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Rainfall-runoff modeling and impact assessment of land parameters on water availability in Bisalpur reservoir, semi-arid Banas basin, Rajasthan, India

SANJAYKUMAR AGARWAL[1*], PRIYAMITRAMUNOTH[2], ARCHANA SARKAR[3]and ROHIT GOYAL[4]

[1]*Department of Civil Engineering, Research Scholar, Malaviya National Institute of Technology,*

Jaipur – 302017, Rajasthan, India

[2]*Department of Civil Engineering, Assistant Professor, Maulana Azad National Institute of Technology,*

*Bhopal, Madhya Pradesh, India (***munoth.priyamitra79@gmail.com***)*

[3]*National Institute of Hydrology, Roorkee, Roorkee – 247667, Uttarakhand, India* **(archana.nihr@gov.in)**

[4]*Department of Civil Engineering, Professor, Malaviya National Institute of Technology,*

Jaipur – 302017, Rajasthan, India **(rgoyal.ce@mnit.ac.in)**

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***Corresponding author's email: ska1971@gmail.com**

सार – जलाशय में पानी की उपलब्धता, विशेष रूप से अर्ध-शुष्क क्षेत्रों में, कमांड और जलग्रहण क्षेत्रों के निवासियों के लिए अत्यंत महत्वपूर्ण है। भारत के राजस्थान के अर्ध-शुष्क भूभाग में स्थित बीसलपुर बांध कमांड क्षेत्र की कृषि आवश्यकताओं को पूरा करने के अलावा जयपुर, अजमेर और टोंक जिलों को पेयजल उपलब्ध कराने में भी महत्वपूर्ण भूमिका निभाता है। जल संसाधन विभाग (WRD) के लिए जल संसाधनों के उपयोग और योजना को अनुकूलतम बनाने के लिए जलाशय में जल की उपलब्धता जानना महत्वपूर्ण है। इसलिए, इस अध्ययन में, SWAT मॉडल का उपयोग करके बीसलपुर बांध में अंतर्वाह का मॉडल बनाने और अनुमान लगाने का प्रयास किया गया है। मॉडल का अंशांकन 2001-2008 के लिए 2 वर्ष (2001-2002) की वार्म-अप अवधि के साथ किया गया तथा मासिक पैमाने पर 2009-2013 के लिए मान्य किया गया। R2, NS और PBIAS जैसे प्रदर्शन सूचकांकों का अनुमान लगाया गया और अंशांकन में मान क्रमशः 0.90, 0.91 और 23.6% और सत्यापन में 0.84, 0.70 और -20.6% आए जो निष्कर्ष निकालते हैं कि जल संभर के लिए मॉडल सफलतापूर्वक कार्य करता है। परिणाम संतोषजनक मॉडल प्रदर्शन दर्शाते हैं तथा मृदा एवं जल मूल्यांकन उपकरण (SWAT) मॉडल ने बीसलपुर जल संभर क्षेत्र की गतिशीलता को प्रभावी ढंग से दर्शाया है। इस अध्ययन के परिणामस्वरूप, जलाशय में जल उपलब्धता को प्रभावित करने वाले सबसे महत्वपूर्ण भूमि परिमाप मृदा की विशेषताओं जैसे पारगम्यता, मृदा का वाष्पीकरण और गहरे जलभृत में अंतः स्रवण अंश से संबंधित हैं। विकसित मॉडल का उपयोग बीसलपुर जल संभर क्षेत्र के जल विज्ञान, भूमि आवरण, भूमि उपयोग और जलवायु परिवर्तन विश्लेषण के लिए किया जा सकता है तथा प्रेक्षित आंकड़ों के सत्यापन के बाद इसे अन्य अर्ध-शुष्क क्षेत्रों में भी दोहराया जा सकता है।

ABSTRACT. The accessibility of the water in the reservoir, particularly in semi-arid regions, holds paramount significance for the residents of the command and catchment areas. Situated in the semi-arid landscape of Rajasthan, India, the Bisalpur Dam plays a crucial role in providing drinking water to Jaipur, Ajmer, and Tonk districts, apart from catering to the command area's agricultural needs. Knowing the water availability in the reservoir is important for the Water Resources Department (WRD) to optimise the utilisation of water resources and planning. Therefore, in this study, efforts have been made to model and predict inflow at Bisalpur Dam using the SWAT model. The calibration of the model was done for 2001-2008 with a warm-up duration of 2 years (2001-2002) and validated for 2009-2013 on a monthly scale. The performance indices like R^2, NS, and PBIAS have been estimated, and the values were 0.90, 0.91, and 23.6% in calibration and 0.84, 0.70 and -20.6% in validation, respectively, which conclude that the model for the watershed fits successfully. The results show satisfactory model performance, and the Soil and Water Assessment Tool (SWAT) model effectively captured the dynamics of the Bisalpur watershed. As a result of this study, the most important land parameters that affect the water availability in the reservoir are related to soil characteristics such as permeability, soil evaporation, and deep aquifer percolation fraction. The developed model can be utilised for hydrological, land cover, land use, and climate change analysis of the Bisalpur watershed and may be replicated in other semi-arid areas after validation with the observed data.

Key words – Bisalpur Dam, Inflow forecast, Banas Basin, Rainfall-runoff model and SWAT.

