The Application of SWAT for Hydrological Modeling in the Semantan River Basin, Pahang, Malaysia

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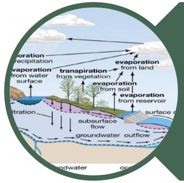
Introduction

Background of Study

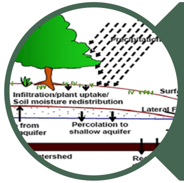
Natural Disaster

Floods, landslides, and draught have continuously affected and altered the natural hydrological cycle (Djebou & Singh, 2016). These disasters, disrupted the pattern of water flow, modified the recharge rate of groundwater, as well as influencing the availability of surface water.



Hydrological Cycle

A continuous process where water travels through the Earth's system in order to sustain ecosystems (Ostovar, 2024), climate patterns (Quevauviller, 2010), and freshwater supplies (Bowen et al., 2007).



Hydrological Modelling

Can be done with empirical, conceptual, or physical-based models (Pandi et al., 2021). HEC-HMS and SWAT are some of the most prevalent physically-based models.

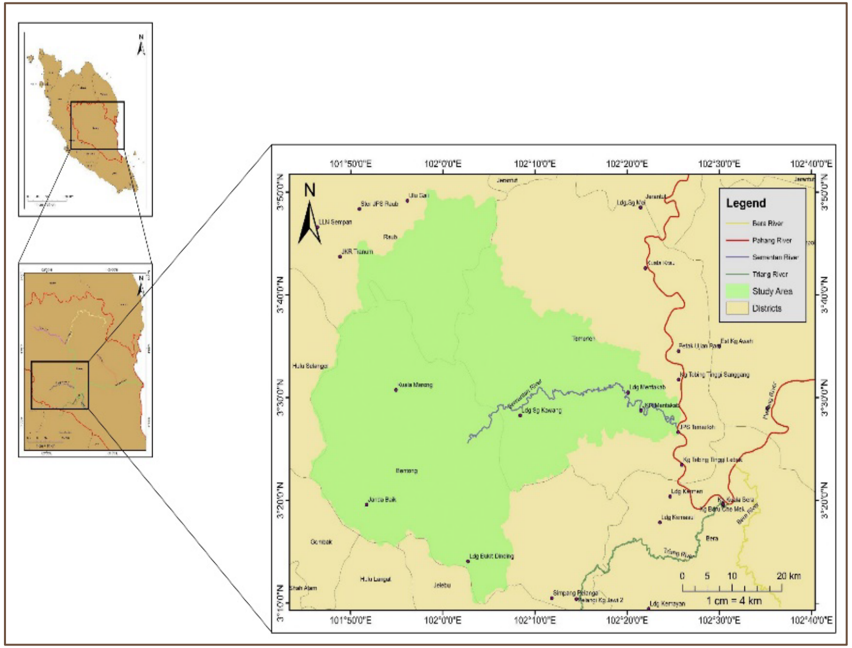
SWAT

Developed by combining three existing models – CREAMS, GLEN, and, EPIC (Glavan & Pintar, 2015). SWAT can operate on several different time step, enabling comprehensive analysis of land use, management practices, and climate change impacts on water quantity and quality over long periods.

Study Area

Semantan River basin, Pahang, Malaysia

- A fundamental subbasin of the larger Pahang River basin.
- Experiences hot and humid climate throughout the year with an average temperature of 25°C to 27°C (Lim et al., 2020).
- Received heavy rainfall approximately 1600 mm/yr that may be exacerbated by the Northeast monsoon in November to March.
- Multiple type of land use within the basin – agricultural land, evergreen forest, urban, wetland forest.



Research Gap

- SWAT's underuse in Semantan Basin
- Bias towards larger watersheds in prior research
- Needs for tropical-specific validation

Objectives of Study

Main:

To evaluate the performance of SWAT2012 in predicting the streamflow of the Semantan River, Pahang, Malaysia

Specific:

- To calibrate and validate SWAT2012 using observed streamflow data from gauging stations in the Semantan River Basin
- To assess model sensitivity by identifying the key hydrological parameters

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Methodology

1. Data Collection
2. Data Pre-processing
3. Watershed delineation in ArcSWAT
4. SWAT model setup
5. Export files for calibration
6. Calibration using SUFI-2
7. Validation in SWAT-CUP
8. Update parameters in ArcSWAT
9. Final SWAT run and evaluation

Phase	Year
Warm-up	2001-2002 (2 years)
Simulation	2003-2022 (20 years)
Calibration	2013-2016
Validation	2017-2019

