

Hydrological Modelling of Karanja Reservoir by Using HEC-HMS Model

Shushma¹, Akshata A Shah², S K Ingankal³, Dr. Doddappa Appa Patil⁴

P.G Student, Department of Civil Engineering [Environmental Engineering] P.D.A. College of Engineering,
Kalaburagi, India¹

Asst. Professor, Department of Civil Engineering [Environmental Engineering] P.D.A. College of Engineering,
Kalaburagi, India²

Asst. Professor, Department of Civil Engineering [Environmental Engineering] P.D.A. College of Engineering,
Kalaburagi, India³

Asst. Professor, Department of Civil Engineering [Environmental Engineering] P.D.A. College of Engineering,
Kalaburagi, India⁴

ABSTRACT: This study presents the hydrological modelling of the Karanja Reservoir watershed in Karnataka, India, using the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) integrated with QGIS. Spatial data including a 30 m SRTM Digital Elevation Model (DEM) were used for watershed delineation and drainage network extraction. Historical rainfall and temperature data from 1995–2025 were obtained from NASA POWER, while future climate projections for 2026–2056 were collected from the Copernicus Climate Data Store (CDS). The HEC-HMS model was developed using the SCS Curve Number method for loss estimation and the SCS Unit Hydrograph method for runoff transformation. The study demonstrates the capability of HEC-HMS in simulating watershed hydrological responses and assessing future runoff behavior under changing climatic conditions. The findings can support sustainable reservoir operation, flood management, and water resources planning in the Karanja Reservoir basin.

KEYWORDS: HEC-HMS, Hydrological Modelling, Karanja Reservoir, Rainfall–Runoff Simulation, Watershed Management, Climate Change, QGIS, Runoff Analysis.

I. INTRODUCTION

Hydrological modelling is an effective tool for understanding watershed behavior and simulating rainfall–runoff processes. It plays a vital role in water resources planning, flood forecasting, reservoir operation, and climate change assessment. The Karanja Reservoir watershed in Karnataka is an important water resource system that supports irrigation, drinking water supply, and regional development.

In this study, QGIS and HEC-HMS were integrated to develop a hydrological model of the Karanja Reservoir watershed. Spatial data derived from a 30 m SRTM Digital Elevation Model (DEM) were used for watershed delineation and drainage network extraction. Historical rainfall and temperature data (1995–2025) obtained from NASA POWER and future climate projections (2026–2056) from the Copernicus Climate Data Store were utilized to simulate watershed runoff responses. The study aims to evaluate historical and future hydrological conditions and support sustainable water resources management in the basin.

II. STUDY AREA

The Karanja Reservoir is located in Bidar district, Karnataka, India, and is constructed across the Karanja River, a tributary of the Godavari River basin. The reservoir serves as an important source of irrigation, drinking water supply, and flood moderation for the surrounding region. The watershed covers an area of approximately 652.3 km² and is

characterized by undulating terrain, black cotton soils, and predominantly agricultural land use. Due to its significance in regional water resource management, the Karanja Reservoir watershed was selected for hydrological modelling and runoff analysis using HEC-HMS.

III. OBJECTIVE

1. To delineate the Karanja Reservoir watershed using DEM data in QGIS.
2. To develop a rainfall–runoff model of the watershed using HEC-HMS.
3. To simulate historical hydrological conditions using rainfall and temperature data from 1995–2025.
4. To assess future runoff behavior under projected climate conditions for the period 2026–2056.
5. To evaluate the impact of climate variability on streamflow and water resource availability in the Karanja Reservoir basin.

IV. METHODOLOGY

1. DATA COLLECTION:

For the present study of the Karanja Reservoir watershed, historical rainfall and temperature data from **1995 to 2025** were collected from the NASA POWER Data Access Viewer developed by the National Aeronautics and Space Administration. NASA POWER provides freely accessible meteorological and climatological datasets derived from satellite observations, reanalysis products, and global climate datasets. The database offers daily, monthly, and annual records of precipitation and temperature, which are widely used in hydrological and climate studies. To assess future hydrological conditions, projected rainfall and temperature data for the period **2026 to 2056** were obtained from the Copernicus Climate Data Store (CDS). The CDS provides climate projection datasets based on CMIP6 global climate models under different future climate scenarios. These datasets are used to evaluate the potential impacts of climate change on rainfall patterns, temperature variations, runoff generation, and water resource availability within the watershed. The collected historical and future climate data were processed and prepared for hydrological modelling in HEC-HMS. These datasets serve as essential inputs for runoff simulation, calibration, validation, and future water resource assessment of the Karanja Reservoir basin.

