Testing ArcSWAT Global Database Application in Simulating the Streamflow Hydrograph for the Langat River Basin

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ABSTRACT: Heavy storm and high amount of rainfall-runoff has led to severe flood problems in the Langat River Basin annually due to the northwest monsoon. This often caused huge physical damages such as casualties, social disconnection, and economic loss. Hence, it is essential to establish a comprehensive hydrological modelling scheme for this basin. The objectives of this study are to delineate the land characteristics of the Langat River Basin using remotely-sensed global database, and simulate the streamflow hydrographs adopting the ArcSWAT model in ArcGIS. The topography, land used and soil types were generated based on the remote sensing information provided in the global database integrated with the ArcSWAT extension. For the hydrological data, both the global data and observed data were used. The rainfall periods selected for calibration and validation of the hydrological model were during the monsoon season from September to January. There were one calibration and 3 validations performed for each streamflow station using SWAT-CUP. The performance of the hydrological model was measured using RSR and PBIAS analyses. From the topographical analysis, there were 13 sub-basins generated in the Langat River Basin. The performance of this hydrological model found as 1.51 of RSR and -1.7 of PBIAS.

Keywords: *Hydrograph; ArcSWAT; SWAT-CUP*

1. INTRODUCTION

Malaysia including the Langat River Basin is receiving averaged annual rainfall of approximately 3000 mm (Muhammad et al., 2020). In general, this region is affected by two types of floods occurrence: monsoon flood and flash flood (Soo et al., 2019). According to Memarian at al. (2012), Langat River Basin receives highest rainfall from the northeast and southwest monsoon annually. In hydrological prospects, monsoon flood will take at least a month to recede back to the normal water level however flash flood just only taking few hours.

This study was carried out to establish the Langat River Basin rainfall-runoff model adopting ArcSWAT global database application integrated with ArcGIS. Hydrological modelling serves as a useful approach to solve many flood related issues. An accurate hydrological model can determine the runoff streamflow pattern of various rainfall events for the water related design solutions. The advancement in SWAT modelling has offered hydrologist a tool that are capable to handle and analyse large database in land surface characteristic and rainfall.

2. METHODOLOGY

Topographical information of the NASA Shuttle Radar Topography Mission (SRTM) Global 1 arc second (~30m) DEM was downloaded from Earthdata webpage. The SRTM was utilized in ArcGIS to delineate the basin and sub-catchments of the Langat River Basin. In this study, the coordinate system was projected to Kertau RSO (Malaya).

The hydrologic response unit (HRU) divided the sub-basins into smaller area which represent different value of HRU in which each value behaves differently during precipitation. Land use data, soil type data and slope in watershed were also assigned to the HRU value for each sub-basin.

Land use/ land cover (LULC) data was retrieved from the Land Processes Distributed Active Archive Center (LP DAAC) MODIS Land Cover V6 which was readily downloadable from USGS. Soil types dataset was obtained from FAO Digital Soil Map of the World (DSMW). Slope definition was generated from the STRM DEM using ArcGIS. In the slope definition, the slopes were categorized into several classes. The weather geodatabase provided by SWAT was adopted to simulate the weather pattern in this study. WGEN_CFSR_World was used as the Weather Generator Data, while Relative Humidity, Solar Radiation, Wind Speed and Temperature data were simulated from the Weather Generator. Meanwhile, the observed rainfall and streamflow data were collected from the Department of Irrigation and Drainage Malaysia (DID). All the data were merged in the ArcSWAT function as preparation for SWAT simulation.

SWAT model simulation was setup to begin from 1st January 2011 and end on 31st December 2018 covering the selected rainfall periods. The duration interval was customized as daily with 2 years of warm-up period. For this study, there were 2 sets of rainfall periods selected based on the completeness of data.

The calibration process was done by adjusting the model parameters to fit the simulated result from with

the observed data using SWAT-CUP application. The calibration and validation were based on the streamflow gauging stations at Dengkil (2816441). The calibrations were repeated 5 times for each parameter to ensure the accuracy of the result. The wet season of Selangor and Negeri Sembilan were determined to occur from September to January in accordance to the analysis of the observed streamflow data.

