Accuracy Comparison of Machine Learning and Statistical Methods for Daily Rainfall Estimation in the Kelani River Basin, Sri Lanka

S.W. Kamburugamuwa*, M.M.G.T. De Silva, H.M.D.K. Herath, N.G.P.B. Neluwala

Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka
**sachini.kamburugamuwa@gmail.com*

Accurate estimation of daily rainfall at local scales remains a major challenge in hydrology due to the highly nonlinear and spatially variable nature of precipitation. For flood forecasting and water resource management, accurate rainfall prediction is essential. This study evaluates the performance of machine learning and conventional techniques for estimating daily rainfall at the Hanwella station, located within the Kelani River Basin, based on rainfall data from four neighbouring stations. An Extreme Gradient Boosting (XGBoost) model and a Long Short-Term Memory (LSTM) model were developed using multi-station rainfall data from 2020 to 2025, while spatial interpolation techniques such as Inverse Distance Weighting (IDW) and the Normal Ratio method were used as reference techniques. The LSTM model was trained using 3-day temporal sequences with various loss functions (Mean Absolute Error (MAE), Mean Squared Error (MSE), Huber loss, Mean Squared Logarithmic Error (MSLE), and Log-Cosh loss). The performance of all four models was assessed using Root Mean Square Error (RMSE), MAE, and Nash–Sutcliffe Efficiency (NSE). These evaluation metrics were calculated separately for the validation and testing datasets to provide a comprehensive comparison of model performance. Among the evaluated methods, the IDW approach ($p = 2$) exhibits the highest performance, achieving an RMSE of 18.32 mm/day and an NSE of 0.63, indicating a moderate level of predictive accuracy, whereas the remaining methods demonstrate comparatively lower predictive accuracy. XGBoost demonstrated competitive performance on the structured tabular dataset, followed by the Normal Ratio method, while LSTM showed the lowest overall accuracy. This behaviour may be attributed to the dominance of spatial relationships over temporal dynamics, thereby limiting the effectiveness of sequence-based learning. These outcomes imply that model configuration, feature representation, and data properties significantly impact model performance. The LSTM model has difficulty predicting peak rainfall events, even if it was able to capture overall rainfall variability. XGBoost shows superior performance on the structured dataset compared to LSTM, but both methods can be further improved. This study helps to make more accurate flood predictions and water resource management by offering useful insights for enhancing rainfall estimation techniques.

Keywords: LSTM, XGBoost, inverse distance weighting, normal ratio method, RMSE, MAE, MSE, NSE, Kelani River Basin

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