The Digital Elevation Model (DEM) data used in this study was obtained from the USGS EarthExplorer, which is a widely used platform developed by the United States Geological Survey (USGS) for accessing geospatial and remote sensing datasets. The DEM dataset selected for the Karanja Reservoir watershed was the **SRTM 30 m (Shuttle Radar Topography Mission)** data, which provides elevation information with a spatial resolution of 30 meters. DEM data plays an important role in hydrological modelling using HEC-HMS and QGIS. The elevation data was used to delineate the watershed boundary, identify drainage patterns, generate stream networks, calculate flow direction and flow accumulation, and determine terrain characteristics such as slope and basin area. These parameters are essential for understanding the hydrological behavior of the watershed and for accurate runoff simulation. The SRTM 30 m DEM provides reliable topographic information for large-scale watershed studies and is commonly used in hydrological and GIS-based analyses. The downloaded DEM data was preprocessed in QGIS to remove errors and prepare it for integration into the HEC-HMS model for runoff and streamflow analysis of the Karanja Reservoir basin.

2. QGIS PREPROCESSING:

The preprocessing of spatial data for the Karanja Reservoir watershed was carried out using QGIS. The Digital Elevation Model (DEM) obtained from the SRTM 30 m dataset was first imported into QGIS for terrain and watershed analysis. The projection system of the DEM was converted to **WGS 84 / UTM Zone 43N (EPSG:32643)** to ensure accurate spatial analysis and measurement of area, distance, and drainage characteristics within the study area. After projection, the DEM was processed using hydrological tools available in QGIS and GRASS GIS. The **Fill Sink** operation was performed to remove depressions and errors present in the DEM surface, which improves water flow continuity. The **r.watershed** tool was then used to generate flow direction, flow accumulation, drainage basin boundaries, and stream networks based on terrain elevation. This process helps in identifying the natural movement of water within the watershed. Using the flow accumulation results, the **channel network** and drainage pattern of the watershed were extracted. The drainage basin and stream network outputs were further refined and converted into vector layers for hydrological modelling in HEC-HMS. These preprocessing steps are essential for accurate watershed delineation and runoff simulation.

3. HEC HMS MODEL SETUP:

In this study, the HEC-HMS model setup for the Karanja Reservoir watershed was carried out using spatial and hydrological data prepared in QGIS. The watershed boundary, drainage network, stream lengths, slope, and sub-basin parameters were generated from the Digital Elevation Model (DEM) using hydrological preprocessing tools such as sink filling, flow direction, flow accumulation, and watershed delineation. The delineated basin was imported into HEC-HMS through qgis created. The meteorological model was developed using daily rainfall data and temperature collected from 1995 to 2025. Loss, transform, baseflow, and routing methods were selected based on watershed characteristics. Commonly used methods include the SCS Curve Number method for infiltration loss and the SCS Unit Hydrograph method for runoff transformation.

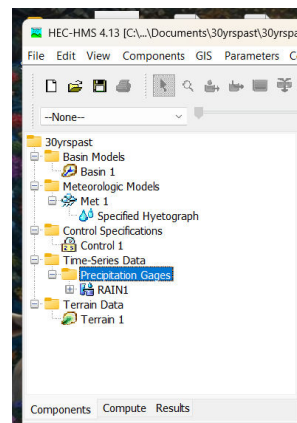


Fig.no.1:-Model Setup For past data

The future simulation of the Karanja Reservoir watershed using the HEC-HMS model was carried out for the period from 2025 to 2026 using projected rainfall and hydrological parameters. The Basin Model, Meteorological Model, Loss Method, and Time Series Data were updated to analyze future runoff behavior and watershed response. Future rainfall data were applied in the meteorological model to estimate runoff generation under changing climatic conditions. The SCS Curve Number loss method was used to estimate infiltration and excess rainfall for future scenarios.