1. Introduction

The effective management of reservoirs and dams requires an in-depth understanding of the inflows and sediment loads they receive. The sedimentation in reservoirs reduces their storage capacity, affects water quality, reduces their lifespan, and makes it difficult for dam operations (Morris & Fan, 1998). Therefore, many models were developed in the past to study the inflow patterns and rate of sediments in reservoirs. The most utilized model is the Soil and Water Assessment Tool (SWAT). This model is employed in hydrological studies to predict these parameters and the complex interactions between land, soil, vegetation and climate in river basins and watersheds. SWAT is a useful tool for predicting inflow and sediment load, aiding in better dam management. Arnold *et al.* (1998) used SWAT to predict the impact of land management practices in complex and large watersheds. SWAT is a continuous time model and is designed to be applied in a long-term mode. SWAT was applied in various regions globally for water resource management and sediment prediction (Abbaspour *et al.*, 2015; Halefom *et al.*, 2017; Kumar *et al.*, 2018; Munoth and Goyal, 2019, 2020). SWAT's capability to simulate complex watershed processes with detailed spatial inputs makes it a suitable tool for such studies (Gassman *et al.*, 2007). Arid and semi-arid regions, like Rajasthan, present unique challenges for hydrological modeling. Since these regions, rely heavily on their reservoirs and dams, therefore, the hydrological modeling in these regions requires specific considerations. Studies suggest that model calibration is crucial in this type of area to ensure its efficacy with limited rainfall and distinct evapotranspiration patterns (Samimi *et al.*, 2020).

Setegn *et al.* (2010) utilized SWAT for hydrological modeling for the Lake Tana Basin of Ethiopia, indicating its utility in local conditions. In this study, uncertainty analysis algorithms and calibration parameters such as SUFI-2, Para-Sol, and GLUE were used and compared. The study concluded that GLUE &SUFI-2 methods showed good results during calibration. Mengistu *et al.* (2019) employed the methodologies for calibrating and validating the SWAT model in data-deficient arid and semi-arid catchments within South Africa. The evaluation and categorization of these catchments hinge on their resemblance in terms of physical variables such as physiography, geology, soils, climate, and vegetation. The calibration process has been executed, leading to the proposition that the calibrated parameters can be transferred from a monitored and calibrated catchment to unmonitored and data-sparse catchments. The SWAT tool was also used by Molla *et al.* (2020) in the assessment of the inflow of sediment in Dire Dam in Ethiopia. Echogdali *et al.*, (2022) estimated the sedimentation rate using SWAT in the Tata basin, southeast Morocco for the construction of future dams. The developed model underwent calibration and validation processes utilizing the SUFI-2 algorithm at a monthly time scale. The findings indicate that sediment yield is notably influenced by basin characteristics, including lithology, slope and soil type.

Bisalpur Dam, located on the Banas River in the Tonk district of Rajasthan, plays a crucial role in providing water for both irrigation and consumption purposes. Due to uncertainty in the availability of water, important factors that affect the runoff in the reservoir may be identified. Previous studies globally and in India affirm the utility of SWAT in similar applications. Ensuring the sustainability of its water resources has become increasingly crucial due to growing water demands and changing climate patterns in these regions (Dubey *et al.*, 2019). Therefore, efforts have been made in this study to identify the rainfall-runoff relationship and the parameters affecting the inflow in Bisalpur Dam using the SWAT model.

2. Data and methodology

2.1. *Study area*

The Banas basin is part of the Ganga basin, located in the Aravali Mountain range in eastern Rajasthan. The basin ranges between 24° 17'14” to 27° 18'15” and 73° 20 54" to 77° 00 36". The Banas basin comes under six districts of Rajasthan, namely Ajmer, Bhilwara,Tonk, Udaipur, Rajsamand and Chittorgarh, having a total area of 27,661 km^2. This study aims totheBisalpur Dam reservoir built across the Banas River atDeoli in Tonk district, Rajasthan, India (Fig. 1). It is about 125 km south-west of Jaipur, the capital of Rajasthan state. The construction of theBisalpur dam was finalised in 1999 for irrigation and water supply. The details of the Dam are given in Table 1.

The annual average rainfall in the catchment area varies from about 340 mm to 860 mm, while the annual mean rainfall in the basin is 589mm. Similarly, the range of rainfall range during the monsoon period varies from

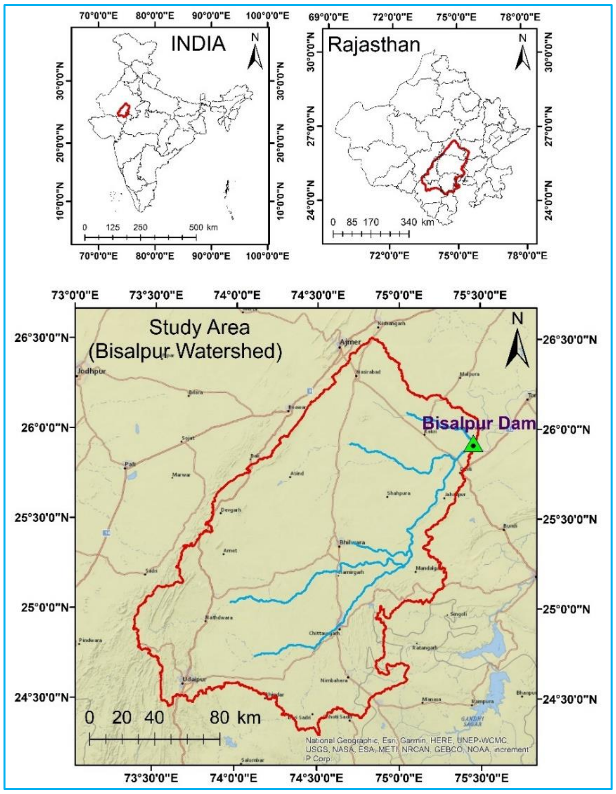


Fig. 1. Bisalpur catchment Map

TABLE 1

Salient Features of Bisalpur Dam

Reservoir Characteristics	
Top Bank Level	322.50 m
Max Water Level	316.345 m
Full Reservoir Level	315.50 m
Sill Level of irrigation sluices	308.28 m
Maximum Drawdown Level	298.60 m
Dead Storage Capacity	1.50 MCM
Ht of the dam from the foundation level	39.50 m
Ht of the dam from the riverbed	27.50 m
Length of Dam	338 m
Gross Storage	1095.862 MCM

