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Performance of HEC-HMS and SWAT to simulate streamflow in the sub-humid tropical Hemavathi catchment

N. C. Sanjay Shekar[a,*] and D. C. Vinay[b]

[a] Department of Civil Engineering, JSS Academy of Technical Education, Bangalore 570060, Karnataka, India
[b] Department of Civil Engineering, P.E.S. Institute of Technology and Management, Shimoga 577201, Karnataka, India
*Corresponding author. E-mail: sanjayshekarnc@jssateb.ac.in

ABSTRACT

The present study was conducted to examine the accuracy and applicability of the hydrological models Soil and Water Assessment Tool (SWAT) and Hydrologic Engineering Center (HEC)- Hydrologic Modeling System (HMS) to simulate streamflows. Models combined with the ArcGIS interface have been used for hydrological study in the humid tropical Hemavathi catchment (5,427 square kilometer). The critical focus of the streamflow analysis was to determine the efficiency of the models when the models were calibrated and optimized using observed flows in the simulation of streamflows. Daily weather gauge stations data were used as inputs for the models from the 2014–2020 period. Other data inputs required to run the models included land use/land cover (LU/LC) classes resulting from remote sensing satellite imagery, soil map and digital elevation model (DEM). For evaluating the model performance and calibration, daily stream discharge from the catchment outlet data were used. For the SWAT model calibration, available water holding capacity by soil (SOL_AWC), curve number (CN) and soil evaporation compensation factor (ESCO) are identified as the sensitive parameters. Initial abstraction (I_a) and lag time (T_{lag}) are the significant parameters identified for the HEC-HMS model calibration. The models were subsequently adjusted by autocalibration for 2014–2017 to minimize the variations in simulated and observed streamflow values at the catchment outlet (Akkihebbal). The hydrological models were validated for the 2018–2020 period by using the calibrated models. For evaluating the simulating daily streamflows during calibration and validation phases, performances of the models were conducted by using the Nash-Sutcliffe model efficiency (*NSE*) and coefficient of determination (R^2). The SWAT model yielded high R^2 and *NSE* values of 0.85 and 0.82 for daily streamflow comparisons for the catchment outlet at the validation time, suggesting that the SWAT model showed relatively good results compared to the HEC-HMS model. Also, under modified LU/LC and ungauged streamflow conditions, the calibrated models can be later used to simulate streamflows for future predictions. Overall, the SWAT model seems to have done well in streamflow analysis for hydrological studies.

Key words: calibration, hydrological models, sensitivity, simulation, streamflow, validation

HIGHLIGHTS

- The study's novelty is the comparative study of performances to simulate streamflow by using both HEC-HMS and SWAT hydrological models for the first time in the sub-humid tropical Hemavathi catchment.
- The study's scope focuses on streamflow analysis to determine the efficiency of the models when the models were calibrated and optimized using observed flows in the simulation of streamflows.

1. INTRODUCTION

Water demand increases with the rising population; therefore, water management is essential through watershed models by better understanding and handling water budget equations. Streamflow simulations are necessary to produce hydropower, consumptive use and irrigation, etc. Therefore, the depth of rainfall converted into streamflow is to be estimated effectively. Researchers have undertaken numerous studies for many decades to simulate streamflow using hydrological models on the catchment scale (Gosling *et al.* 2011). The estimation of the streamflow on a basin-scale by executing water budget equations in the hydrological models was necessary (Vijverberg *et al.* 2009). LU/LC affects the streamflow pattern in hydrological modeling due to the infiltration variations (Yamamoto *et al.* 2020). To capture the spatial diversity of the catchment, hydrological models require data inputs such as DEM, soil map, weather gauge stations data and LU/LC, and are then subdivided into homogenous sub-watersheds. Hydrological models are used to analyze hydrologic parameters variations due to various anthropogenic and climate change impacts. However, in all of the world's hydroclimatic regimes, no single model can be assumed to perform well.

The essential fundamental data for hydrologic research is streamflow, representing the runoff phase of the hydrologic cycle. Unfortunately, continuous streamflow measurement is quite challenging. As a result, direct streamflow monitoring is a time-consuming and expensive process (Chow Te 2010). Thus, the hydrologist's fundamental problem is the relationship between rainfall and streamflow conversions for water resources management. Streamflow measurements are often limited and unavailable in developing countries, making it more challenging to assess water resources (Shaw *et al.* 2010). Cunderlik (2003) evaluated the available hydrologic models that can be used to assess the risk and vulnerabilities of water resources to changing climatic conditions. The availability of meteorological data and open-source computational tools have stimulated hydrologic research and development during the last decade. The number of new hydrological models to strengthen water resource assessment represents the growth of hydrologic research (Slater *et al.* 2019; Astagneau *et al.* 2021).

Various hydrological models like SWAT, Hec-HMS, MIKE SHE, PRMS and WetSpa simulate the significant water balance components using regularly available data. The models mentioned above are available free in the public domain as open-source software except for MIKE SHE (Dhami & Pandey 2013). The USDA's Agricultural Research Service developed the Soil and Water Assessment Tool (SWAT) model (Arnold *et al.* 1998), which is a physically-based continuous-time, conceptual, long-term, distributed watershed-scale hydrologic model developed by the Agricultural Research Service (ARS). Surface runoff, percolation, erosion and other hydrological processes from small, medium and large watersheds can be simulated. It can be used to assess a large un-gauged catchment of over 100 sub-watersheds. As a result, SWAT is constantly being used to make water management strategies in land use, climate change and water management. The Hydrologic Modelling System (Hec-HMS) is a continuous and event-based hydrologic modeling system developed by the US Army Corps of Engineers Hydrologic Engineering Center (USACE 2010). It was initially developed to simulate the precipitation-runoff processes of dendritic watershed systems. It was later improved to address a broader range of problems, such as large river basin water supply distribution, flood hydrographs and small urban or natural watershed runoff. It is physically based and requires portable data inputs to produce realistic results. MIKE SHE (DHI 2007) is a deterministic, distributed, physically-based modeling system that can simulate all major processes in the hydrologic cycle. For any of the hydrologic systems, it requires a complete set of processing tools and a versatile combination of advanced and simple solution techniques. Precipitation, interception, infiltration, evapotranspiration, subsurface flow in unsaturated and saturated zones, surface flow and flow in channels or ditches are even included in the MIKE SHE model. However, it is a more complex model than SWAT and Hec-HMS and it is not freely available in the public domain. The Precipitation Runoff Modeling System (PRMS) is a physically-based, distributed-parameter watershed model that was developed to evaluate the effects of precipitation, climate, land use on streamflow, sediment yields and basin hydrology (Markstrom *et al.* 2008). PRMS is well suited for simulating streamflow and its hydrologic components from snowmelt-dominated basins since it simulates melting snowpack formation. WetSpa (Water and Energy Transfer between Soil, Plants and Atmosphere) is a grid-based distributed hydrological model (Wang *et al.* 1996) to predict water and energy transfer between soil and plants and atmosphere on a regional or basin-scale only and daily time step. The atmosphere, canopy, root zone, transmission zone and saturation zone are considered part of the basin's hydrological system. The model simulates precipitation, snowmelt, surface runoff, infiltration, evapotranspiration and groundwater flow.

