



(RESEARCH ARTICLE)



Hydrological Model for Estimating Volume of Inflow into the Peppara Dam Reservoir Using GIS and SWAT

Midhila M* and Lenin Babu S

Department of Civil Engineering, Vidya Academy of Science and Technology Technical Campus, Kerala, India.

International Journal of Science and Research Archive, 2025, 17(02), 065-070

Publication history: Received on 24 September 2025; revised on 01 November 2025; accepted on 03 November 2025

Article DOI: <https://doi.org/10.30574/ijrsra.2025.17.2.2964>

Abstract

This article presents an application of SWAT model to simulate and predict the volume of inflow into Peppara dam reservoir. The model was calibrated and validated using SWAT CUP (SWAT-Calibration Uncertainty Programs). The calibration was done from 2004 to 2013 and validation was performed from 2014 to 2018. The coefficient of determination (R^2) and Nash Sutcliffe Efficiency (NSE) obtained were 0.77 and 0.69 respectively during calibration stage and 0.79 and 0.74 respectively during validation stage. Model showed good performance during calibration and validation stage. This rainfall runoff can be used for predicting the volume of inflow into the reservoir for various rainfall events and it can help in planning the water distribution to TVM corporation.

Keywords: Watershed Model; GIS; SWAT; Peppara Dam Reservoir

1. Introduction

Hydrological model is a simplification of real-world system, that helps in understanding, predicting and managing water resources. Soil and Water Assessment Tool (SWAT) are one type of tool used for developing a hydrological model. Hydrological processes occur in watershed. The analysis of watershed is a fundamental step. Hydrological models are used to determine the stream flow over a long period. This model which produces historical current or natural stream flow records and is used to generate the future yields. Objective of this research is to develop a model for predicting volume of inflow into the Peppara dam reservoir. This model will help in planning the water distribution as well as for electricity generation planning in TVM corporation. The SWAT-CUP tool is a program that interfaces with Arc SWAT to perform calibration, validation and sensitivity analysis.

1.1. Study area

The catchment area of Peppara dam reservoir is the study area. Peppara dam is located at Peppara around 55 km from Trivandrum City. Peppara dam is constructed across Karamana river. It is the main drinking water supply to Thiruvananthapuram district and sub urban areas. Peppara wild life sanctuary is one of the most beautiful wildlife sanctuaries of kerala. Peppara dam reservoir located in latitude of 8.6228° N and longitude of 77.1379°E. Area of the reservoir is 5.82 sq.km

* Corresponding author: Midhila M

Table 1 General performance rating

	Very good	Good	Satisfactory	Un Satisfactory
R2	>0.7	$0.60 < R^2 \leq 0.70$	$0.50 < R^2 \leq 0.60$	≤ 0.50
NSE	$0.75 < NSE < 1.00$	$0.65 < NSE \leq 0.75$	$0.5 < NSE \leq 0.65$	≤ 0.50

2.2. Calibration and validation

The SWAT-CUP tool is a program that interfaces with Arc SWAT to perform calibration, validation and sensitivity analysis. The method SUFI-2 (Sequential Uncertainty Fitting Version 2) was selected. SUFI 2 provides good accuracy and has the ability to capture the observed data with small uncertainties. Calibration was done for 10 years (2004-2013) along with sensitivity analysis that is same data set and parameters are used for both. The sensitivity analysis is so used to identify and rank the most responsive hydrological parameters that have significant impact on specific model output. Calibration and sensitivity analysis were carried out for 3 iterations each having 500 simulations. 18 parameters were used. In each of the simulations the values of parameters get updated in such a way that more data are bracketed in the 95 PPU. It calculated at the 2.5% and 97.5% level of the output variables disallowing 5 % of the bad simulation. To evaluate the significance of the relative sensitivity t-stat and p- value were utilised. t- stat provides a measure of sensitivity. p-value determines the significance of sensitivity. The larger absolute t-stat signifies greater sensitivity. Closer to zero the p-value, the higher significance. Validation is the process of comparing the model and its behaviour to the real system and its behaviour. The purpose of validation is to check the accuracy and performance of the model basis on the past data for which we already have actuals. Validation was done from 2014 to 2018. Observed data is the Peppara dam reservoir inflow. The surface area of the reservoir was multiplied with reservoir water level difference to obtain volume of inflow into Peppara dam reservoir.