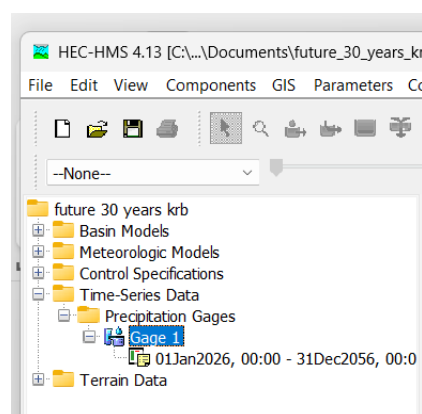


Fig.no.2:- Model Setup for future data

4. RUN SIMULATION:

The historical hydrological simulation of the Karanja Reservoir watershed was performed in HEC-HMS using daily rainfall, temperature, and discharge data for the period 1995–2025. The basin model, meteorological model, and control specifications were configured using watershed parameters derived from QGIS. The simulation was executed to estimate runoff generation and streamflow characteristics within the watershed. Results indicated that the watershed experienced a maximum peak discharge of 843.7 m³/s on 4 August 2006. The total runoff volume generated during the

simulation period was 48,084.81 mm. The hydrographs revealed seasonal variations in streamflow with significant peaks during monsoon periods, demonstrating the influence of rainfall intensity on runoff generation within the basin.

Table.no.1:-Summary of HEC-HMS simulation results of historical period

Global Summary Results for Run "Run 1"

Project: 30yrspast Simulation Run: Run 1

Start of Run: 01Jan1995, 00:00 Basin Model: Basin 1
 End of Run: 31Dec2025, 00:00 Meteorologic Model: Met 1
 Compute Time: DATA CHANGED, RECOMPUTE Control Specifications: Control 1

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Watershed Explorer

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
S1	652.3	843.7	4 August 2006, 07:00	48084.78
Reach-1	652.3	843.7	4 August 2006, 08:00	48084.81
Junction-1	652.3	843.7	4 August 2006, 08:00	48084.81
Sink-1	652.3	843.7	4 August 2006, 08:00	48084.81

