NUS-TUD Double Degree Program
MSc. Hydraulic Engineering & Water Resources Management

CIE5060 MSc. Thesis
(40 ECTS)

Conceptual Modelling of the Padas Catchment:
Understanding Catchment Behaviour with Expert Knowledge & Model Realism

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1.0 Executive summary

Lumped conceptual and physically based distributed hydrological models are two ends of the modelling spectrum ranging from simplicity to complexity. Lumped conceptual models are often used to simulate the main hydrological processes of a catchment at the catchment scale. A lumped conceptual model usually requires less data but stronger dependency on calibration for parameter estimation compare to distributed physically based models. A physically based distributed model is more complex where small-scale physics apply. Such model is more complex and assumes that the catchment response is an aggregation of all these small-scaled processes.

The aim of this study is to understand the Padas catchment by means of a lumped conceptual model through a stepwise approach. Three primary source of information have been obtained from the Drainage and Irrigation Department of Sabah – hourly rainfall, daily evaporation and hourly discharge. In addition, DEM data from CGIAR-CSI was also used in the modelling practice.

This study initiated with a simple three-reservoir lumped model. It is then built up by incorporating additional rain inputs, parameters and reservoirs. Spatial variation of the rain input was incorporated through Thiessen-averaging. When a sufficiently good model was achieved, complexity was further increased. This was done by incorporating the catchment’s topography and introducing different landscape units – wetland (floodplain), hillslope and plateau. These landscapes represent the different hydrological response units (HRU’s), each representing a dominant hydrological process thus making the model semi-distributed.

Due to equifinality, the final model evaluation was not confined to just one best parameter set with the optimum objective function. Instead, 95% confidence interval has been used for reporting the simulated values. The hydrograph results were thus presented as an envelope hydrograph. The uncertainty was measured and compared by the area bounded by this hydrograph envelope. Before calibration, the final models were firstly constrained. The application of process and parameter constraints greatly improves the model performance in terms of hydrograph envelope as well as uncertainty measure. Validation was also greatly improved for a constrained model compared to an unconstrained model. Although it is not the intention of this study to find the best model, Model I is found to represent the catchment the best. The dotty plots for Model I also showed no obvious trend and may indicate that all parameters have already been optimised – a case of equifinality as well.

Results showed that the runoff coefficient has a linearized response respect to the moisture content in the unsaturated soil layer. The runoff coefficient is expected to be between 0.27 and 0.73. This is consistent with the observed data of between 0.33 and 0.57. In the final landscape models, it is found that the maximum percolation rate and preferential recharge exhibit a stronger trend in the dotty plots. This indicated that the ground water plays some significant influence to the catchment response. Low flows may therefore be equally important and should be studied in future research. When considering low flow, the Pangi run-of-river power plant may play a significant role. In
this thesis study, it has been considered as insignificant during high flows and had been excluded due to limited data.