Table 2 Calibration Parameters

Parameter code	Parameter's name
R_CN2.mgt	Initial SCS CNII value
V_ALPHA_BF	Base flow alpha factor
V_GW_DELAY.gw	Ground water delay time (days)
V_GWQMN.gw	Threshold water depth in Shallow aquifer for flow
R_ESCO.hru	Soil evaporation compensation factor
R_EPCO.hru	Plant uptake compensation factor
R_CH_N2.rte	Manning's "n" value for the main
R_CH_K2.rte	Effective hydraulic conductivity in main channel (mm/hr)
R_OV_N.hru	Manning's "n" value for the Overland flow
R_REVAPMN.gw	Threshold depth of water in Shallow
R_GW_REVAP.gw	Ground "revap" co efficient
R_SURLAG.bsn	Surface runoff lag time
R_SOL_K.sol	Saturated hydraulic conductivity
R_SOL_BD	Moist bulk density (Mg/m3)
R_SOL_AWC.sol	Available water capacity of the Soil layer
R_ALPHA_BNK.rte	Baseflow alpha factor for bank storage
R_RCHRG_DP.gw	Deep aquifer percolation factor
R_SLSUBBSN.hru	Average slope length

3. Result and discussion

Table 3 Parameter value obtained from calibration

Parameter name	Fitted value
R_CN2.mgt	0.700500
V_ALPHA_BF.gw	0.459190
V_GW_DELAY.gw	93.449997
R_OV_N. hru	0.121
R_SOL_K.sol	93.699974
R_SOL_AWC.sol	0.76
R_SOL_BD.sol	1.580314
R_GW_REVAP.gw	0.021320
R_SLSUBBSN.hru	67.540001
R_SURLAG.bsn	1.302350
R_ESCO.hru	0.564086
R_REVAPMN.gw	55.000004
R_CH_K2.rte	95.275002
R_RCHRГ_DP.gw	0.745000
R_EPCO.hru	0.975500
V_GWQMN.gw	0.767737
R_ALPHA_BNK.rte	0.558250
R_CH_N2.rte	0.297800

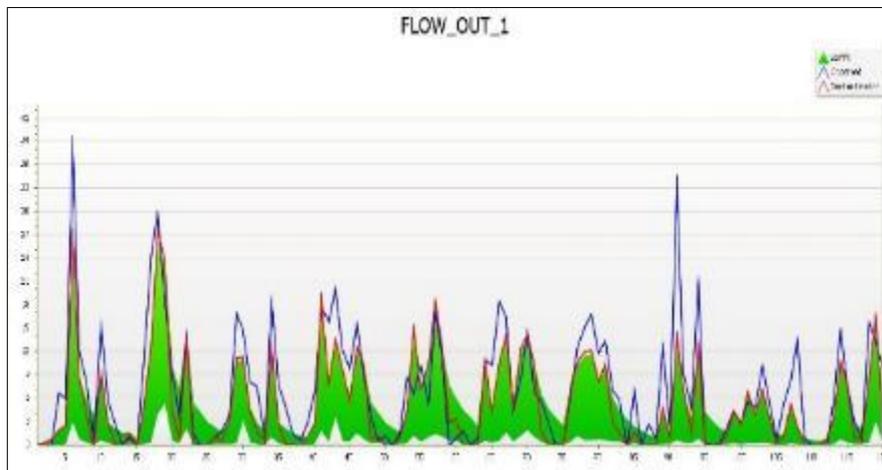


Figure 2 Monthly observed and simulated flow in calibration

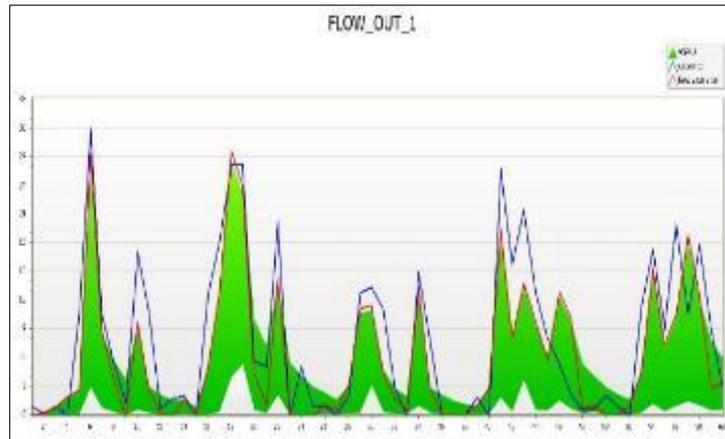


Figure 3 Monthly observed and simulated flow in validation

Table 4 Summary of the calibration and validation result

	Calibration (2004 -2013)	Validation (2014-2018)
R2	0.77 (Very good)	0.79 (Very good)
NSE	0.69 (Good)	0.74 (good)

