C07

Comparison of Runoff Generation Methods for Land Use and Climate Change Impact Assessments in the Humid Tropics using SWAT Model

〇Eva Mia Siska YAMAMOTO, Takahiro SAYAMA, Kodai YAMAMOTO, APIP

Introduction:

Number of research on land use and climate change impact assessments on hydrological response have been increasing recently, including in the humid tropics. At a river basin scale, a typical approach to assess changes is through application of hydrological models which are mostly developed based on experimental studies in temperate regions.

In the recent decades, the increasing number of experiments in the humid tropics showed different hydrological characteristics to temperate regions, particularly due to its deep soil layer and high soil permeability. Furthermore, summarized research in the region (Elsenbeer and Vertessy, 2000 and Bonell, 2005) shows that flow pathways are dominated by subsurface flow.

Considering these differences, there is still limited knowledge on how the selection of runoff generation method influences simulation results in the impact studies, particularly on the change in annual water budget and flow regimes. Therefore, this study compares two runoff generation methods, Curve Number (CN) and Green-Ampt (GA), using SWAT model to address the question.

Study Area:

This study area is Batanghari River Basin (42,960 km^2) in Sumatera, Indonesia. The whole river basin is categorized as humid tropics, based on Chang and Lau (1993) with basin average annual rainfall of 2,021 mm and average temperature ranging from 22 ºC to 26.8 ºC. Prior studies show that soil layer in the basin ranging from 1,100 to 4,500 mm with high hydraulic conductivity up to 320 mm/h (Sayama *et al.*, 2019; Susiwidiyaliza, 2015).

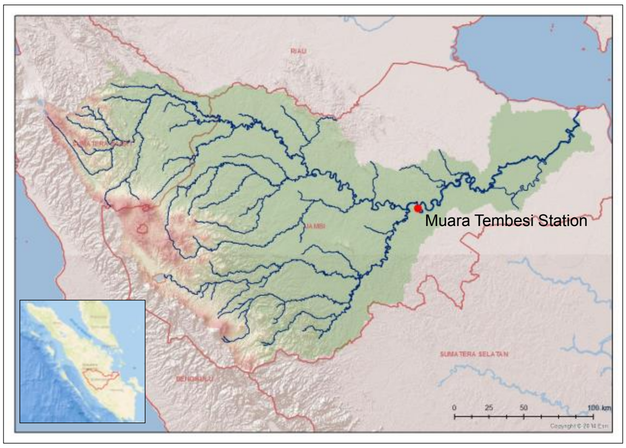

Fig.1 Study Area

Methods:

This study uses Soil and Water Assessment Tool (SWAT) model to simulate runoff in Batanghari River Basin. We compare two runoff generation methods i.e. CN and GA. The potential evapotranspiration is calculated collectively using Penman-Monteith equation and runoff is routed through the channel network using Muskingum methods.

The study divides the river basin into 359 sub-basins/HRU based on DEM, land use and soil maps. The plantation and crop management databases were modified to fit the plantation growth in tropical region.

Two SWAT models were set up with GA and CN based on present land use condition (2015). A four-year simulation (2012-2015) was carried out with two years warm up period using GSMaP rainfall. Models were calibrated using SWAT-CUP software for period of 2012-2013. This study particularly optimized soil parameters based on data from the field. Validation was carried out for period of 2014-2015.

Assessment of land use change impact is estimated using the calibrated models using MRI-NHRCM present (1980-2000) rainfall datasets and past (1990) and future (2040) land use maps. The climate change impact was estimated through simulation using MRI-NHRCM future (2079-2098) rainfall with the same land use maps.

Data description:

The simulation uses DEM data from HydroSHEDS (30-s) and soil map of FAO/UNESCO DSMW. Land use maps were taken from the work of Utami (2017). Past and present land uses were classified from LANDSAT images (30m res.) and future land uses were classified using CLUE-S model.

Calibration and validation of model uses GSMaP version 6 rainfall dataset and WFDEI climatic data for period of 2012-2014. Then, simulation was carried out using MRI-NHRCM present and future rainfall datasets. Note that climatic datasets used for both present and future scenario is the present WFDEI climatic datasets for period of 1980-1999.

Results and Discussion:

Overall, both methods show satisfactory performance based on Nash-Sutcliffe Efficiency (NSE) in calibration period and good performance in validation period.

The simulation results from both methods give similar trend in water budget i.e. annual average evapotranspiration (ET) decreases and discharge (Q) increases. The magnitude of change in discharge as impact of climate change is much larger than impact of land use change.

The FDCs of both methods shows that the impact of climate change is much more significant than the land use change. The use of CN method shows that high flow increases about three fold in the future while GA method shows an increase for 1.5 times.

In the future climate, this study shows that the CN method shows increase of high flow in both present and future climate as impact deforestation. In future climate the change is much larger. The GA method however, shows significant change in the low flow in present and future climates with higher change in the future.

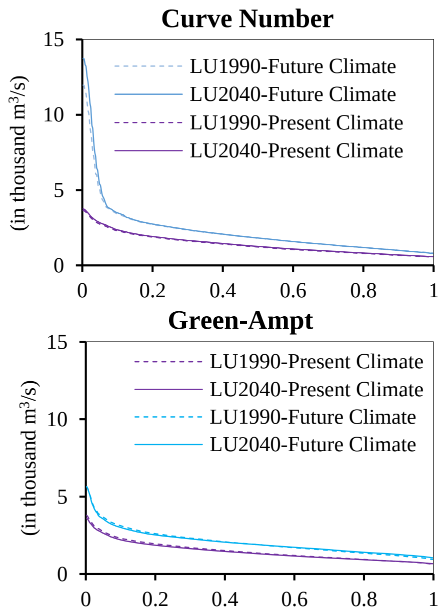

Fig 2. FDCs of simulation using CN and GA

Conclusions:

The two methods show that discharge in all flow regimes increases due to climate change and it affects the highest 5% of the flow. In future climate, the FDC slope is steeper for discharge larger than Q_5 but does not change so much for the rest of the flow. Land use change gives more impact in future climate than in present climate.

The CN method, however, shows much larger impact compares to GA method. The deforestation causes significant increase in high flow in CN method but causes significant increase of low flow in GA method.

References:

[1] Sayama T, Araki R, Yamamoto K, Apip. 2019. Groundwater and soil moisture monitoring in humid tropical forest for assessing the impact of land use change, Journal of Hydrology (submitted)

[2] Utami, N. 2017. Land use change projection and its impact on flood hazard in the Batanghari River Basin. *Master's Thesis*. Bogor Agricultural University. Bogor. Indonesia