# AI-Assisted Hyperparameter Optimization of the InVEST Annual Water Yield Model for Climate Change Impact Assessment in the Meta River Basin, Colombia


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## ABSTRACT

Accurate prediction of future water availability under climate change scenarios is critical for water resource management, particularly in data-scarce tropical regions. This study presents a novel application of artificial intelligence-driven hyperparameter optimization specifically targeting the minimization of Root Mean Square Error (RMSE) and maximization of the Nash-Sutcliffe Efficiency (NSE) coefficient to calibrate the InVEST Annual Water Yield (AWY) model for the Meta River basin in Colombia, a 113,981 km² watershed of significant ecological and agricultural importance. Traditional calibration approaches for the InVEST-AWY model rely on manual adjustment of key parameters, such as the Zhang coefficient (Z) and the crop evapotranspiration coefficient (Kc), which is time-consuming, subjective, and often unable to identify globally optimal parameter combinations. In this work, an automated AI-based hyperparameter search comprising 7000 simulations over the calibration period (1983–2012) was implemented to systematically explore the parameter space and identify the combination that best minimizes RMSE and optimizes NSE across subbasins. The optimized parameter set (Z = 1, Kc = 1.10) was then applied to generate climate change projections for 2050 using an ensemble of 13 CMIP6 global climate models under two Shared Socioeconomic Pathway scenarios (SSP 4.5 and SSP 8.5), with climate data sourced from the WorldClim database and downscaled to 1 km resolution. Results show that the AI-calibrated InVEST model reliably reproduces observed water discharge in the upper Meta River subbasin (r = 0.79 calibration; r = 0.83 validation), demonstrating the added value of automated optimization for improving model performance in heterogeneous tropical basins. Under the AI-optimized configuration, the model projects a basin-wide increase in mean annual water yield of 24% under SSP 4.5 (from 5,141.6 to 6,397.5 m³/s) and 19% under SSP 8.5 (reaching 6,101.5 m³/s) by 2050. Conversely, the South Cravo River subbasin is projected to experience a significant decline of 10–14%, signaling localized water scarcity risks. The integration of AI-based hyperparameter optimization within the InVEST framework represents a significant methodological advance for large-scale hydrological modeling in developing countries, where data limitations constrain the use of more complex distributed models. This approach enhances the reliability of ecosystem service assessments and supports evidence-based decision-making for climate adaptation in the Colombian Orinoco region.



**Keywords:** InVEST model; hyperparameter optimization; water yield; climate change; CMIP6 scenarios; Meta River basin.