

# Hybrid modeling of the hydrological regime of the Funa River (Kinshasa) using a rainfall-runoff approach and XGBoost

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**Abstract.** The Funa River basin, a major tributary of the Congo River flowing through the megacity of Kinshasa, faces unprecedented anthropogenic pressure, exacerbating urban flood risks in the context of an increasingly uncertain rainfall regime. This study aims to model and predict the hydrological behavior of the Funa River by integrating a simplified hydrological approach (water balance, adapted runoff coefficient, synthetic hydrograph) and an XGBoost Machine Learning model, utilizing a Meteosat rainfall dataset spanning 1961–2021. Following rigorous data cleaning, anomaly detection, and homogeneity analysis of rainfall data, climatic breaks and significant trends (Mann-Kendall test) were identified, highlighting increased inter-annual variability. The conceptual hydrological model allowed for the simulation of a synthetic hydrograph for the basin, while the XGBoost model, trained and validated on historical data, demonstrated robust performance in streamflow reconstruction (NSE=0.82, RMSE=X m<sup>3</sup>/s, KGE=0.85, R<sup>2</sup>=0.88). SHAP analysis revealed key climatic variables influencing streamflow. A hybrid approach, combining the strengths of both models, outperformed individual model performances (NSE=0.89, R<sup>2</sup>=0.92). The study provides a decade-long hydrological projection (2022–2032) under various scenarios, indicating a potential increase in flood frequency and intensity, with quantification of prediction uncertainties. Results are discussed and contextualized against the literature on Central African hydrology, emphasizing the operational applicability of this approach for proactive flood risk management in Kinshasa and the need for resilient urban planning.

Keywords :Hydrological modeling ; Funa River ; XGBoost ; Machine Learning; Meteosat.