(*Source*: Government of Rajasthan, WRD Rajasthan, 2015)

326 mm to 810 mm, with a mean value of 544mm. Moreover, the maximum mean temperature in the study area varies from 32.11°C -33.2 °C, while the mean value is 32.77 °C. The observed maximum temperature in the study area was in the range of 43.2 °C to 46.3 °C and the mean value was 44.9 °C. The average minimum

TABLE 2

Sources of data: rainfall, temperature, land use, soil data and streamflow

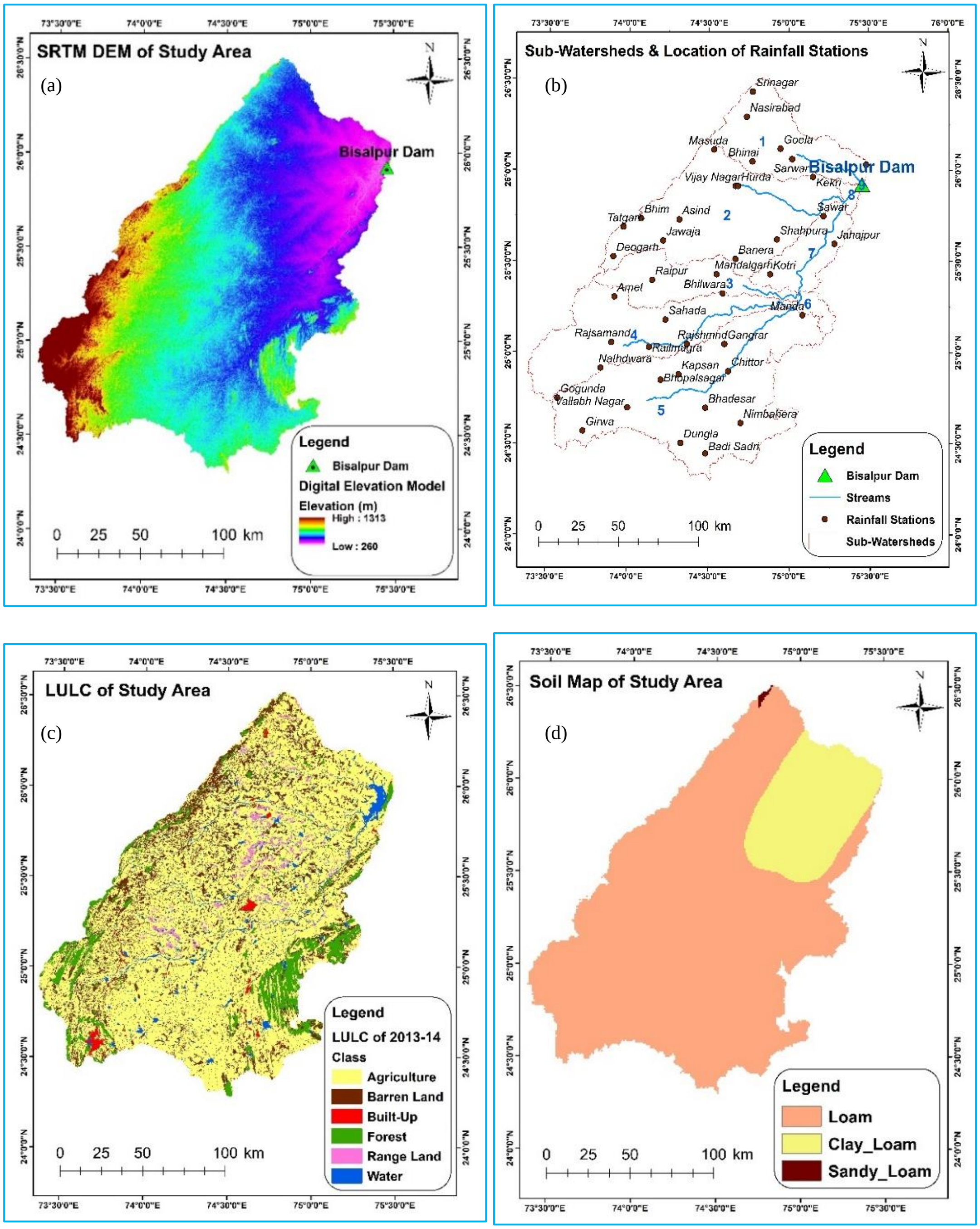
Type of Data	Resolution/Range	Source of data
DEM	30m	SRTM www2.ipl.nasa.gov/srtm
Soil Data	1.0 km	FAO-UNESCO www.fao.org/nr/land/soils
Rainfall Data (1979-2013)	Stations (Daily)	WRD Rajasthan www.wrdrajasthan.gov.in
Discharge (1980-2013)	Observed (Daily)	
Land Use Land Cover (LULC) (2014)	30m	LANDSAT-7 https://earthexplorer.usgs.gov
Relative Humidity (1979-2013)	0.35° by 0.35°	Global weather data (CFSR data)https://globalweather.tamu.edu
Temperature (1979-2013)		
Wind Speed (1979-2013)		
Solar Radiation (1979-2013)		

fluctuates between 17.5 °C and 20.6 °C, and the mean value is 19.05 °C. Specifically in the Banas Basin, the range of minimum temperatures range spans from 1.76 °C to 6.05 °C, and the mean value is 3.8 °C.

