APPLICABILITY OF ABCD WATER BALANCE MODEL FOR THE ASSESSMENT OF WATER RESOURCES IN KELANI BASIN, SRI LANKA

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June, 2018

DECLARATION

I, Ugyen Wangchuk, would like to declare that this thesis is composed of my own work, this dissertation 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. I belief it does not contain any material previously published or written by another person except where the acknowledgment is made in text.

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Ugyen Wangchuk Date

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

…… ……

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

Applicability of ABCD Water Balance Model for the Assessment of Water Resources in Kelani Basin, Sri Lanka

ABSTRACT

Water resources management in watersheds has become increasingly important due to rapid expansion of human settlements while pollution caused by industrial development has led to the part of the available precious water resources unusable for consumption, thus aggravating scarcity of fresh water resources. The impacts are further exacerbated due to global warming. The use of the multi-parameter, distributed hydrologic models for water resources assessment in the local basins are hindered due to scarcity of data and other resources. The lumped parameter rainfall runoff hydrologic models are widely applied to predict watershed response of small watersheds by simulating rainfall runoff generation and thus useful in water resource management in ungauged basins. This study aims at identifying distinct characteristics of one such widely used model, ABCD Water Balance Model, and studying its applicability to a selected sub basin in Kelani River Basin for simulating catchment response in terms of rainfall runoff. The model was subsequently applied to analyze surface and groundwater resources available in the basin, targeting effective and sustainable water resources development and management.

The data required for the ABCD water balance model were precipitation, evapotranspiration, average temperature and minimum and maximum temperatures. The model was developed in Excel spread-sheet format focusing on the data period from 1994~2011 in the Kelani basin. For model calibration, precipitation and potential evapotranspiration data during the period 1994 to 2001 were used. The generated model streamflow was compared with observed streamflow at Glencorse station for the same period. For the validation of the model, the precipitation and potential evapotranspiration data in the latter 10-year period were used. For estimating the goodness-of-fit, Nash-Sutcliff efficiency coefficient method was used, while model response to four distinct parameters were assessed based on sensitivity analysis and parameter optimization.

The calibrated model has shown that the model is less sensitive to parameters *a* (0.9) and *b* (20) while on the other hand, the model was highly sensitive to parameter *c* (0.68) and *d* (0.01). It was noted that even with the lesser amount of moisture infiltration from the upper soil zone, the aquifer was able to produce runoff. Hence, it proved that in the wet zone, the propensity of the area to produce runoff was largely independent of rainfall intensity. For the model calibration runs, the correlation or coefficient of determination (R^2) between model flow and observed flow was 0.77 with NASH coefficient value of 0.71 and MRAE of 0.27. The model produced a better response to medium flows between 5% ~ 82% with NASH value of 0.78 and good response for high flows below 5% of percent exceedance with acceptable results (NASH = 0.62). The model could not response well for low flows (NASH = 0.45).

This model with four parameters could adequately simulate the rainfall runoff response of the selected sub-watershed area in Kelani Basin (at Glencorse). Hence, this lumped parameter model was deemed suitable for streamflow forecasting and water resources assessment in Kelani basin and it can also be applied in areas elsewhere with similar hydrological characteristics.

Keywords: Lumped parameter model, model applicability, model efficiency and sensitivity

DEDICATION

This thesis is dedicated to all my siblings who stood by me in the time of need and also for their support and encouragement for my further studies. I also would like to dedicate this work to all my relatives, my primary school teachers, especially Madam Kalpana Moktan, who played a key role in molding my education and career.

Last but not the least, I would like to dedicate this especially to my parents, Mom and Dad, who are no longer with me. They would have been very proud over their son accomplishing a Master in Engineering for sure.

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LIST OF ABBREVIATIONS

Abbreviation	Description
ABCD	ABCD Water Balance Model
ANN	Artificial Neutral Network
BFI	Base flow index
CN	Curve Number
DEM	Digital elevation model
DSD	District Secretariat Divisions
E-RCM	Complex Assemble Regional Climate Models
GA	Genetic Algorithm
GCM	Global Climate Model
GCM	General Calculation Model
GCM	General Circulation Model
GIS	Geographic information system
GND	Grama Niladhari Divisions
HEC–HMS	Hydrology Engineering Center's Hydrologic Modelling System
HMLE	Heteroscedastic Maximum Likelihood Estimator
MAE	Mean Absolute Error
MCM	Million Cubic Meter
M-GCM	Multi-General Circulation Model
MM5	Mesoscale Model five
MRAE	Mean Ratio of Absolute Error
MSE	Mean Square-Error Estimator
NSE	Nash-Sutcliffe Efficiency
P-model	Palmer and Alley Model
RCM	Regional Climatic Model
RMSE	Square root of the standard mean square error
SCE	Shuffled Complex Evolution
SCS	Soil Conservation Service
S-RCM	Simple Single Regional Climate Model
SWAT	Soil and Water Assessment Tool
SWB	Simple Water Balance
TM / T-model	Thortnwaite and Mather Model
WMO	World Meteorological Organization