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The Performance of NAM (Nedbør-Afstrømnings Model) Water Balance Model in Sodong Basin, West Java, Indonesia

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Water balance model is a model that pictures hydrologic cycle. It helps people to understand the cycle by simplifying its characteristics. The simplification is done by adding several parameters to the model. Well known models like: NAM, HBV 96, Tank, and Sacramento were built in certain basin, with certain characteristics, and certain data quality. In other words, each model has its own simplification and there is a possibility that one model is more suitable for a certain basin than the other models. However, this study will only simulate the basin by using NAM model, because: its parameter number is in between HBV96 and Sacramento, can simulate snow effect, and has two analysis boxes and the third one is routing box which calculated in the end of simulation. The purpose of this study is to test NAM Model performance in simulating Sodong Basin in West Java. Data availability, basin complexity, the number of parameters is used, and model similarity are some of the considerations when choosing model. The reason behind choosing daily basis model is because daily basis model give the more detailed result compared to monthly basis model.

Keywords: *water balance model, monthly basis, daily basis, NAM model, sodong basin, West Java.*

1. Introduction

Rainfall-runoff models convert precipitation into discharge by using parameters to describe the conditions of a watershed. One of the models is NAM. This model has been used in several different countries including Indonesia[7]. This model is popular in Indonesia because, the input data and parameter numbers are suitable for Indonesia data capability. This research aims for: analyzing parameter sensitivity, calibrating the model, evaluating the model, and continuing Alley[9], Vandewiele et al.[3], and Xu and Singh[1] study which resulted "Monthly basis model can simulate annual discharge better than annual model". The difference between this research and the previous ones are: watershed location, watershed condition, data basis, and the simulation was done by using daily basis model. The research was done by doing several analyses: sensitivity analysis, parameter calibration, verification, and evaluation. The input data are precipitation year 2003 to year 2008, watershed area, and evapotranspiration. Calibration was done by adjusting the parameter so that simulated discharge is close to the observed discharge. The verification was done by comparing geological map with parameter value. Evaluation was done by comparing observed duration curve with simulated duration curve.

2. Literature Review

NAM model has 13 parameters that describe the watershed condition, those parameters are[7]: CLOF (threshold value overland flow, 0-1); CQOF (overland flow runoff coefficient, 0-1); CMELT (snow melt coefficient, >0); Umax (upper zone storage capacity, >0); CLIF (threshold value overland flow, 0-1); CQIF (interflow runoff coefficient, 0-1); CLG (threshold value groundwater flow, 0-1); Lmax (lower zone storage capacity, >0); CBFL (groundwater flow coefficient, 0-1); CKBFU (time constant upper groundwater flow, >0); CK1 (time constant overland and interflow, >0); CKBFL (time constant lower groundwater flow, >0); CK2 (time constant river flow, >0).

The similarity between observed discharge and simulated discharge can be determined by calculating Nash-Sutcliffe (NS) value. NS is one of statistics methods to calculate data difference. The bigger NS value is, the better simulation result is and vice-versa. NS can be calculated by using formula below.

$$NS = 1 - \frac{\sum(Q_{observation} - Q_{simulation})^2}{\sum(Q_{observation} - Q_{observation\ average})^2} \qquad (1)$$

3. Analysis Results and Discussion

Sodong Watershed is located in Central Java with an area of 44.87 Km^2. The nature of rain is normal and starts around November. The temperature throughout the years ranged from 22.5℃-25℃. To simulate the watershed, time series data is needed. However due to Indonesia data capability, the analysis was used year 2003 to 2008 data. Since the aim for this research is evaluating a model performance on a certain watershed during certain period of time, then newest data series is not necessarily needed. However, it is advised to use the newest time series data.

Sensitivity analysis was done to predict which parameters give bigger impact and which parameters give less impact to the simulation. Sensitive parameters are ones that the angle between horizontal line and parameter graphics can easily be seen. Based on Figure 1 the sensitive parameters are: Lmax, CQOF, CBFL, CK1, and CK2. Calibration was done by comparing observed discharge and simulated discharge. The similarities between them can be determined by calculating NS (Nash-Sutcliffe). NS is one of statistics methods to calculate difference between data. The bigger NS value is, the better simulation result is and vice-versa. Table 1 shows NAM calibrated parameters and NS value. The parameters can be verified by comparing them with geological map. Just as the geological map, the simulation resulted that the watershed's porosity is high. Based on NS value and verification, then it is safe to say that "NAM can simulate the watershed very well". Evaluation can be done by comparing observed and simulated duration curve. Figure 2 shows that NAM can simulate low flow better than simulating high flow. By comparing Permata[2] NRECA[6] and HBV 96[5,8] study result to this paper result, then conclusions that can be taken is NAM performance in simulating the watershed is lower than HBV 96. The reason is because watershed year 2003-2008 data capability is more suitable with HBV 96 parameters.