2.2. *Data collection*

The major data required for the development of the SWAT model are summarised in Table 2, indicating their sources. The rainfall data of the Banas basin area were collected from the Water Resources Department, Govt. of Rajasthan website. The additional climate data, including parameters such as wind speed, minimum and maximum temperatures, solar radiation and relative humidity, were collected from the Global weather data available on the SWAT website. The Digital Elevation Model (DEM) required for the catchment delineation was obtained through the Shuttle Radar Topography Mission (SRTM). The minimum and maximum elevation varies from 200m to 1313m within the Bisalpur watershed [Fig. 2(a)].

The watershed was delineated using the SWAT tool and divided into sub-watersheds. The Bisalpur watershed is divided into 9 sub-watersheds [Fig. 2(b)]. LANDSAT-7 data was employed to create the LULC map of the



Figs. 2(a-d). Inputs for SWAT (a) SRTM DEM(b) Sub-watersheds & Rainfall stations (c) LULC and (d) Soil map of the Banas catchment

catchment area of the Banas basin by using the supervised algorithm of maximum likelihood. Based on the spectral responses of satellite images, the basin area was classified into six classes of LULC, such as agriculture, barren, built-upland, forest, range land and water. Around 70% of the study area comes under the agriculture class. The other major land use types of the basin are barren land (11%), forest land (7%) and water (5%) [Fig. 2(c)]. The soil data were extracted for the basin from the global soil map of FAO. Soil data was divided into three different soil groups according to the FAO. The major types of soil in the basin are loamy (81%) and clay loamy (17%) [Fig. 2(d)].

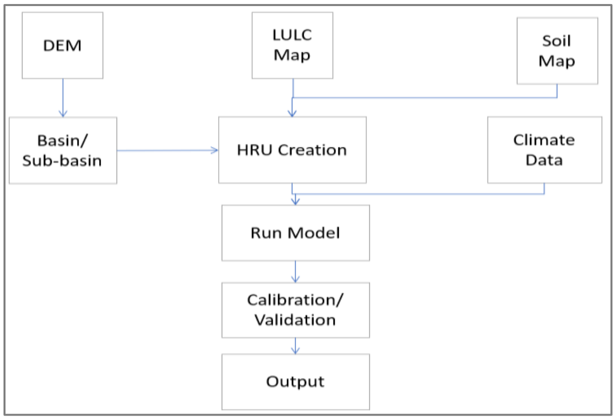


Fig. 3. Methodology of the SWAT Model

2.3. *Working of SWAT*

The SWAT model was developed by the United States Department of Agriculture, Agricultural Research Service, as outlined in the work of Arnold *et al.*1998. SWAT is a semi-distributed and physical model, designed for studying the hydrology, soil, sediment and water quality aspects of any watershed. The SWAT model, after delineation, divides the watershed into several sub-watersheds, and on the basis of soil, slope and land use characteristics, these sub-watersheds are then divided into hydrologic response units (HRUs). The transformations of water and nutrients are identified at every HRU level in SWAT, which are combined at the sub-watershed level and routed via the channel network to the watershed outflow. The climate data are integrated with the HRUs, and the water balance equation is computed at every HRU level. Then processes like surface runoff, infiltration, evapotranspiration, percolation and lateral flow are simulated on the soil profile (Neitsch *et al.*, 2005; Zhang *et al.*, 2014; Fan & Shibata, 2015). The working methodology of SWAT is shown in Fig. 3.

In this study, the soil conservation service (SCS) curve number approach is utilized to compute the surface runoff from HRUs by using the daily rainfall data. For potential evapotranspiration, the Penman-Monteith equation is used. The working of the SWAT was also described by Munoth and Goyal (2019) & (2020) and on (https://swatm odel.tamu.edu/).

2.4. *Performance Evaluation of SWAT*

The calibration and validation of the developed model involved the use of the SWAT-CUP and the SUFI-2 algorithm (Abbaspour, 2011). The SUFI-2 is a popular method for calibrating the SWAT output for stream flow. Since it takes into account all potential sources of uncertainty, such as parameter, model input

TABLE 3

Minimum, maximum and fitted values of calibration parameters

Name of Parameters	Minvalue	Maxvalue	Fittedvalue
CN2	-0.4	-0.1	-0.413
GWQMN	0	5000	2763
SOL-AWC	-0.2	0.2	0.485
ESCO	0	1	0.312
RCHRG-DP	0	1	0.131
GW-REVAP	0.02	0.2	0.153
GW-DELAY	0	500	7.11
ALPHA-BF	0	1	0.098
REVAPMN	0	500	56.58

observed data and structure (Abbaspour *et al.*, 2007). Statistical indicators such as percentage bias (PBIAS), coefficient of determination (R2), and Nash-Sutcliffe model efficiency (NS) were used in evaluating the performance of the model as suggested by Moriasi *et al.* 2007.

$$R^2 = \left[\frac{\sum_{i=1}^{n} \left(O_i^{obs} - O_i^{mean}\right) * \left(S_i^{sim} - S_i^{mean}\right)}{\sqrt{\left[\sum_{i=1}^{n} \left(O_i^{obs} - O_i^{mean}\right)^2\right]} * \sqrt{\left[\sum_{i=1}^{n} \left(S_i^{sim} - S_i^{mean}\right)^2\right]}} \right]^2 \quad (1)$$

$$NS = 1 - \frac{\sum_{i=1}^{n} \left(O_i^{obs} - S_i^{sim}\right)^2}{\sum_{i=1}^{n} \left(O_i^{obs} - O_i^{mean}\right)^2} \quad (2)$$

$$PBIAS = 100 * \frac{\sum_{i=1}^{n} \left(Q_0 - Q_s\right)_i}{\sum_{i=1}^{n} Q_{0,i}} \quad (3)$$

Here, O_i is observed and S_i is the simulated value, $\hat{O}_i$ denotes the mean observed data, and *'n'* signifies the total quantity of data. An accurate model is indicated by a high value for NS. Similarly, better model performance is indicated by a lower absolute value of PBIAS.