Since the main objective of the study was to simulate the streamflow, in recent years, across a wide range of hydroclimatic environments, the SWAT and HEC-HMS models have achieved universal prominence for streamflow simulation and very few comparative studies have been conducted (Rezazadeh *et al.* 2015; Khoi 2016). The SWAT model is a suitable tool to simulate runoff with temporal and spatial variability in watershed management (Raju & Nandagiri 2018). The random forests precipitation generator is integrated into the SWAT model for long-term streamflow simulation (Liang *et al.* 2018). The SWAT model can simulate runoff in a humid tropical basin under low to high flow conditions (da Silva *et al.* 2018). The effect of spatial variations in precipitation on streamflow simulation was assessed by the SWAT model (Xue *et al.* 2019). In the tropical region, runoff simulations were evaluated based on LU/LC transition using the SWAT model (Yamamoto *et al.* 2020). Under data scarcity conditions in the river basin, the SWAT model was used for hydrological assessment to water resource management (Dutta & Sarma 2021). The SWAT model was used to project mean to extreme streamflow simulations under climate change (Alam *et al.* 2021). GIS and remote sensing data were integrated into HEC-HMS rainfall–runoff modeling to assess the effect of arid area urbanization on flash floods (El Alfy 2016).

The hydrological analysis can be processed using the HEC-HMS model, which generates pre-flood inundation maps using numerical weather predicted forecasted precipitation as input data for flood warning systems (Thakur *et al.* 2017). The HEC-HMS model runs the streamflow analysis from climate datasets and computes flooding due to the impact of critical precipitation, similar to the SWAT model (Yuan *et al.* 2019). The HEC-HMS model is implemented to delineate the basin automatically and compute various hydrologic parameters (Castro & Maidment 2020). An advanced united hydrological modeling system can be used effectively in flood management by flood prediction (Ramly *et al.* 2020). An output basin text file is produced in HEC-HMS format for rapid model initialization. Climate change impacts on the catchment's streamflow were analyzed under climate scenarios (Bekele *et al.* 2021).

In order to simulate the streamflows for a medium to a large river basin, both HEC-HMS and SWAT models were developed for continuous and event-based hydrological simulation. However, the performance comparison of both SWAT and HEC-HMS models in humid tropical regions has been investigated in very few studies. In the presence of moist tropical evergreen forests and well-drained lateral soils, the accuracy with which streamflow can be simulated under exceptionally high precipitation conditions has not been thoroughly studied. It is often necessary to evaluate how to collect data, process data and input data for the model under data-scarce conditions. HEC-GeoHMS and ArcSWAT are ArcGIS extension toolbars and graphical user interfaces for the HEC-HMS model used in this study. The key objective is to explore the applicability of the SWAT and HEC-HMS models to a humid tropical catchment and under data-scarce conditions to determine the type of input data sources/requirements. The model's output is to be evaluated in terms of the accuracy with which streamflows can be simulated. The study will also investigate how the SWAT and HEC-HMS models can be used to examine the effects on streamflows due to LU/LC changes in different years. Therefore, the present study was conducted to test the efficiency of models in catchment located in the humid tropical area extending from the mountain range of the Western Ghats.

2. STUDY AREA

One of the main tributaries to join the river Kaveri on its northern bank is the Hemavathi river. The river rises in the Ballalarayanadurga at Western Ghats of Mudigere taluk, Chikmagalur district. The watershed ranges between East longitudes 75° 31′30″ to 76°39′45″ and North latitudes 12°35′15″ to 13°22′30″. The Hemavathi river joins the Cauvery in the Krishnarajasagar reservoir (KRS) near Akkihebbal after reaching 245 km in length. The watershed stretches over an area of 5,427 square kilometers. Annual precipitation ranges from a low of 1,364 mm to a high of 2,178 mm, with a mean annual precipitation of 1,632 mm from the year 2014 and 2020 period. Precipitation was 1,364 mm in 2014, which is lower than the mean precipitation and 2,178 mm of high precipitation was experienced in 2020. The economy of the basin relies primarily on planting and agriculture. Watershed is the typical example of a monsoon type of climate. The summer season lasts March to May. The catchment area is a typical example of a monsoon type of climate. The rainy season lasts from June to October. During the rainy season, very strong rainstorms are observed. The winter months are November to February. During these months, severe colds are felt. Hilly catchment with a steep to intermediate slope is observed in the study area. In the upper reaches, the slope is very high and decreases steadily in the lower reaches. The river basin elevation varies between 748 m and 1,853 m above the mean sea level. The whole basin can be classified into hilly fields, moderately sloping and low lying lands (valley lands).

3. DATA

Daily records of precipitation, temperature, relative humidity, wind speed and hours of sunshine received from weather gauge stations of IMD (India Meteorological Department) are used. Information on the locations of weather gauge stations is shown in Figure 1. For a span of seven years (2014 to 2020), daily streamflow data for the catchment outlet (Akkihebbal) is collected from the Department of Water Resources, Government of Karnataka, which is used for the hydrological models calibration and validation. From the NBSS & LUP (National Bureau of Soil Survey and Land Use Planning), soil map and databases are collected for the watershed. Important soil parameters data is extracted for 20 groups of soil types that occur in the river basin. LU/LC maps for the study region were downloaded from the Bhuvan – Thematic Resources website for the corresponding time span. The LU/LC data utilized in the present study is from the Resourcesat-1 Linear Imaging Self-scanning Sensor (LISS-III). The LU/LC changes data for the study area are shown in Table 1 for 2014 and 2020 for reference. Figure 2 depicts the Hemavathi river basin's derived LU/LC map. By comparing Figure 3 and the LU/LC map, it can be seen that

