Understanding Impacts of Urban Flooding and Climate Change with Advanced Technologies

by:

Ir. Lt. Kol. Bersekutu (PA) Dr. Tan Woon Yang

Senior Principal Assistant Director at National Flood Forecasting and Warning Centre, Department of Irrigation and Drainage Malaysia.

Ir. Prof. Dr. Lai Sai Hin

Professor at Department of Civil Engineering, Faculty of Engineering, University Malaysia Sarawak (UNIMAS). His research is focused on flood, drought, and water resources management in the context of climate change.

Ir. Ts. Prof. Dr. Teo Fang Yenn

Professor of Water & Environmental Engineering at University of Nottingham, Malaysia and Deputy Chair of IEM Environmental Engineering Technical Division.

Climate change is not just about fluctuating temperatures; it is reshaping our world in profound ways. One significant consequence is the impact on streamflow patterns, making rainfall unpredictable and temperatures fluctuate wildly. These changes disrupt the delicate balance of ecosystems and pose serious threats to urban areas.

Urban areas, like Kuala Lumpur, face significant risks from flooding due to intense rainfall and rapid urbanisation. These floods not only damage infrastructure but also put lives and livelihoods at risk.

So, how do we tackle this growing problem? One solution lies in advanced forecasting models. These models, powered by cutting-edge technology, can give us early warnings of impending floods, allowing us to better prepare and protect our communities.

There are two main types of forecasting models: Process-driven and data-driven. Process-driven models rely on physics to simulate flood formation, while data-driven models use historical data and statistical techniques to predict future outcomes. Both have their strengths and weaknesses, but when combined, they are a powerful tool for flood management.

One exciting development in this field is the rise of deep learning, particularly Long Short-Term Memory (LSTM) networks. These networks excel at understanding complex patterns in data, making them ideal for forecasting streamflow. By harnessing the power of deep learning, we can improve the accuracy of our flood forecasts and better protect our cities.

Our study focused on Kuala Lumpur and the Stormwater Management & Road Tunnel (SMART) project (Figure 1), a groundbreaking initiative aimed at mitigating urban flooding. By analysing data from telemetry stations along the Klang River basin, we hoped to develop more accurate forecasting models that could help us anticipate and respond to floods more effectively.

But developing these models is not easy. They are sensitive to input variables and uncertainties. Getting them right requires careful calibration and validation. This was where our research came in. By combining the latest advancements in deep learning with real-world data, we aimed to create forecast models that were not only accurate but also practical and easy to use.

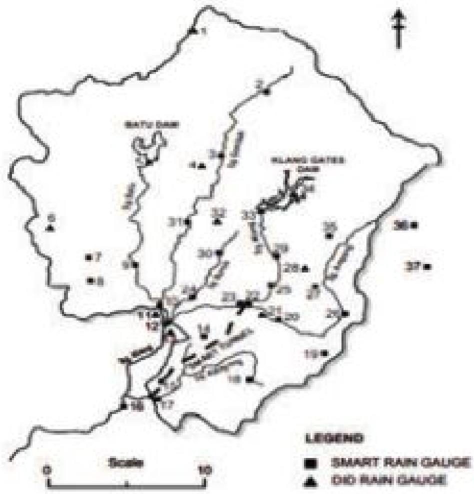

Figure 1: Study location and rain gauge sites

Our goal is simple: To make our cities safer and more resilient in the face of climate change. By understanding the complex dynamics of floods and harnessing the power of technology, we can build a better future for all.

This section presents the results obtained from training various models for streamflow forecasting. The models used were the Multilayer Perceptron (MLP) network, specifically the Feedforward Backpropagation (FFBP) model, and LSTM models. Initially, the analysis was conducted without any preprocessing steps. Later, a preprocessing step was introduced to enhance the accuracy of the forecasts. The results were assessed based on different input parameters and target variables.

The input parameters consisted of precipitation data from 11 stations located in the upper catchment area of the SMART watershed, with readings taken at 30-minute intervals. The data was used to train both the FFBP and LSTM models to predict flows at the confluence of the Ampang River and Klang River.

For the FFBP model, the analysis began with one hidden layer and was later extended to include two hidden layers. The number of neurons in each hidden layer varied