3. Results and discussion

3.1. *Calibration and validation*

The drainage pattern of the land surface terrain and the Bisalpur watershed are delineated in the QSWAT

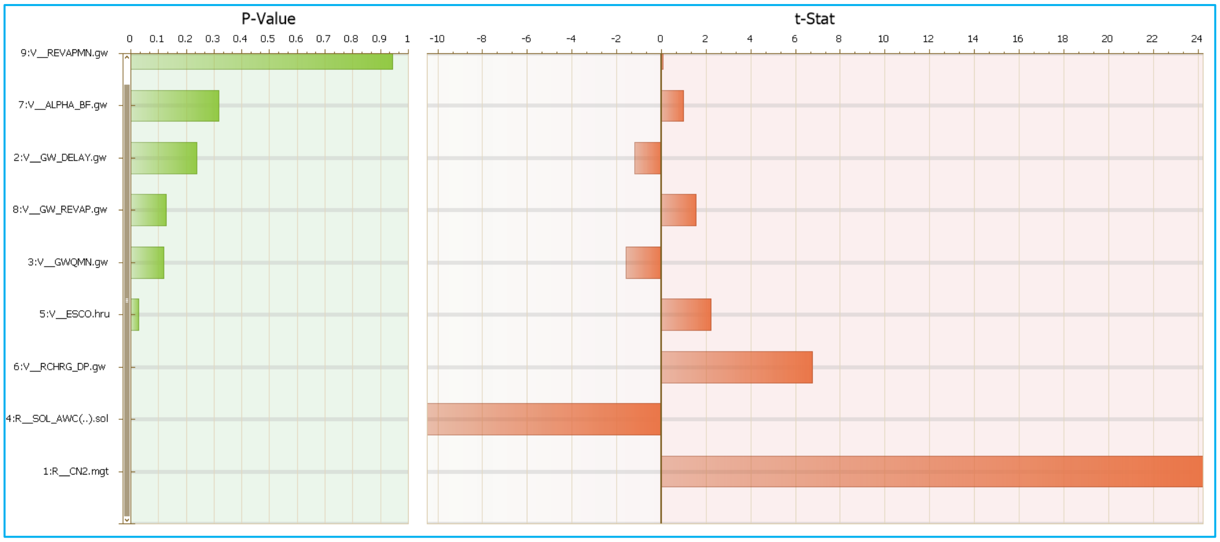


Fig. 4. P-value and t-Stat results for Sensitivity analysis

model with an area threshold value of 2000 km^2 using the SRTM DEM. Consequently, the basin is subdividedinto9sub-watersheds and 86 HRUs. The water balance equation is utilized to simulate the hydrologic cycle for all HRUs, which is then combined with the sub-watershed and watershed levels. The model was simulated for the years 2001 to 2013 with a warm-up period of 2 years. Further, the simulated model was calibrated and validated with the data of the period 2003 to 2008 and of the period 2009 to 2013, respectively, using the observed inflow data available at the Bisalpur Dam location.