Table 1. Calibrated Parameters and NS Value for Each Year and Continuous

Parameter	2003	2004	2005	2006	2007	2008
Lmax	10.92	11.00	11.00	10.98	11.00	11.00
Umax	13.56	20.54	0.00	12.27	0.00	0.00
Cmelt	0.00	0.00	0.00	0.00	0.00	0.00
CQOF	1.88	1.90	2.00	2.00	1.90	1.90
CQIF	0.11	0.11	0.00	0.12	0.11	0.17
CBFL	0.90	0.90	0.90	0.90	0.90	0.90
CLIF	0.00	0.00	0.00	0.00	0.00	0.00
CLOF	0.00	0.00	0.00	0.00	0.00	0.00
CLG	0.00	0.00	0.00	0.00	0.00	0.00
CK1	1.70	1.26	3.41	2.20	3.26	1.54
CK2	0.94	1.37	1.20	0.76	0.85	0.84
CKBFU	579.97	579.95	17.91	580.01	14366.89	6735906.87
CKBFL	1000.00	1000.00	952.06	1000.00	3306.74	1130285.97
NS	0.84	0.77	0.86	0.81	0.14	0.24
NS All	0.69					

4. Conclusions and Recommendations

Overall NAM model can simulate watershed's discharge very well especially its low flow. The conclusion was taken based on NS value (NS >0.50) and duration curve similarity. This means, NAM simulation is reliable for water availability. Even though NAM model can simulate the watershed very well, but its

simulation result quality is lower than HBV. This means, HBV 96 parameter number covers the lack of data better. Furthermore, it is advised to use better data quality and longer data series so that the verification can be done by using observed discharge as well and the study can result the more in depth analysis.

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Figure Captions

Figure 1. NS Sensitivity Analysis Result.
Figure 2. NAM Duration Curve.
Figure 3. NRECA and HBV Duration Curve.

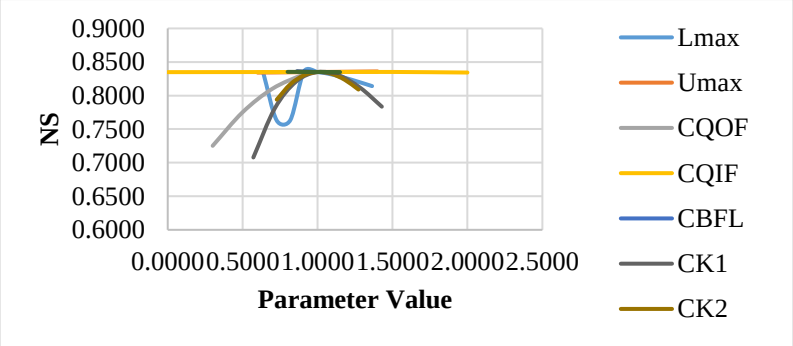

Figure 1. Permata et al.

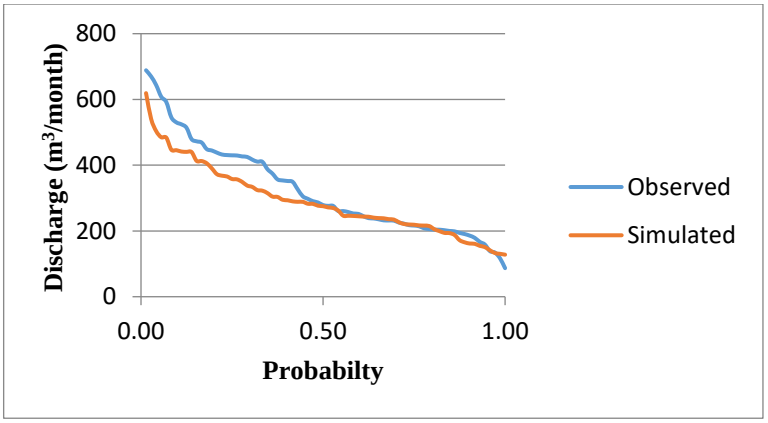

Figure 2. Permata et al.

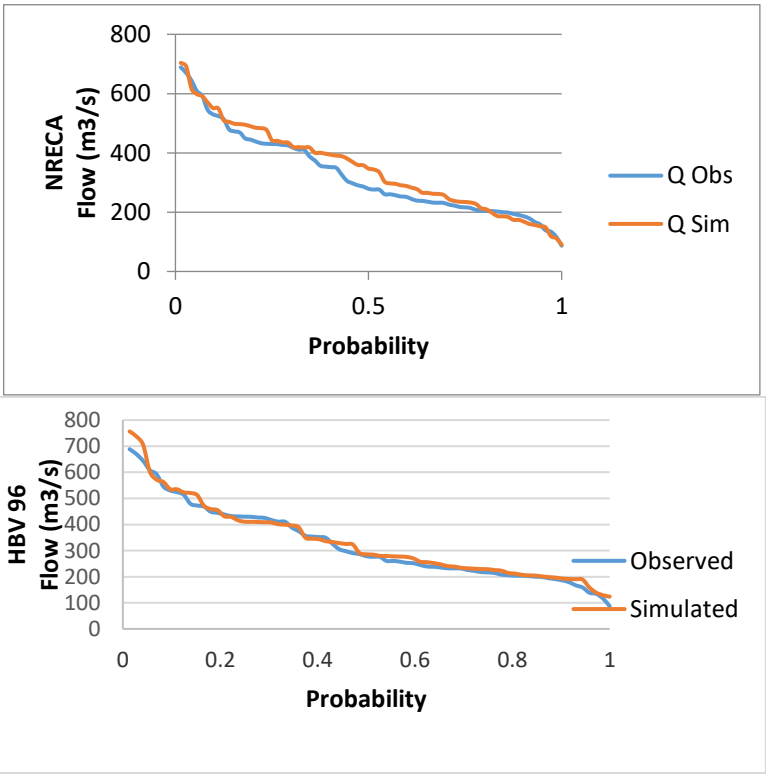

Figure 3. Permata et al.