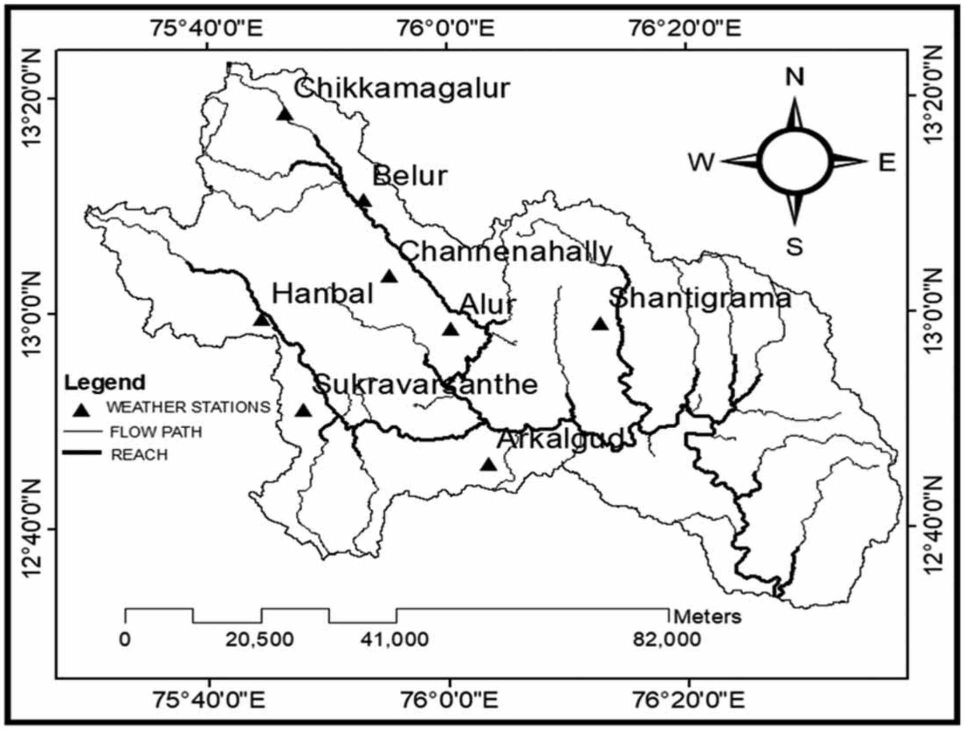

Figure 1 | Weather gauge stations in the Hemavathi river basin.

Table 1 | Composition of LU/LC classes in the Hemavathi river basin

Sl. No	LU/LC class	Year 2014%	Year 2020%
1	Built-up	0.25	0.46
2	Kharif only	29.31	22.67
3	Rabi only	12.93	5.68
4	Double/Triple	21.81	22.18
5	Current fallow	5.66	17.76
6	Plantation/Orchard	21.05	22.52
7	Evergreen forest	1.04	0.89
8	Deciduous forest	3.37	3.34
9	Scrub/Degraded forest	1.27	1.13
10	Grassland	0.14	0.12
11	Other wastelands	0.42	0.45
12	Gullied	0.16	0.17
13	Scrubland	0.07	0.05
14	Waterbodies	2.52	2.58
Total		100	100

plantations occur in the higher elevations of the basin (towards the West). Agricultural crops and plantation/orchards were the predominant classes in the Hemavathi river basin. Table 2 and Figure 4 depict the soil types found in the study area and their descriptions.

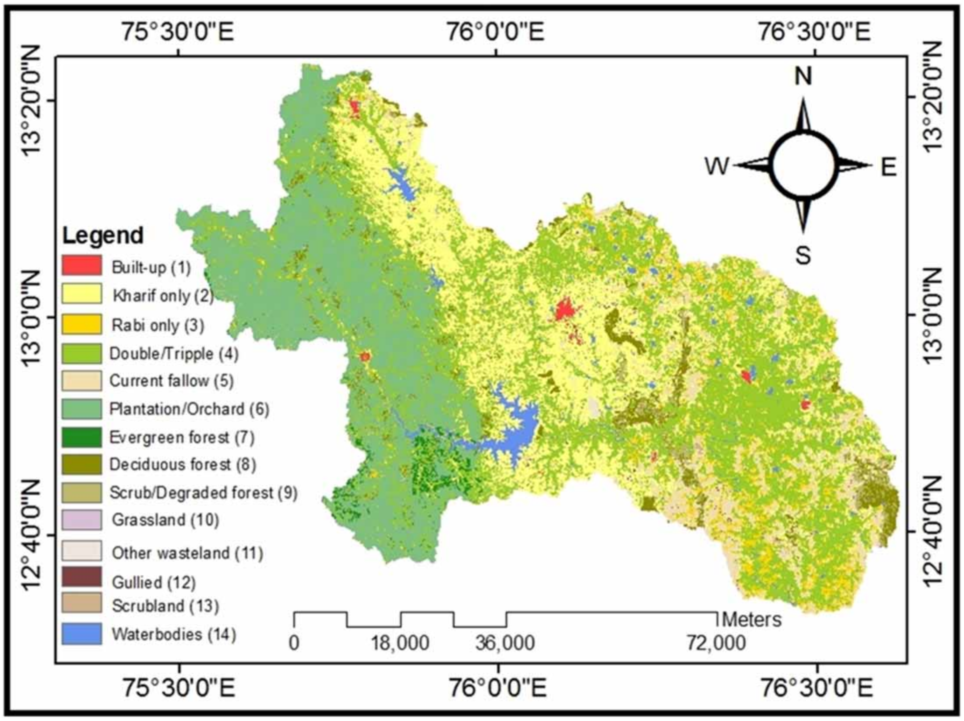

Figure 2 | LU/LC map of Hemavathi river basin for the Year 2020 (reference).