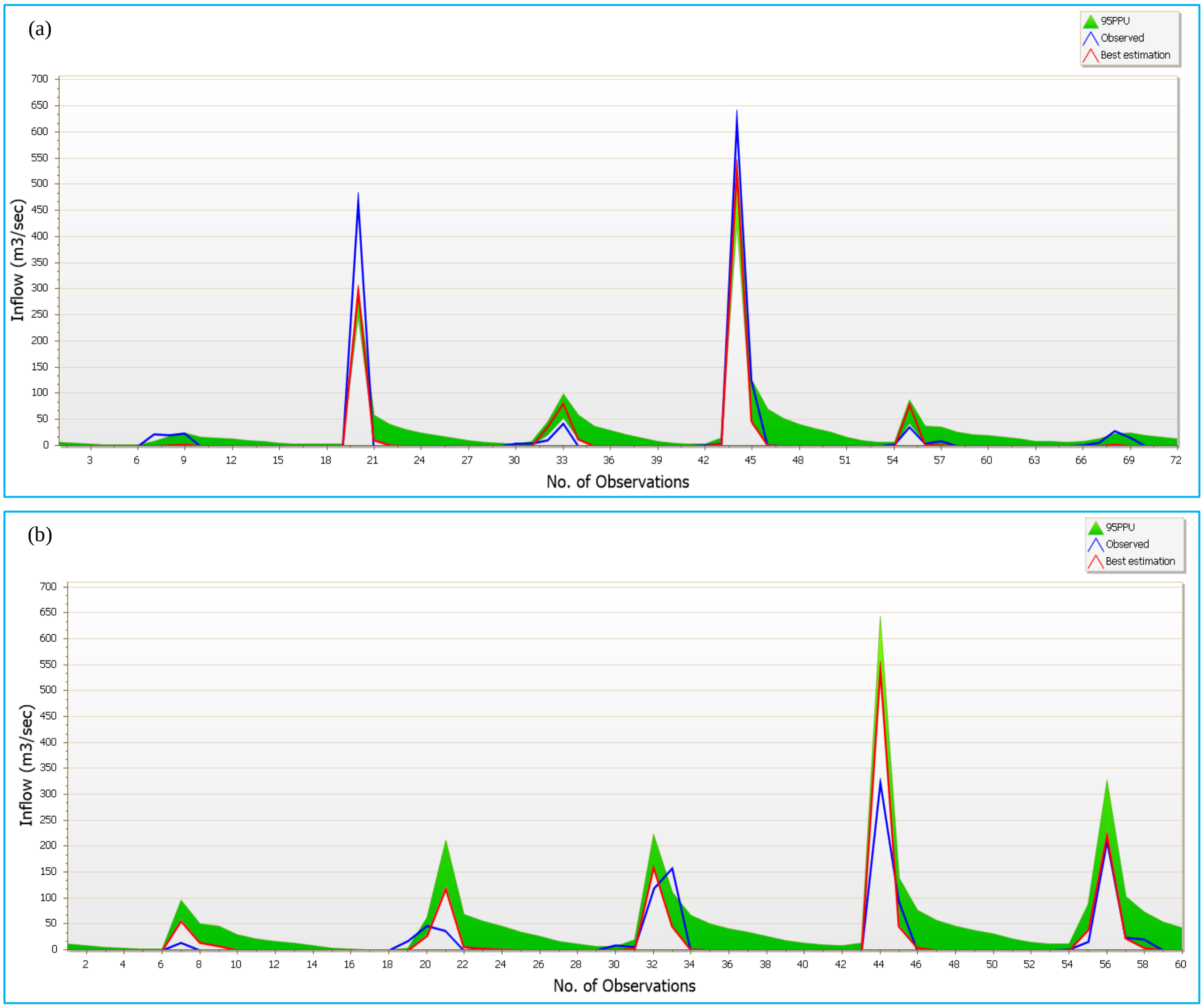
For calibration, nine parameters were chosen, *viz.*, CN2, Sol-AWC, RCHRG-DP, ESCO, GWQMN, GW-REVAP, ALPHA-BF, REVAPMN and GW-DELAY, that were based on the protocol given in Abbaspour *et al*. (2015). Table 3 shows the calibration parameters along with minimum, maximum and fitted values of the parameters used in the development of the model.

To know the sensitivity of the parameters that affected the results, the global sensitivity analysis method was used in SWATCUP. Based on the values of the t-test and P-state, the most sensitive parameters for the present study are CN2, Sol-AWC, RCHRG-DP, ESCO and GWQMN (Fig. 4 & Table 4). The CN2 is a key parameter in the estimation of surface runoff. It is influenced by hydrological conditions, soil type and land use. Given the various land uses, agricultural practices, and soil types in the Banas Basin, the CN2 could be particularly sensitive in determining runoff. The Sol-AWC determines how much water the soil can store and hence influences how much water is available for plants, evaporation and runoff. In areas with varied soil and agricultural activities, such as the Banas Basin, this parameter is crucial for understanding water availability. The RCHRG-DP parameter is critical in areas that rely on groundwater for irrigation and drinking. The Banas Basin, with its significant irrigation activities and water demands, would be sensitive to how much water percolates to recharge the deep aquifers. Similarly, evaporation is also an important parameter in the hydrological cycle, especially in regions with high temperatures. The ESCO parameter adjusts the soil evaporation rates and given the climatic conditions (High Temperature) of the Banas Basin, it might be a sensitive parameter affecting water balance. The GWQMN parameter determines when water from the shallow aquifer begins to contribute to streamflow. Given the reliance on groundwater in the

TABLE 4

Sensitivity analysis of parameters

Parameter Name	t--Stat	P value	Rank
CN2	24.23	0.00	1
SOL-AWC	-10.48	0.00	2
RCHRG-DP	6.74	0.00	3
ESCO	2.22	0.03	4
GWQMN	-1.57	0.12	5
GW-REVAP	1.54	0.13	6
GW-DELAY	-1.19	0.24	7
ALPHA-BF	1.00	0.32	8
REVAPMN	0.07	0.94	9



Figs. 5(a&b). Monthly inflow comparison for simulated and observed data for Bisalpur Dam for (a) calibration (period 2003-2008) and (b) validation (period 2009-2013)

Banas Basin and its interaction with surface water; this parameter would be sensitive in understanding streamflow dynamics.

Figs. 5 (a&b) show the 95PPU (95 Percentage Prediction Uncertainty) band and the best fit observed and simulated values. The 95% prediction uncertainty band was determined by considering the 2.5% and 97.5% levels of the cumulative distribution function of the output variables. The parameter uncertainty was represented by a multivariate uniform distribution in a parameter hypercube, and then a set of parameter ranges was mapped with all the sources of uncertainty. For the assessment of the quality of calibration-uncertainty performance, two distinct indices were employed: the P-factor, which measures the percentage of data enclosed by the 95 PPU band, and the R-factor, which quantifies the average width of the 95 PPU. For discharge, it is recommended to have a P-factor value greater than 70% and an R-factor value of approximately 1. There is no set amount that these two factors should be, the larger they are, the better, they are. (Abbaspour, 2011).

Table 5indicates that model performance is satisfactory for the validation and calibration period. The R^2, NS, and PBIAS values were 0.90, 0.91 and 23.6% in calibration and 0.84, 0.70 and -20.6%in validation. The P-factor and R-factor values were found to be 0.26, 0.14 and 0.30, 0.10, respectively, for calibration and validation (Table 5).