Error analysis was conducted to identify the SWAT model performance. The ratio of the Root Mean Square Error (RMSE) to the standard deviation of measured data (RSR) and Percent Bias (PBIAS) were the evaluation methods chosen in the error analysis.

3. RESULTS AND DISCUSSION

The Langat river basin and river network have been successfully delineated using ArcSWAT extension in ArcGIS as shown as Figure 1. From the result, the total area of the basin wsa 2186.3 km² with 13 sub-basins. The total length of stream branches watershed is 183 km.

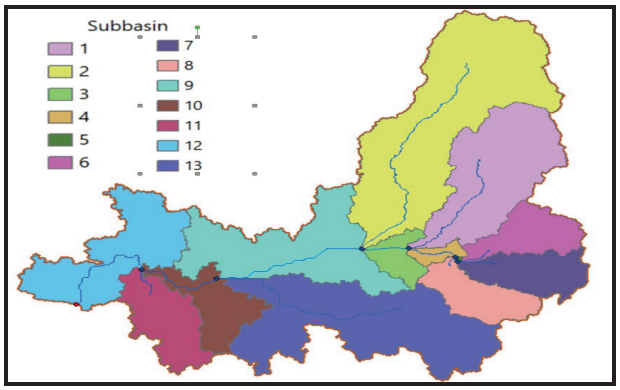

Figure 1 Delineated Langat river basin and network

The streamflow station 2816441 is located at the Sub-basin 2. Parameters used in the calibration process is shown as Table 1 and the result comparison is displayed in Figure 2. The 95PPU indicated the 95% prediction uncertainty of the simulation. Overall result of this event was fair with the value RSR and PBIAS of 1.49 and 19.1, respectively.

Table 1 Parameters used for Station 2816441

Parameter Name	Modify Value Method	Min. Value	Max. Value	Fitted Value
CN2	Relative	0	20	18
ALPHA_BF	Replace	0	1	0.9
GW_DELAY	Replace	160	450	189
GWQMN	Replace	0	1	0.7
HRU_SLP	Relative	0	1	0.1

Validation was done with the event from September 2016 to January 2017 and the result is presented in Figure 3. The outcome of the validation also shows fair agreement between the simulated and observed streamflow. RSR and PBIAS values of the 2016/2017 simulation were 1.51 and -1.7, respectively.

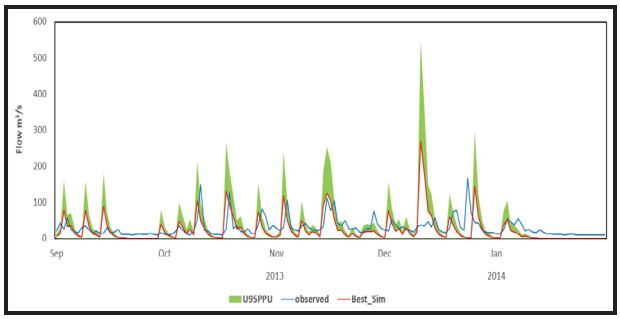

Figure 2 Calibration result of Station 2816441 (September 2013 – January 2014)

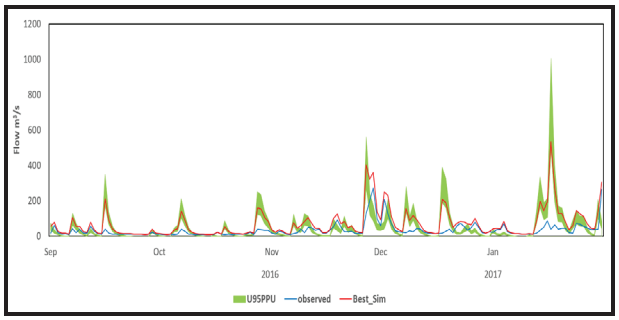

Figure 3 Validation result of Station 2816441 (September 2016 – January 2017)

4. CONCLUSION

In spite some result deficiencies in the simulated hydrograph, the ArcSWAT and SWAT-CUP tools can still be considered to be applicable to simulate the streamflow hydrograph for Langat River Basin. The level of accuracy in simulating the results are highly dependent on the quality of input data, the more precise the input data, the more accurate the simulated result.

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