4. Conclusion

The Arc-SWAT model was developed to estimate reservoir volume of inflow performed effectively for Peppara reservoir catchment. During calibration of model the value of R^2 and NSE obtained were 0.77 and 0.69 which were within the good limits and the values for the same obtained during validation were 0.79 and 0.74 which shows good performance of the model. 18 Parameters were used in this study. Curve number, Base flow alpha factor, Ground water delay time, Manning's "n" value for the overland flow, Saturated hydraulic conductivity, Available water capacity of the soil layer and moist bulk density are the most sensitive parameters in the Peppara dam reservoir catchment. This rainfall runoff model can be used for predicting the volume of inflow into the reservoir for various rainfall events and it can help in planning the water distribution to TVM corporation.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict-of-interest to be disclosed.

References

- [1] Arnold.J.G, Moriasi. D.N, Gassman. P.W, Abbaspour.K.C, White.M.J, Srinivasan.R, Santhi.C, Harmel.R.D, Van Griensven.A, Van Liew.M.W, Kannan.N, Jha.M.K (2012), SWAT:Model use, Calibration, Validation, American Society Agriculture and Biological Engineers, 55(4), pp 1491-1508
- [2] Shima M. Ghoraba (2015), Hydrological modeling of the Simly dam watershed (Pakistan) using GIS and SWAT model, Journal of hydrology, 54, pp 583-594.
- [3] Bounhieng Vilaysanea, Kaoru Takaraa, Pingping Luob, Inthavy Akkharathc, Weili Duana (2015) Hydrological stream flow modelling for calibration and uncertainty analysis using SWAT model in the Xedone river basin, Lao PDR, Environmental sciences, 28, pp 380-390
- [4] Abbaspour.K.C, Rouholahnejad.E, Vaghefi.S, Srinivasan.R, Yang.H, Klove.B (2015), A Continental scale hydrology and water quality model for Europe: Calibration and Uncertainty of a high resolution large scale SWAT model, Journal of Hydrology, 524, pp 733-752

- [5] Milad Jajarmizadeh, Lariyah Mohd Sidek, Sobri Harun, Mohsen Salarpour (2017), Optimal calibration and uncertainty analysis of SWAT for an Arid Climate, *Air Soil and water research*, 10, pp 1-14
- [6] Tejaswini.V, Sathian.K.K (2018), Calibration and validation of SWAT model for Kunthipuzha Basin using SUFI 2 Algorithm, *International Journal of Current Microbiology and Applied Sciences*, 7(1), pp 2162-2172
- [7] Andriano Ansari, Tasuku Kato, Atiqotun Fitriah (2019), Simulating stream flow through the SWAT model in the Keduang sub watershed Wonogiri ,Indonesia, *Agritech*, 39(1), pp 60-69
- [8] Thair Sharif Khayyan, Imzahim Abdulkareem Alwan , Ali Mohsen Hayder (2019), Hydrological model for Hemren dam reservoir catchment area at the middle river Diyala reach in Iraq using ArcSWAT model, *Applied water science*, 9(5), pp 1-15
- [9] Gianluigi Busico, Nicolo Colombani, Davide Fronzi, Marco Pellegrini, Alberto Tazioli, Micol Mastrocicco (2020), Evaluation SWAT model performance considering different soil data input to quantify actual and future runoff susceptibility in a highly urbanized basin, *Jounral of environmental management*, 266, 11062
- [10] Sharlene L. Beharry, Ddonald Gabriels, Deyanira Lobo, Deanesh Ramsewak, Richard M. Clarke (2020), Use of the swat model for estimating reservoir volume in the upper navet watershed in Trinidad, *SN Applied science*, 3(2), pp 1-13
- [11] Md Sharafat Chowdhury (2023), Modelling hydrological factors from DEM using GIS, *MethodsX*, Vol. 10, 102062
- [12] <http://www.2w2e.com> accessed on 1.12.2022 @ 3.30 pm