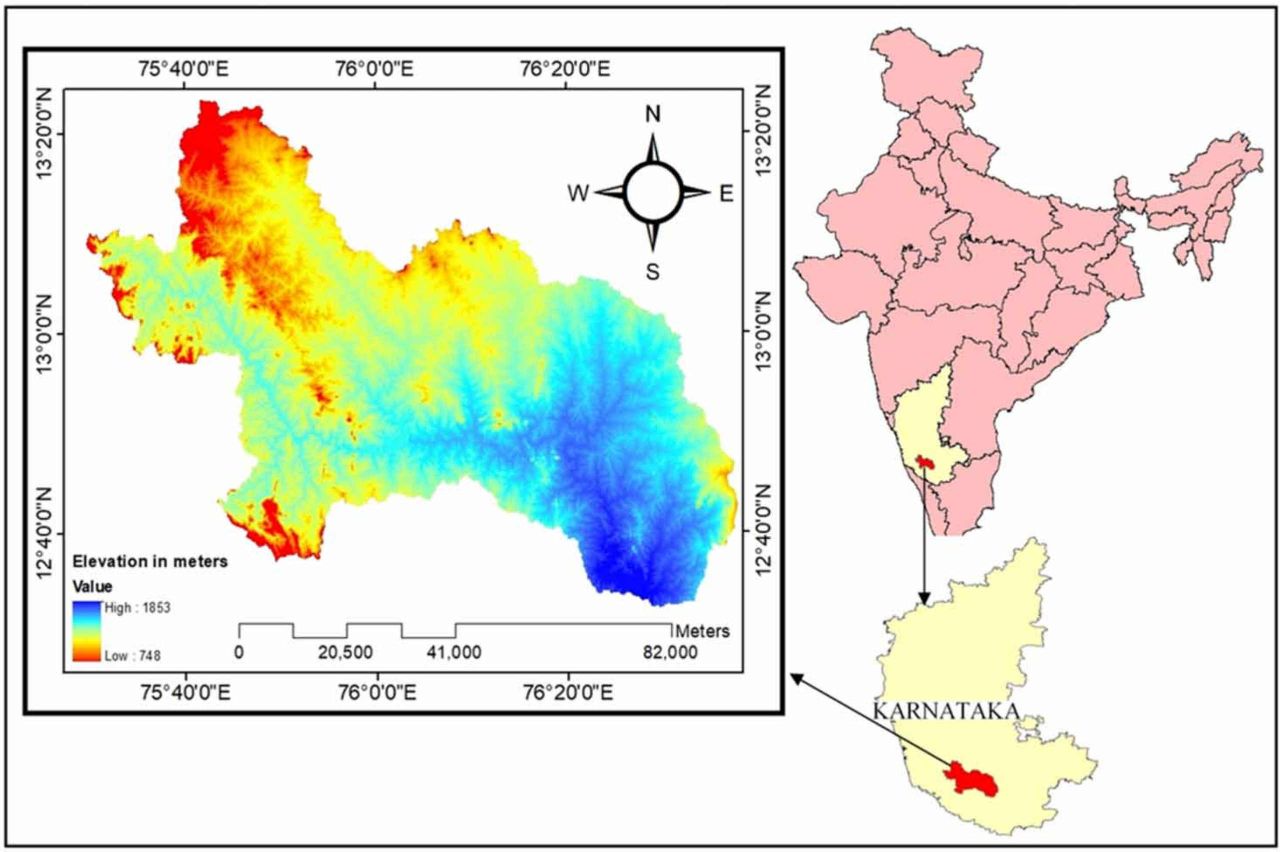

Figure 3 | Location and Digital Elevation Model (DEM) of Hemavathi river basin.

Table 2 | Soil type description

No.	Soil Description according to Soil Type (Figure 4)
1	Deep, somewhat excessively drained, gravelly clay soils with mild erosion on gently sloping interfluves
2	Deep, well drained, gravelly clay soils with mild erosion on gently sloping interfluves
3	In undulating interfluves, relatively thick, well drained, artificial soils, with mild erosion
4	Moderately shallow, well-drained, gravelly clay soils with moderate erosion on gently sloping interfluves
5	Moderately thick, well-drained, artificial soils of medium water content with mild erosion on undulating interfluves
6	Deep, well-drained, clay soils with mild erosion on undulating interfluves
7	Deep, relatively well-drained, artificial valley soil, with drainage issues and slight salinity in patches
8	On ridges with steep slopes, heavy runoff and mild erosion, very deep, excessively drained, artificial soil
9	Shallow, very excessively drained, gravelly clay soils with very poor rolling ground water content, mildly eroded
10	Quite deep, well drained, on undulating interfluves, clayey soils, with minor erosion
11	Outcrops of rock
12	Quite deep, well drained, gravelly clay soils, on steeply sloping high hills with mild erosion, heavily gravelly in the subsoil
13	Deep, well drained, gravelly clay soils with mild erosion on slopes of steeply sloping high hill ranges
14	Quite thick, well-drained, medium-water clay soils on laterite plateaus, with mild erosion
15	Deep, well-drained, artificial soils with medium water content and low erosion on laterite plateaus
16	Quite deep, moderately well drained, loamy, sandy valley soils, with a table of shallow water
17	Quite thick, well drained, gravelly clay soils on the laterite plateau with low water content, with extreme erosion
18	Quite rich, well-drained, gravelly clay soils on low hills with low water content, with mild erosion
19	Deep, well-drained, artificial soils with medium water quality with low erosion in the high hill ranges
20	Body of water

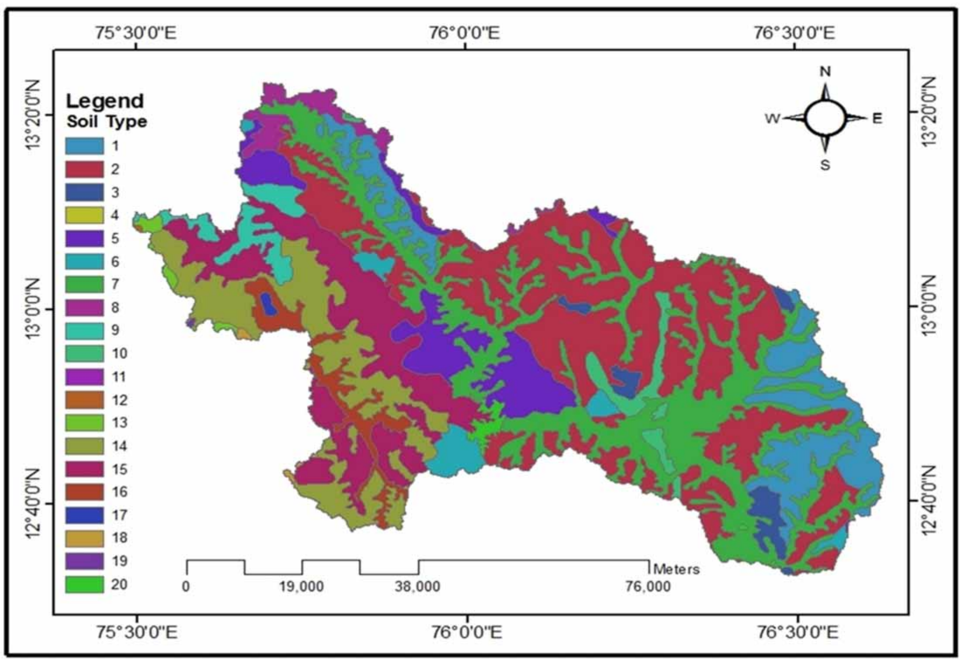

Figure 4 | Soil map of Hemavathi river basin.

