% to -5%	-4% to 1%	1% to 21%
Change in Precipitation During 2021-2040	Change in Precipitation During 2041-2060	Change in Precipitation During 2061-2080