3.2. *Inflow Predictions*

Fig. 6 shows the yearly predictions of inflow at the Bisalpur dam. The average inflow rate predicted by SWAT for the period 2003 to 2013 was 21.65 m^3/sec

TABLE 5

Performance evaluation results

Process	Year	P-factor	R-factor	R^2	NS	PBIAS
Validation	2009-2013	0.30	0.10	0.84	0.70	-20.6%
Calibration	2001-2008	0.26	0.14	0.90	0.91	23.6%

(Fig. 6) while the average inflow rate estimated for the same period from the observed data was 19.70 m^3/sec. The difference between the observed and predicted average inflow rate was found to be around 1.95 m3/sec, which is very marginal, and it can be further improved with the use of high-resolution spatial data. The results show that the established model is suitable for the Banas basin area for the detailed hydrological analysis.

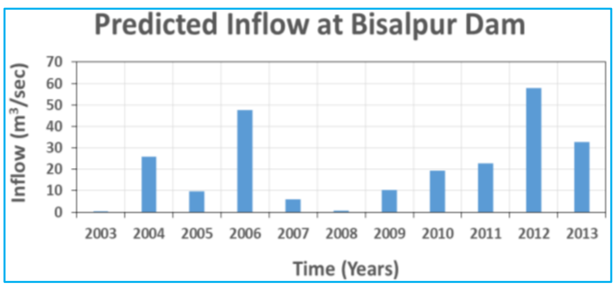


Fig. 6. Predicted inflow at the Bisalpur Dam location

3.3. *Implications for Dam Management*

The predictions derived from this study on the Bisalpur Dam in the Banas Basin can be instrumental in guiding reservoir management strategies in several ways:

(*i*) *Optimized Water Release*

The predicted inflow patterns can be used to adjust water release schedules, ensuring that reservoir levels are optimized throughout the year. This means avoiding unnecessary spillages during peak inflow periods and ensuring availability during lean periods.

(*ii*) Agricultural *Management*

Since 70% of the basin area is under agricultural use, understanding inflow can guide in agricultural management.

(*iii*) *Early Warning Systems*

With a reliable prediction model in place, it's possible to anticipate periods of unusually high inflow. This information can be crucial in giving warnings to downstream communities or making pre-emptive operational adjustments.

(*iv*) *Adaptive Water Allocation*

For areas depending on the dam for drinking and irrigation, the inflow predictions can be used to devise adaptive water allocation schedules. During predicted low inflow periods, water allocations can be reduced, urging farmers to prioritize water-efficient crops or adopt water-saving irrigation techniques. Similarly, the Public Health Engineering Department may work on a contingency plan during the lean period.

(*v*) *Land Use Planning*

Predictions on inflow, when viewed alongside land-use data, can inform land-use policies. Restricting certain activities or promoting land use patterns that minimize erosion in sensitive areas can become part of a larger land management strategy.

(*vi*) *Climate Change Mitigation*

The model's adaptability to predict scenarios based on changing climate patterns means that dam management can be pre-emptive in its strategies, adjusting operations in anticipation of climatic variations.

In essence, the predictions from the study provide a data-driven foundation upon which multiple management strategies can be built, ensuring that the Bisalpur Dam continues to serve its purpose efficiently and sustainably for years to come.

4. Conclusions

The model emerges as a valuable tool for predicting the inflow in Bisalpur Dam, aiding in its management.

(*i*) The study reaffirms the crucial role of understanding inflow patterns in maintaining a sustainable reservoir system. Efficient reservoir management not only ensures water availability but also aids in extending the lifespan of dams, like the Bisalpur Dam, which holds paramount importance for water supply and irrigation in Rajasthan.

(*ii*) The study area has around 70% area under agricultural land use. The study effectively predicted inflow in the Bisalpur Dam. Integrating diverse datasets, such as soil types, daily climate data, land use patterns and topographical data, allows for a holistic approach to modelling the complex dynamics of the Bisalpur watershed.

(*iii*) The in-depth process of delineating the Banas Basin into 9 watersheds and further into 86 HRUs based on varied parameters ensured a high degree of granularity in the study. Calibrating the model using actual inflow data from 2001 to 2008 and validating it for subsequent years (2009-2013) added robustness to the study's methodology.

(*iv*) *The* study highlighted the four most crucial parameters as below:

Curve Number 2 (CN2): This signifies that the permeability of the soil and land cover plays an important part in the study area. The average CN2 value for the Banas basin was found around 50.38, which shows the low surface runoff generation from the basin and further confirms that most part of the Banas basin is under agriculture and open land.

Apart from CN2, Available Soil Water Capacity (Sol_AWC), Deep Aquifer Percolation Fraction (RCHRG_DP) and Soil Evaporation Compensation factor (ESCO) show the higher groundwater recharge potential of the basin and were also reported in a previous study for Banas Basin (Dubey *et al.*, 2019). Knowledge of these sensitive parameters is vital for targeted interventions and fine-tuning management strategies for agriculture and domestic water uses.

(*v*) The SWAT model's ability to capture the Bisalpur Dam watershed's dynamics with satisfactory performance underscores its potential utility for comprehensive hydrological analyses of similar basins of the Rajasthan region.

(*vi*) Insights derived from this study are invaluable for stakeholders, policymakers and water resource managers. The knowledge can be leveraged to draft and implement strategies that prioritize the sustainable management of the Bisalpur Dam and potentially other similar reservoirs of Rajasthan.

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*Authors' Contribution*s

Mr. Sanjay Agarwal and Dr. Priyamitra Munoth: Gathered data, formulated, executed analysis and authored the initial draft of the manuscript.
Dr. Rohit Goyal and Dr. Archana Sarkar: Conceived and formulated the analysis; development of analysis tools and methodology; drafting the manuscript and editing process.