3.1. Land use/land cover (LU/LC) map

LU/LC maps for the study region were downloaded from the Bhuvan – Thematic Resources website for the corresponding time span. The LU/LC data utilized in the present study is from the Resourcesat-1 Linear Imaging Self-scanning Sensor (LISS-III). The LU/LC changes data for the study area are shown in Table 1 for 2014 and 2020 for reference. Figure 2 depicts the Hemavathi river basin's derived LU/LC map.

3.2. Soil map

4. METHODOLOGY OF SWAT AND HEC-HMS MODELS

The watershed basin can be discretized by using physically based hydrologic models by dividing it into a limited number of sub-basins based on terrain features and drainage networks. They can help with data interpretation and hypothesis testing compared with field research and improve our knowledge of processes by their interactions. Physically-based models can simulate the whole runoff regime by generating multiple hydrological outputs such as runoff and evapotranspiration components. Black-box models, on the other hand, will only produce one output at a time. Figures 5 (SWAT) and 6 (HEC-HMS) depict the workflow diagrams of the physically-based hydrological models that have been subject to continuous revision and extension. Both hydrological models need various data concerning climate, topography, LU/LC, soils and streamflow information for model calibration and validation. Maximum, minimum air temperature and precipitation are the minimum weather inputs requested by the models. There are three major components of ArcSWAT, namely Watershed Delineation, HRU analysis and defining of Weather Data. DEM data is necessary for Watershed Delineator for stream network processing. Using LU/LC, soil map and DEM data, HRU analysis is processed. For Weather Data defining for the study area, weather gauge stations are needed. The outputs from these above three major steps are then used as inputs for streamflow simulation using the SWAT model. The HEC-HMS model also simulates runoff through open-channel routing by analyzing meteorological data. Simulation runs contain three different components that can compute results: the simulation runs, optimization trials and analyses. Outputs can be obtained as graphs, tables and with respect to continuous time series. The physically-based HEC-HMS model was also optimized and auto-calibrated using simulated daily stream flows with the observed flow.

Model output is calculated by computing the efficiency of the model between observed and simulated stream flows by determination coefficient (R^2) and Nash-Sutcliffe efficiency (NSE).

Nash-Sutcliffe Efficiency (NSE) and coefficient of determination (R^2) was computed as follows:

$$NSE = 1.0 - \sum_{t=1}^{T} \frac{(y_t - f_t)^2}{\sum_{t=1}^{T} (y_t - \bar{y})^2}$$

where y_t is the observed data values for time period t, f_t is the simulated data values for the same period, $\bar{y}$ is the mean observed data values per time period and T is the number of time periods. The maximum NSE value possible is 1.0 and occurs if simulated values perfectly match observed values. The lower the NSE value, the lower the goodness of fit between the simulated and observed time series. The larger NSE values denote better model performance.

$$R^2 = \left\{ \frac{\sum_{t=1}^{T} (y_t - \bar{y})(f_t - \bar{f})}{\left[\sum_{t=1}^{T} (y_t - \bar{y})^2\right]^{0.5} \left[\sum_{t=1}^{T} (f_t - \bar{f})^2\right]^{0.5}} \right\}^2$$

where $\bar{y}$ is the mean of observed values for the entire evaluation time period and $\bar{f}$ is the mean of simulated values for the entire evaluation time period. The other symbols have the same meanings as defined in the preceding equation. The R^2 value is equal to the square of Pearson's product-moment correlation coefficient. R^2 ranges from 0.0 to 1.0. Higher values equate to better model performance.

The autocalibration for the models' parameters is done until the acceptable streamflow simulation is attained. Sensitivity/optimization analysis examines the relative changes concerning the observed streamflow and also indicates the importance of

