Analysis of Climate Change Effects on Hydrology in Stung Chinit River Basin

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Introduction

Cambodia is consistently ranked among the top ten most vulnerable countries to climate change due to mainly on low adoptive capacity. Global warming leads to changes in precipitation and temperature which affects the hydrological cycle and therefore changes the streamflow conditions (Khoi and Suetsugi, 2014). Hence, climate change is a crucial factor that impacts on water availability by causing floods and droughts. In Cambodia, historical extreme flood and drought events which were caused by climate change had a great impact on water availability and it influenced on many sectors like infrastructure, social, agriculture etc. Therefore, it is very important to assess climate change impacts on water resource for promoting water resources planning efforts and sustainable development. The objectives in this research are (1) to evaluate the performance of Soil and Water Assessment Tool (SWAT) in predicting daily streamflow of Stung Chinit River Basin, Cambodia and (2) to analyse the effects of climate change on hydrological conditions in this area. The findings would be beneficial for building adaptation to climate change to avoid water scarcity during the dry season and the heavy flooding during the wet season.

Material and Methods

The study is concentrated on Stung Chinit which is a tributary of the Tonle Sap River System (Figure 1). Draining more than 8,200 km^2 of the catchment area, it extends over parts of 6 provinces in Cambodia. The key datasets used in this study are hydrometeorology, topography, land use/cover, soil type and future climate change data (Table 1). Firstly, SWAT was applied to calibrate and validate daily streamflow in the area. After a successful simulation, the calibrated SWAT model was employed to forecast the future hydrological characteristics using a suitable climate change scenario. Lastly, the forecasted results were compared with the baseline so as to understand the climate change effects.

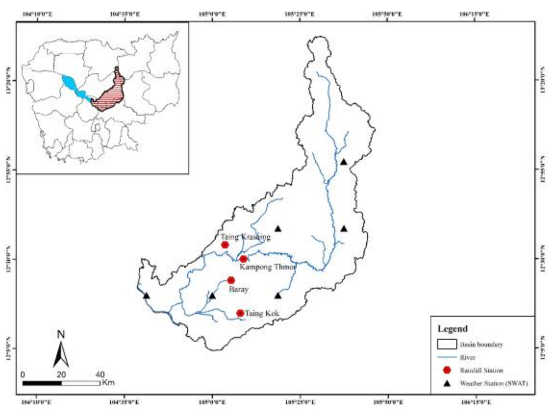

Figure 1 Map of the study area

Table 1 Key data used in this study

Data type	Description	Resolution	Period	Source
Topography	DEM	30 m	-	ASTER GDEM 2
Land use	Land use classification	250 m	2002	MRC
Soil	Soil type	250 m	2002	MRC
Meteorology	Rainfall	Daily	2000-2011	MOWRAM
	Weather	Daily	2000-2011	SWAT Database
Hydrology	Streamflow	Daily	2000-2011	MOWRAM
Climate change project	Precipitation & temperature (Scenario A2)	20 km	2000-2011 2021-2041	Southeast Asia START Regional Center

SWAT allows different physical processes associated with water movement, sediment movement, crop growth and so on, to be simulated in a watershed and then are modeled using input data (Arnold *et al.*, 2012). From topographic data, the watershed is divided into a number of sub-catchments. The use of sub-catchments in a simulation is particularly beneficial when different areas of the catchment are dominated by land-uses or soils dissimilar enough in properties to impact hydrology. Every sub-catchment is then subdivided into Hydrologic Response Units (HRUs). HRU is a unique combination of land-use, soil and management practices in a sub-catchment. The model simulates the hydrology at each HRU using water balance equations.

The entire data was divided into three sets, the first two years (2000-2001) for the model warm-up, seven years (2002-2008) for the model calibration and the last three years (2009-2011) for the model validation. The model performance was measured by three popularly used indicators: Nash-Sutcliffe efficiency (NSE), ratio of the root mean square error to the standard deviation of observed data (RSR) and percent bias (PBIAS) (Moriasi *et al.*, 2007). The input data of climate change was based on the IPCC SRES Scenario A2 of ECHAM 4 downloaded from PRECIS. This scenario is suitable for developing countries like Cambodia. The PRECIS data was downscaled to reduce the possible deviation and match with conditions of the study area using the Change Factor Method. Bias correction was also carried out to enhance the quality of climate change input data. Moreover, the observed data between 2000 and 2011 was used as the baseline and the forecasted results of the next 30 years (up to 2041) was considered to analyse the climate change effects.

