APPLICATION OF 'abcd' MONTHLY WATER BALANCE MODEL FOR KALU GANGA AND GIN GANGA BASINS AND ITS APPLICATION POTENTIAL FOR WATER RESOURCES INVESTIGATION

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Water Resources Engineering and Management

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person expect where the acknowledgment is made in text. Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

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Dulan Nalaka Gunasekara Date

The above candidate has carried out research for the Master's thesis under my supervision.

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Dr. R. L. H. L. Rajapakse Date

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ABSTRACT

Application of 'abcd' monthly water balance model for Kalu Ganga and Gin Ganga basins and its application potential for water resources investigation

Only a limited number of mathematical models have been developed currently in Sri Lanka for water resources management purposes in Kalu and Gin River basins which predominantly provide water for the water supply schemes, irrigation and mini hydropower schemes. The developed models contain either a large number of parameters which increase the model complexity or less number of parameters which increase the amount of details in a parameter thus compromising the simulation accuracy. Based on available case studies, it is sufficient to have three to five parameters to reproduce most of the information in a hydrological record in monthly models for humid regions. Therefore, the “abcd” model which is a monthly lump hydrological model with four parameters was selected for the present research for the investigation of water resources in Kalu and Gin river basins considering Ellagawa and Thawalama sub catchments.

For the corresponding watersheds, precipitation, streamflow and evaporation data were collected for the past 30 years and checked by visual comparison, single and double mass curve analysis and annual water balance budget to ensure data reliability, consistency and to identify suitable data periods for model calibration and validation. For Gin River, a 25 years data period was used, while 20 years of data were selected for Kalu River basin. For the model evaluation, Mean Ratio of Absolute Error (MRAE) was used as the objective function while Nash Sutcliff Efficiency coefficient was used for the comparison purposes. In addition, visual inspection of flow simulation with respect to the observed flow, annual water balance and flow duration curves were used for the model performance evaluation. The optimized a, b, c, and d parameters for Thawalama and Ellagawa watersheds are 0.961, 1066, 0.003, 0.813 and 0.998, 1644, 0.013, 0.741, respectively. The MRAE for the calibration of Thawalama and Ellagawa watersheds are 0.21 and 0.26, respectively while obtaining 0.23 and 0.43 for the validation which show satisfactory results. In both watersheds, low flows have been slightly over estimated while very high flows have been underestimated. But a balanced distribution of simulated flow results can be observed in intermediate flows. Comparatively high dispersion of simulation results can be observed in Ellagawa watershed than Thawalama watershed. In case of parameter sensitivity, parameter “a” and “b” are the most sensitive while parameter “d” is having the lowest sensitivity.

As model outputs, monthly and annual variation of groundwater discharge, direct runoff, soil moisture storage and groundwater storage of the watersheds were obtained. For the overall discharge of both watersheds, the contribution from groundwater is very low. Therefore, the “abcd” hydrologic model can be recommended to use for streamflow simulations and water resources investigations in monthly temporal resolution for the watersheds which are having similar characteristics with parameter values in the ranges of a (0.961-0.998), b (1066-1644), c (0.003-0.013) and d (0.813-0.741).

Key words: ‘abcd’ model, monthly water balance model, parameter sensitivity, water resources investigation

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LIST OF ABBREVIATIONS

Abbreviation	Description
IPCC	Intergovernmental Panel on Climate Change
MSL	Mean Sea Level
P_t	Monthly precipitation
E_t	Actual evapotranspiration,
R_t	Recharge to groundwater storage,
QU_t	Upper zone contribution to runoff
XU_t	Upper soil zone soil moisture storage at the current time step
XUt_{-1}	Upper soil zone soil moisture storage at the previous time step
MRAE	Mean Ratio of Absolute Error
MSE	Mean Square Error
NSE	Nash Sutcliffe efficiency
SC	Field capacity of the catchment
WMO	World Meteorological Organization
EOt	Evapotranspiration opportunity
Rt	Groundwater Recharge
XLt	Soil moisture storage in ground water compartment after recharging
QL_t	Discharge from ground water compartment
Q_t	Total stream flow
PE	Potential Evapotranspiration
FAO	Food and Agriculture Organization
Kc	Crop coefficient
Cp	Pan Co-efficient
RE_m	Relative Maximum Error
SI	Sensitivity Index