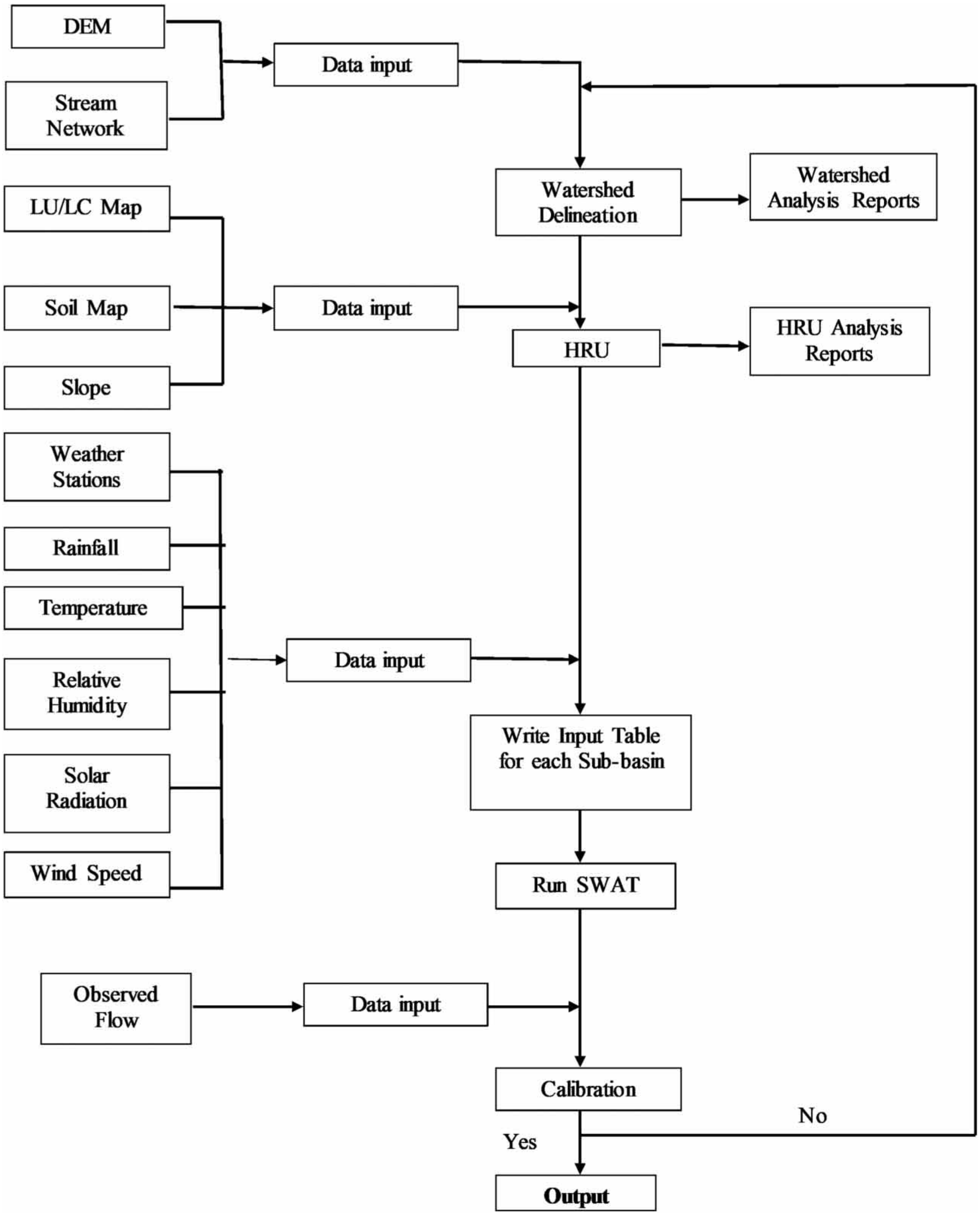

Figure 5 | Workflow diagram for setup and SWAT run.

the parameters in determining the streamflow in the study area. The calibrated models are finally utilized for estimating the effect of different scenarios like change in LU/LC for future streamflow simulation on hydrologic analysis of the basin; later both the models are validated against observed streamflow measured data.

5. RESULTS AND DISCUSSION

The SWAT and HEC-HMS hydrological models were applied to the sub-humid tropical Hemavathi river basin using the procedures defined in the literature review and described workflow diagrams (Figures 5 and 6). Based on the stream and DEM

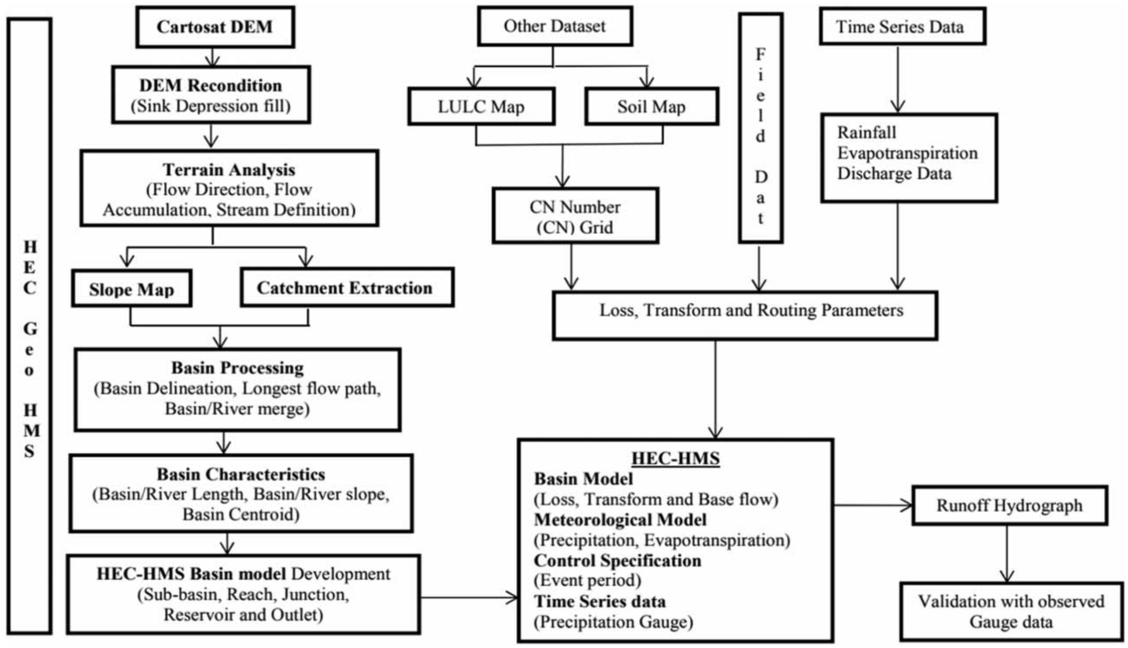

Figure 6 | Workflow diagram for setup and HEC-HMS model run (Source: http://hdl.handle.net/10603/226891).

network, sub-basins of the catchment were delineated separately. The detection of Hydrological Response Units (HRUs) was concluded by overlaying LU/LC, soil map and DEM. For the period year 2014–2020, associated data required as the input variables is observed streamflow availability; hence 2014–2017 was considered the calibration period and 2018–2020 data was considered for the validation period of models.

Hydrological models were implemented and run for the daily time step. Daily weather gauge stations records were used for streamflow simulation. For model validation and calibration, daily streamflow records were used at the Akkihebbal gauging site at the outlet of the basin. To identify the most critical parameters affecting daily streamflow simulation from the models, sensitivity analysis was performed. Observed streamflow is used to minimize the root mean square error (*RMSE*) between daily simulated runoff and daily observed runoff at the gauging site by identifying the critical sensitive parameters found in this manner were auto-calibrated. SWAT and HEC-HMS models identified sensitivity and optimised parameters for calibration in Table 3. The conclusions derived from the analysis are discussed below. Sensitivity analysis is conducted by identifying the essential parameters CN, ESCO and SOL AWC for the SWAT model when applied to the Hemavathi basin with required data inputs for 2014–2017. The significant parameters considered for optimization of the HEC-HMS model were I_a and T_{lag}. These parameters are auto-calibrated to achieve minimum *RMSE* between observed and simulated streamflows at the outlet of the basin.

Results of the below scatter plots (Figures 7 and 8) are derived from the daily observed runoff at the Akkihebbal gauge location (outlet) with those simulated using the calibrated SWAT and HEC-HMS models. Observed daily streamflow values obtained from the Akkihebbal stream gauge station are correlated with streamflow output extracted from the SWAT and HEC-HMS models after calibration to test the models further throughout the validation part.