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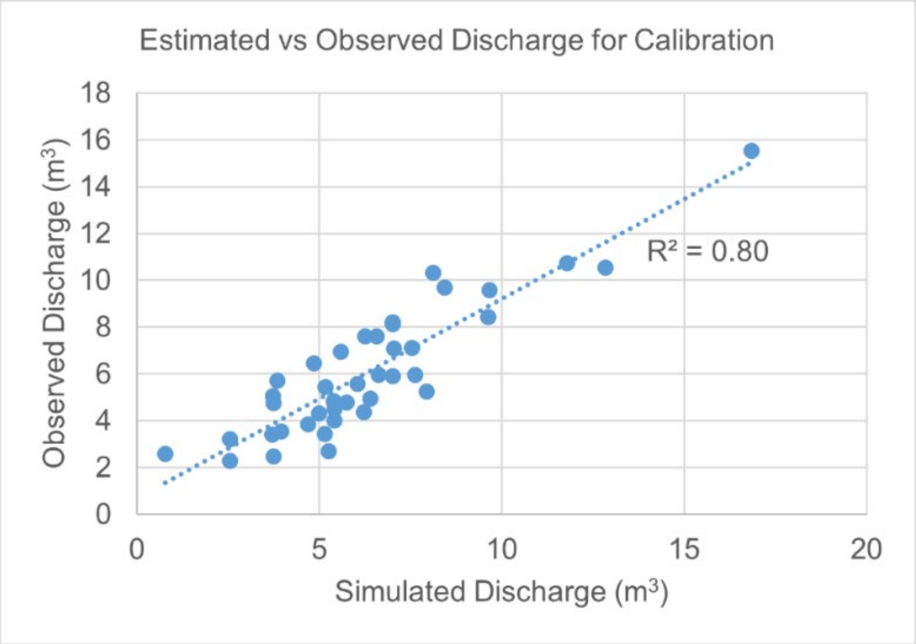
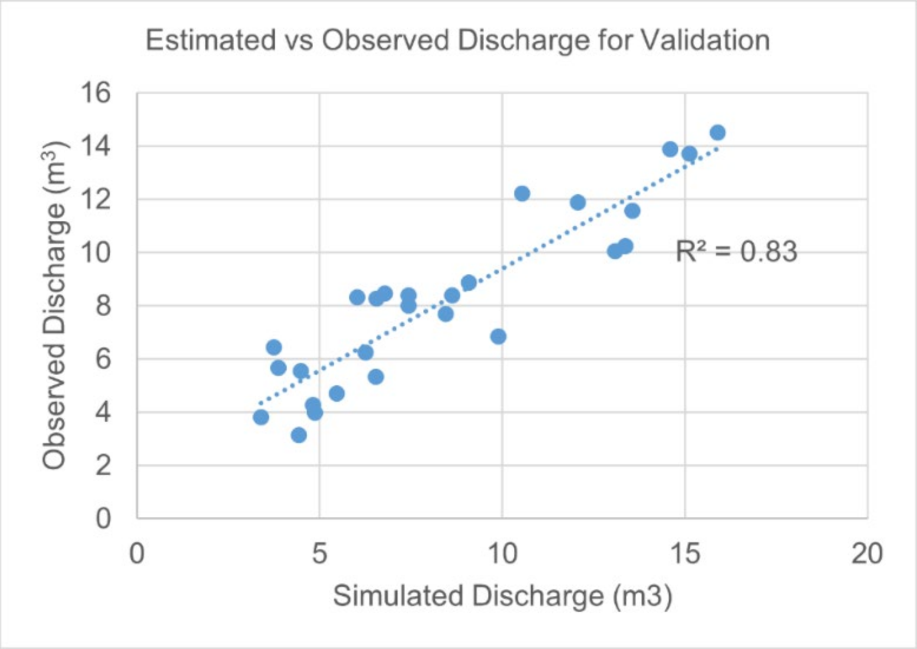
Results

Calibration



Performance Rating	R^2	NSE	RSR	PBIAS
Before Calibration	0.37	-0.23	1.11	-18
After Calibration	0.80	0.79	0.46	4.1

Validation



Performance Rating	R^2	NSE	RSR	PBIAS
Before Validation	0.49	0.46	0.73	5.1
After Validation	0.83	0.82	0.42	2.7

Parameters Sensitivity

Parameter	Parameter Name in SWAT-CUP	t-stat	P-Value	Sensitivity Rank
Groundwater delay (days)	V__GW_DELAY.gw	10.7671	0.0000	1
Groundwater "revap" coefficient	V__GW_REVAP.gw	1.4309	0.1531	2
Baseflow alpha factor (days)	V__ALPHA_BF.gw	1.0512	0.2937	3
Manning's "n" value for the main channel	V__CH_N2.rte	0.8879	0.3751	4
Initial SCS runoff curve number for moisture condition II	R__CN2.mgt	0.8651	0.3874	5
Plant uptake compensation factor	V__EPCO.hru	0.7925	0.4285	6
Threshold depth of water in the shallow aquifer required for return flow to occur (mm)	V__GWQMN.gw	0.7717	0.4407	7
Effective hydraulic conductivity in main channel alluvium (mm/hr)	V__CH_K2.rte	0.6000	0.5488	8
Soil evaporation compensation factor	V__ESCO.hru	0.5458	0.5854	9
Surface runoff lag time	V__SURLAG.bsn	0.4888	0.6252	10
Average slope of main channel along the channel length (m/m)	V__CH_S2.rte	0.4271	0.6695	11
Available water capacity of the soil layer (mm.H2O/mm.Soil)	R__SOL_AWC(..).sol	0.1632	0.8704	12
The threshold water level in a shallow water aquifer for percolation to the deep aquifer to occur	V__REVAPMN.gw	0.0096	0.9924	13

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Conclusion

- Model performance for the model was strong.
    - NSE for calibration = 0.79
    - NSE for validation = 0.82
- The most sensitive parameters for the model are:
    - GW_Delay
    - GW_Revap
    - Alpha_BF
    - CH_N2
- The study provides a robust framework for future water resource management and environmental assessments in the region

Further recommendations

- Use higher resolution for input data
- Integrate more hydrological data into the model
- Expand the scope of study
    - Climate change impacts
    - LULC change scenarios

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Thank You