Results and Conclusions

SWAT showed its good performance in both calibration and validation stage (Figure 2). This was indicated by the value of NSE = 0.67, RSR = 0.57 and PIAS = -13.4% for the calibration results and NSE = 0.57, RSR = 0.65 and PBIAS = 5.44% for the validation ones. Regarding the climate changes effects, the surface runoff, lateral soil discharge, groundwater discharge, and water yield is predicted to be declined; while the evapotranspiration is analyzed to be noticeably increase (Figure 3). The surface runoff, lateral soil discharge, groundwater discharge and water yield would drop not more than 30%. Nevertheless, the evapotranspiration is expected to accelerate about 5% and peaks at 10% in 2041. The future annual streamflow is estimated to be fluctuated about 25%. The discharge in dry season would intensely decrease from about 18% in 2021 to 28 % in 2031 and then reach at 45% in 2041 (Figure 3). Hence, Chinit River basin could be facing with the drought hazard because of the dramatically drop in future streamflow during the dry season, especially in 2041. Therefore, some countermeasures should be considered in advance to improve drought monitoring, better water and crop management, augmentation of water supplies with groundwater, increased public awareness and education, intensified watershed and local planning.

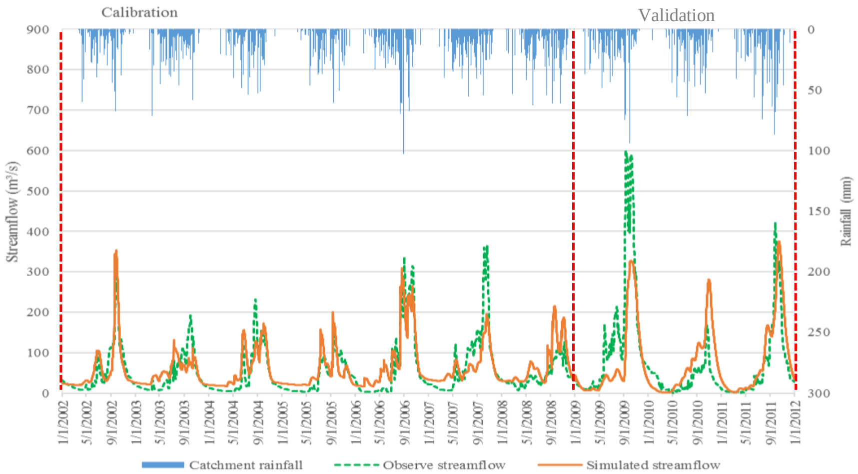

Figure 2 Comparison between observed and predicted streamflow

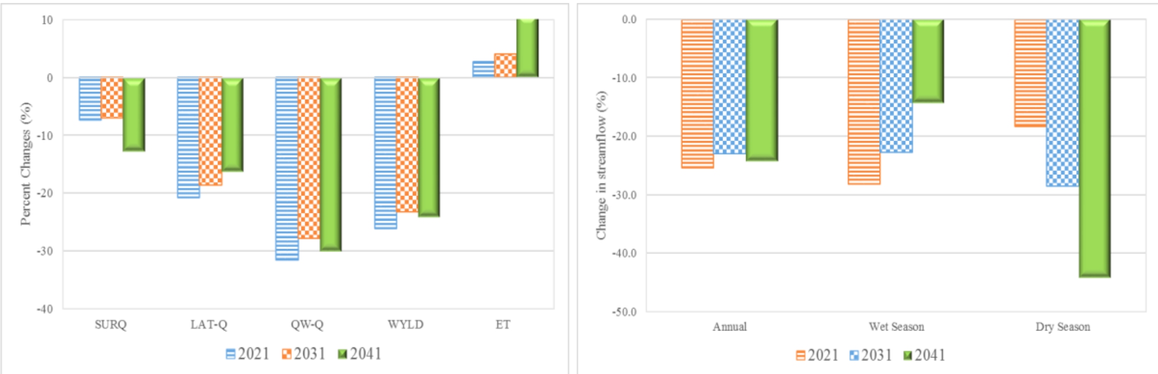

Figure 3 Effects of climate change in the next 30 years

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