Table 4 shows the R^2 and *NSE* values throughout the validation phase (2018–2020) and before calibration (2014–2017). It can be observed from the results that the efficiency of the models is very good and relative to the literature review, as shown

Table 3 | Sensitivity and optimized parameters identified for calibration by SWAT and HEC-HMS models

SWAT	HEC-HMS
Available water holding capacity by soil (SOL_AWC)	Initial abstraction (I_a)
Soil evaporation compensation factor (ESCO)	Lag time (T_{lag})
Curve number (CN)	

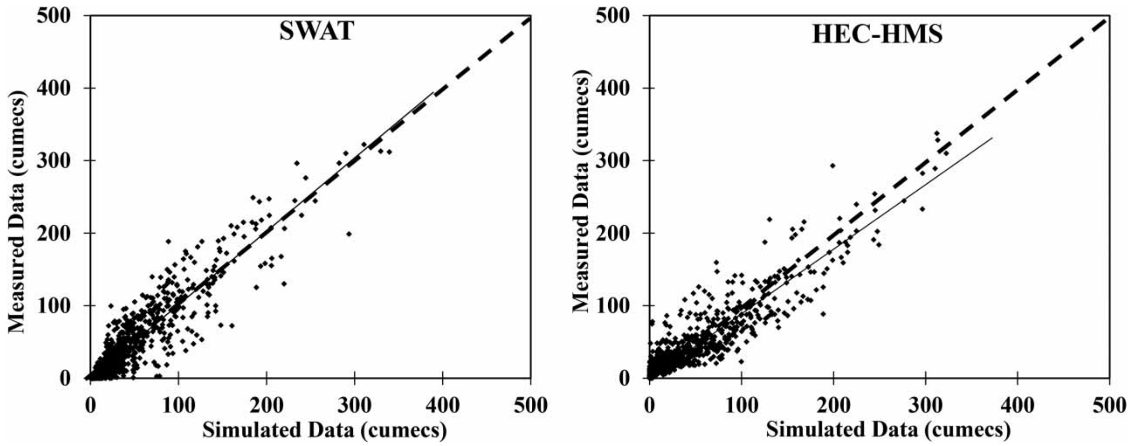

Figure 7 | Daily measured versus observed streamflow before calibration.

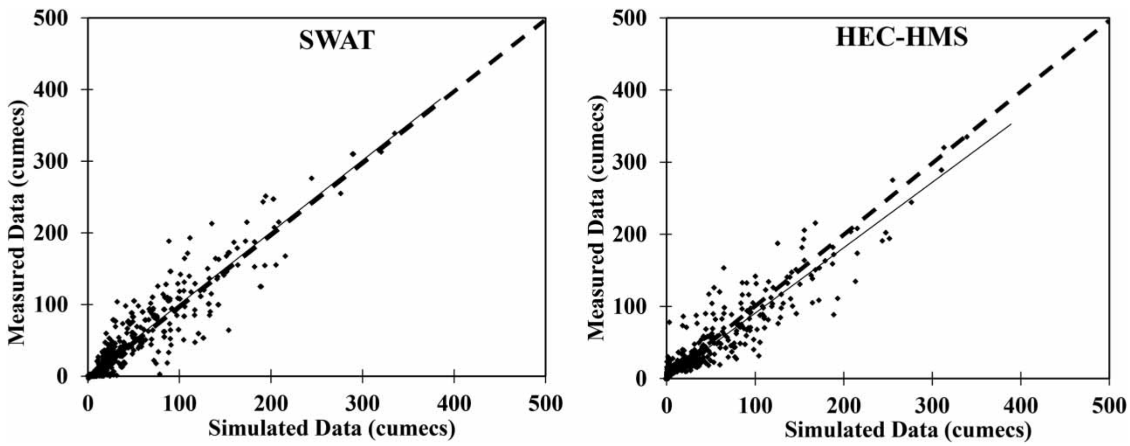

Figure 8 | Daily measured versus observed streamflow after calibration.

Table 4 | R^2 and *NSE* values before calibration (2014–2017) and during the validation period (2018–2020)

	SWAT		HEC-HMS	
Performances	**Validation**	**Calibration**	**Validation**	**Calibration**
R^2	0.85	0.81	0.81	0.78
NSE	0.82	0.76	0.77	0.73

by high R^2 and *NSE* values. By using observed data for the period 2018–2020, calibrated models are subjected to a validation test and efficiency is analyzed. The calibrated and validated models can be later used for future forecasts to simulate streamflows under modified HRU conditions. SWAT model outcomes depicted that *NSE* and R^2 values are 0.76 and 0.81 before calibration (2014–2017) and 0.82 and 0.85 during the validation period (2018–2020). Similarly, for the HEC-HMS model *NSE* and R^2 values are 0.73 and 0.78 before calibration (2014–2017) and 0.77 and 0.81 during the validation period (2018–2020).

The time series hydrograph of the streamflow difference among the simulated and observed flow during the calibration period (2014–2017) is shown in Figure 9. The graph reveals that the peak flow occurred in the monsoon season, moderate

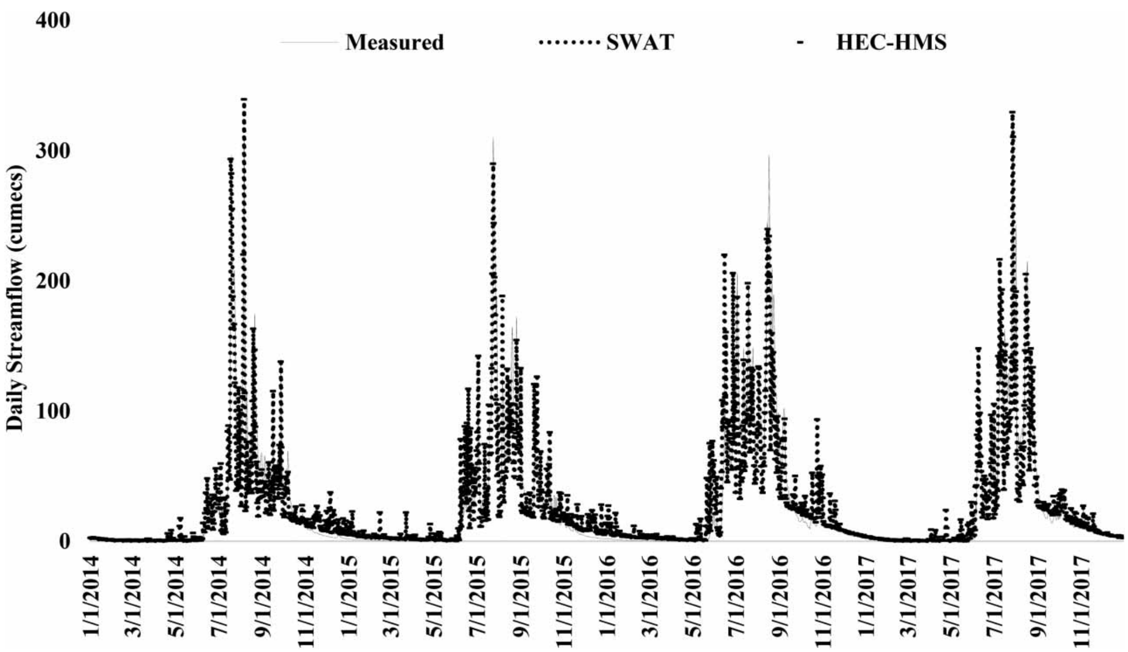

Figure 9 | Daily measured compared with the observed streamflow before calibration.

