気候変動下でのSWATを用いた水収支解析
Water balance analysis under climate change using SWAT in Cidanau watershed, Indonesia

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I. Introduction

Water demand always increases in line with population growth, industry, and business development, then water supply is secured to meet those demands continuously. The purpose of this research was to analyze hydrological processes in determining water availability under uncertain situations with climate change using Soil and Water Assessment Tools (SWAT).

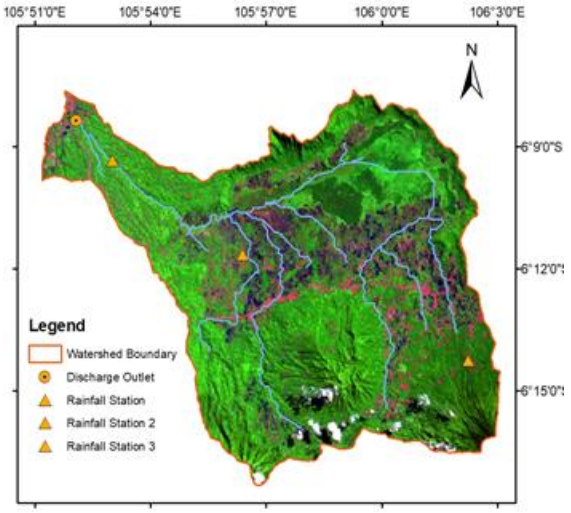

Fig.1 Study area in Cidanau watershed

II. Material and Method

Cidanau watershed is the main water resource to supply water needs in Cilegon City. It is located in Serang district, Banten province, Indonesia with an area of 22.620 ha. According to Koppen's classification of climate types, the study area belongs to type of tropical rainforest and is dominated by monsoons.

The SWAT model, a physically based, semi-distributed hydrological model (Arnold et al., 1998) was used to simulate hydrological processes in the study area. The input data such as Digital Elevation Model (DEM), soil type, land use map, and climate data were required. The hydrological mechanism of the model can be evaluated using the water balance equation which is represented as follow:

$$SWt = SW + \sum_{i=1}^{t}(Ri - Qi - ETi - Pi - QRi) \quad (1)$$

Where SWt is the final water content (mm), SW is the initial soil water content (mm), t is time in days, R is rainfall in mm, Q is surface runoff (mm) ET is evapotranspiration (mm), p is percolation (mm) and QRi is return flow. Several statistics have been used to evaluate the model performance which included Co-efficient of determination (R^2), the Nash-Sutcliffe Efficiency (NSE), and Percent of Bias (PBIAS). The performance of the model is acceptable when R^2>0.5 (Santhi et al., 2001), NSE ≥ 0.5 and PBIAS ≤ 25 (Moriasi et al., 2012). The projected climate data was simulated using downscaled rainfall and mean surface temperature of CIMP5 GCM outputs with the moderate scenario of RCP 4.5 and high scenario of RCP 8.5. The linier scaling method was used

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to correct biases in rainfall and temperature.

III. Results

Sensitivity analysis for the streamflow parameters of the SWAT model showed that Curve Number (CN) is the most sensitive parameter among all parameters. Deep aquifer percolation fraction (RCHRG_DP) is the second most sensitive parameter. In order to obtain a reliable result, calibration and validation of SWAT model were done before analysis water balance component. Hydrograph in Figure 2 shows the performance of model during calibration process from 2002 to 2008. The R2 values were 0.61 and 0.59 for calibration and validation periods, respectively. The NSE values were 0.60 and 0.58 for calibration and validation periods, respectively. Projected temperatures are expected to change by 0.8 C to 1.3 °C under climate change scenarios. Percolation and surface runoff are the most expected to change in water balance components, 39% for percolation and 148%-338% for surface runoff (Fig.3)

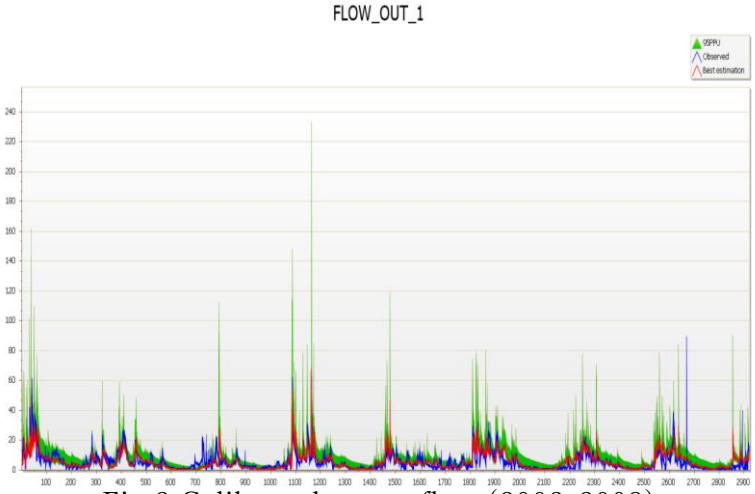

Fig.2 Calibrated streamflow (2002-2008)

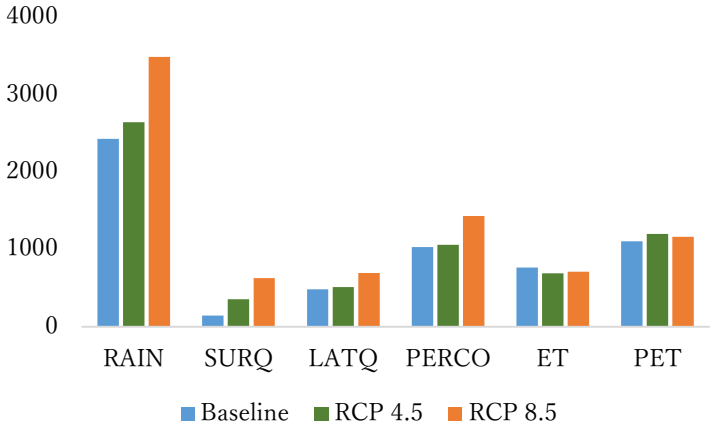

Fig.3 Change in water balance (2051-2058)

IV. Discussion

The estimated water balance component between baseline and climate change scenarios in Figure 3 shows that all water balance components are expected change. An increase in mean annual rainfall and a change in rainfall pattern may result in large increase in surface runoff in rainy season.

V. Conclusion

The performance of SWAT model was satisfactory to describe hydrological processes in the study area indicated by R^2 and NSE values were greater than 0.5. Projected temperatures are expected to change by 0.8 oC to 1.8 oC under climate change scenarios. The highest water balance component was percolation which is expected to change by 39 % under climate change scenario RCP 8.5.