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References

Abbaspour, K. C., 2011, "SWAT-CUP4: SWAT calibration and uncertainty programs - a user manual. EAWAG Swiss Federal Institute of Aquatic Science and Technology", 1-103.

Abbaspour, K. C., Rouholahnejad, E., Vaghefi, S., Srinivasan, R., Yang, H. and Kløve, 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*, p524, 733-752. https://doi.org/10.1016/j.jhydrol.2015.03.027.

Abbaspour, K. C., Yang, J., Maximov, I., *et al.*, 2007, "Modelling hydrology and water quality in the pre-alpine Thur watershed using SWAT", *Journal of Hydrology*, **333**, 2, 413-430.

Arnold, J. G., Kiniry, J. R., Srinivasan, R., Williams, J. R., Haney, E. B. and Neitsch, S. L., 2012, "Soil and Water Assessment Tool: Input/output documentation version 2012", Texas Water Resources Institute.

Arnold, J. G., Srinivasan, R., Muttiah, R. S. and Williams, J. R., 1998, "Large area hydrologic modeling and assessment part I: Model development", *Journal of the American Water Resources Association*, **34**, 1, 73-89. https://doi.org/10.1111/jawr.1998.34.issue-1.

Dubey, S. K., Sharma, D., Babel, M. S. and Mundetia, N., 2019, "Application of hydrological model for assessment of water security using a multi-model ensemble of CORDEX-South Asia experiments in a semi-arid river basin of India", *Ecological Engineering*, **143**, 105641. https://doi.org/10.1016/j.ecoleng.2019.105641.

Echogdali, F. Z., *et al.*, 2022, "Assessment of soil erosion risk in a semi-arid climate watershed using SWAT model: Case of Tata basin, South-East of Morocco", *Applied Water Science*, **12**, 137. https://doi.org/10.1007/s13201-022-01664-w.

Fan, M. and Shibata, H., 2015, "Simulation of watershed hydrology and stream water quality under land use and climate change scenarios in Teshio River watershed, northern Japan", *Ecological Indicators*, **50**, 79-89. https://doi.org/10.1016/j.ecolind.2014.11.003.

Gassman, P. W., Reyes, M. R., Green, C. H. and Arnold, J. G., 2007, "The soil and water assessment tool: Historical development, applications and future research directions", *Transactions of the ASABE*, **50**, 4, 1211-1250.

Halefom, A., Sisay, E., Khare, D., Singh, L. and Worku, T., 2017, "Hydrological modeling of urban catchment using semi-distributed model", *Modeling Earth System and Environment*, (2017). https://doi.org/10.1007/s40808-017-0327-7.

Kumar, N., Singh, S. K., Singh, V. G. and Dzwairo, B.,2018, "Investigation of impacts of land use/land cover change on water availability of Tons River Basin, Madhya Pradesh, India", *Modeling Earth Systems and Environment*. https://doi.org/10.1007/s40808-018-0425-1.

Mengistu, A. G., van Rensburg, L. D. and Woyessa, Y. E., 2019, "Techniques for calibration and validation of SWAT model in data-scarce arid and semi-arid catchments in South Africa", *Journal of Hydrology: Regional Studies*, **25**, 100621. https://doi.org/10.1016/j.ejrh.2019.100621.

Molla, A., Abate, B. and Behonegne, Y., 2020, "Assessment of sediment inflow in Dire Dam Reservoir using SWAT model, Dire Catchment, Ethiopia", *Control Science and Engineering*, **4**, 2, 16-31.

Moriasi, D.N., Arnold, J.G., Van Liew, M.W., Bingner, R.L., Harmel, T.L. and Veith, T.L.,2007, "Model evaluation guidelines for systematic quantification of accuracy in watershed simulations", *Transactions of the ASABE*, **50**, 3, 885-900. doi:10.13031/2013.23153.

Morris, G. L. and Fan, J., 1998, Reservoir sedimentation handbook.McGraw-Hill.

Munoth, P. and Goyal, R., 2019, "Impacts of land use land cover change on runoff and sediment yield of Upper Tapi River Sub Basin, India", *International Journal of River Basin Management*, **18**, 2, 177-189. https://doi.org/10.1080/15715124.2019.1613413.

Munoth, P. andGoyal, R., 2020, "Hydromorphological analysis of Upper Tapi River Sub-basin, India, using QSWAT model", *Modeling* Earth Systems and Environment, **6**, 4, 2111-2127. https://doi.org/10.1007/s40808-020-00821-x.

Neitsch, S.L., Arnold, J.G., Kiniry, J.R. and Williams, J.R., 2005, "Soil and water assessment tool theoretical documentation, version 2005. Temple, TX - Grassland, Soil and Water Research Laboratory", Agricultural Research Service, and Texas A & M Blackl and Research Center (2005).

Samimi, M., Mirchi, A., Moriasi, D.,Ahn, S., Alian, S., Taghvaeian and S., Sheng, Z., 2020, "Modelling arid/semi-arid irrigated agricultural watersheds with SWAT: Applications, challenges, and solution strategies", *Journal of Hydrology*, **590**, 125418 (2020).https://doi.org/10.1016/j.jhydrol.2020.125418.

Setegn, S. G., Rayner, D., Dargahi, B. andSrinivasan, R., 2010, "Hydrological modelling in the Lake Tana Basin, Ethiopia, using SWAT model", *The Open Hydrology Journal*, **4**, 1.

Zhang, S., Liu, Y. and Wang, T., 2014, "How land use change contributes to reducing soil erosion in the Jialing River Basin, China", *Agricultural Water Management*, **133**, 65-73.