flow occurs in the post-monsoon period (September to October) and less streamflow during the pre-monsoon period depending on the rainfall. During the tropical region monsoon season, the discharge varies significantly, ranging from 200 to 350 cumecs due to the high rainfall occurrence. Compared to the literature review, both models' average performance before calibration was considered adequate since most of the simulated values were correlated to the observed streamflow values. Graphs depict that during the monsoon season, the sharp peak occurred annually for all the years (2014–2017). Simulated values are greater than the observed values at the Akkihebbal basin outlet at the catchment.

The time series hydrograph of the streamflow variation between the simulated and observed flow is seen in Figure 10 during the validation period after model calibration. Since the *RMSE* is reduced after model calibration, the graph shows a close correlation between the simulated and observed streamflow at the catchment outlet. Similarly, R^2 and *NSE* values during the validation period (2018–2020) have been increased after model calibration. Due to lower rainfall during the validation period (2018–2020), the discharge variance observed during the monsoon season varies from 180 to 320 cumecs, which is lower than before the calibration period (2014–2017). In comparison to the literature review, both models' overall performance was deemed adequate since the majority of the simulated values were also correlated to the observed values during the validation phase.

6. CONCLUSION

A sub-humid tropical catchment is selected as an excellent case study for assessing the performance of hydrological models. The weather gauge station data, LU/LC, DEM and soil map input data obtained are sufficiently reliable to simulate streamflows, based on the models' relatively good performance. The data sources used in this research are recommended for hydrological studies since they provide reasonably accurate results. In contrast to the literature analysis, the performance of SWAT and HEC-HMS hydrological models simulating temporal variations in the streamflow at the Hemavathi river basin's outlet (Akkihebbal gauging station) was very satisfactory. Compared to the literature, the SWAT and HEC-HMS hydrological models performed better in simulating temporal differences in streamflow at the Hemavathi river basin's outlet (Akkihebbal gauging station). During the validation duration (2014–2017), the R^2 value for the SWAT model was 0.81 and the *NSE* value for regular streamflow comparison was 0.76, indicating a more stable performance than the HEC-HMS model. Moreover, both models performed equally well during the validation phase (2018–2020) for the catchment outlet. During the validation period of daily observed flow comparisons, the R^2 value for the SWAT model was 0.85 and the *NSE* was 0.82, rendering it more precise than the HEC-HMS model. According to the results presented in this paper,

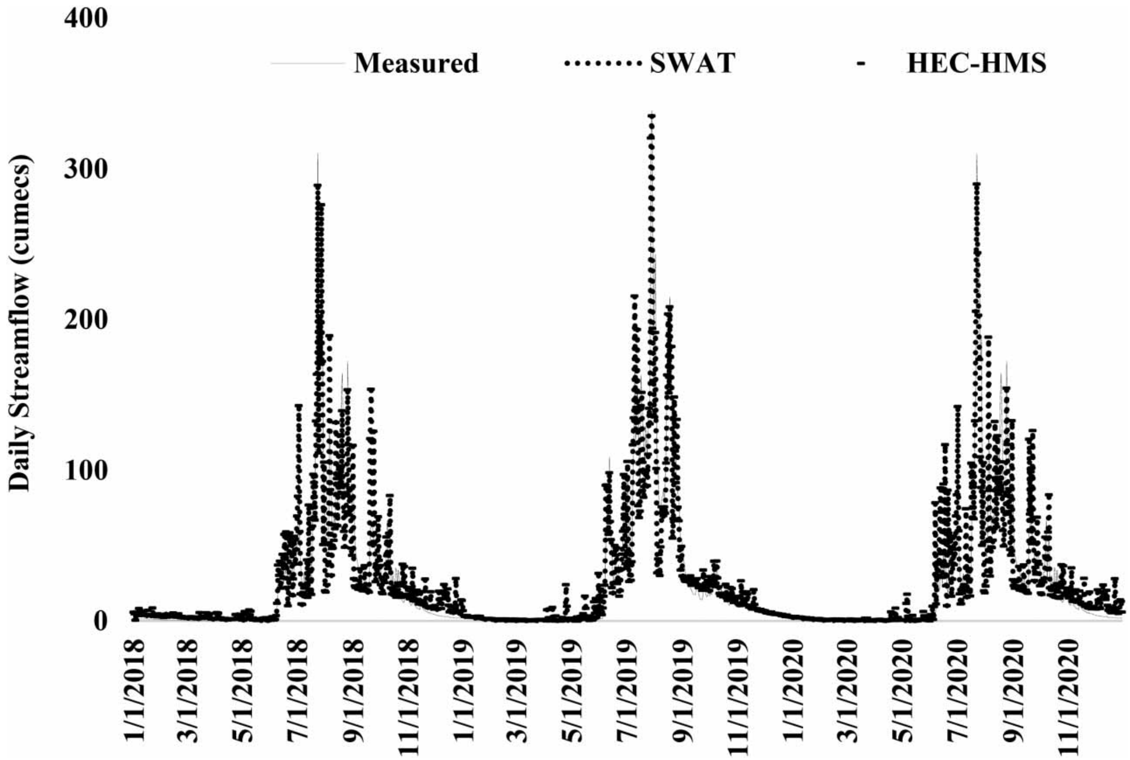

Figure 10 | Daily measured compared with the observed streamflow after calibration.

SWAT performed better and is a proper hydrological modeling technique for water resource management. The SWAT and HEC-HMS models provided an acceptable framework in the ArcGIS platform for streamflow simulation implementation. Input data selection and collection, preliminary analysis and pre- and post-processing will be made quickly and effectively using physically-based hydrological models. Similarly, the models could be implemented and produced good results at different time steps and spatial scales.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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