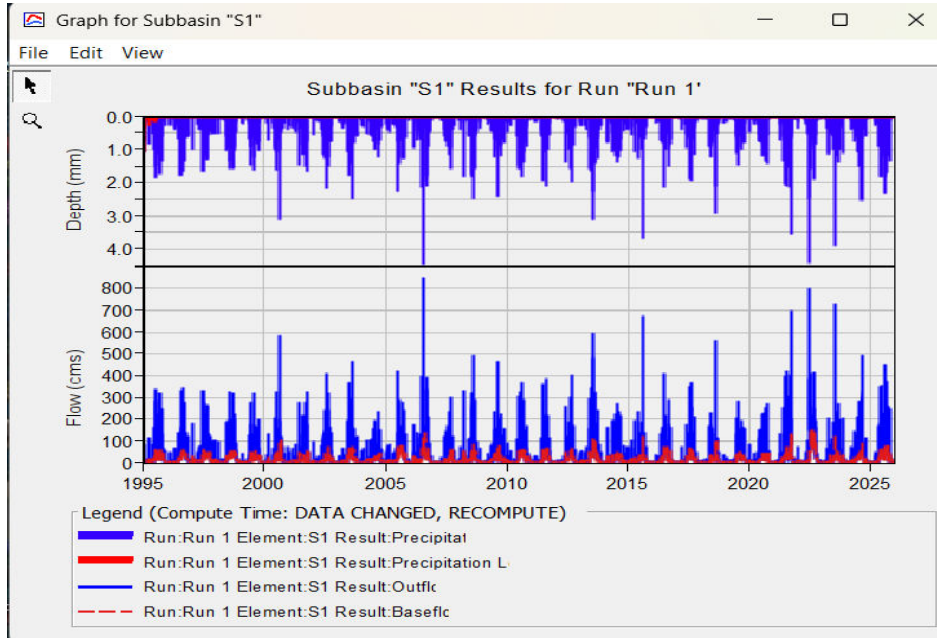


Fig.no.3:-Simulated runoff hydrograph of Sub-basin S1 for the historical period

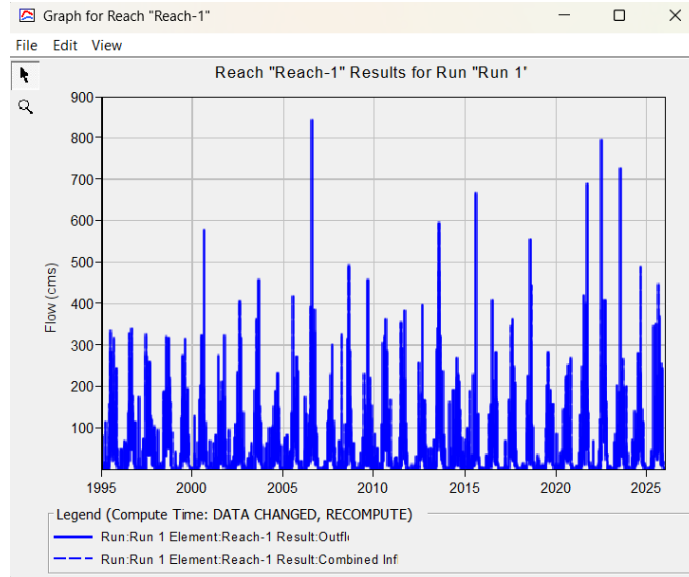
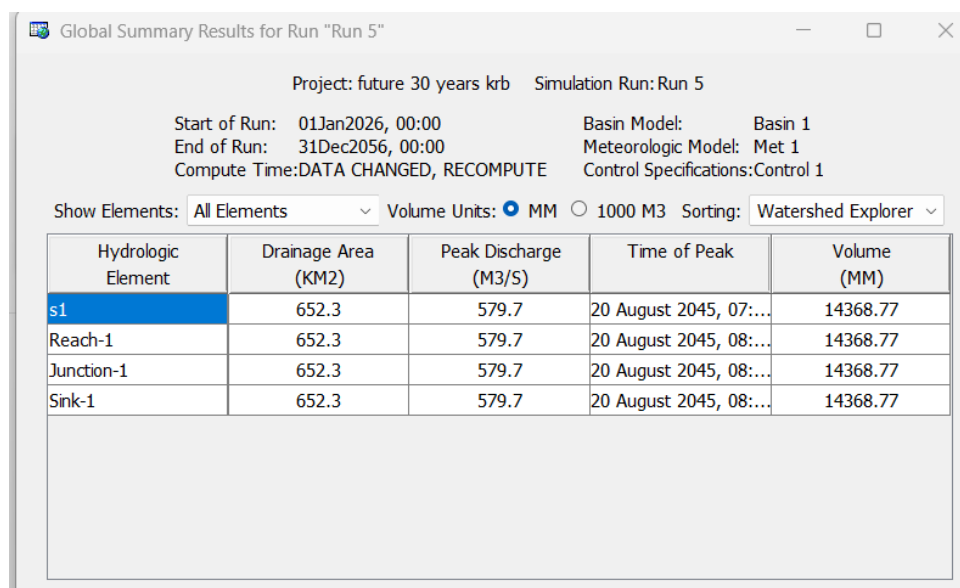


Fig.no.4:- Simulated discharge hydrograph of Reach-1 for the historical period

Future hydrological simulation was carried out for the period 2026–2056 using projected rainfall and temperature data obtained from climate model projections. The future climate dataset was incorporated into the meteorological model of HEC-HMS while maintaining watershed physical characteristics. The simulation predicted future runoff behavior and watershed response under changing climatic conditions. The results showed a peak discharge of 579.7 m³/s occurring on 20 August 2045 and a total runoff volume of 14,368.77 mm. The hydrographs indicated the occurrence of high-flow events during future monsoon seasons, highlighting the potential impacts of climate variability on runoff generation and water availability in the Karanja Reservoir watershed.

Table.no.2:- Summary of HEC-HMS simulation results of future period



Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
s1	652.3	579.7	20 August 2045, 07:...	14368.77
Reach-1	652.3	579.7	20 August 2045, 08:...	14368.77
Junction-1	652.3	579.7	20 August 2045, 08:...	14368.77
Sink-1	652.3	579.7	20 August 2045, 08:...	14368.77

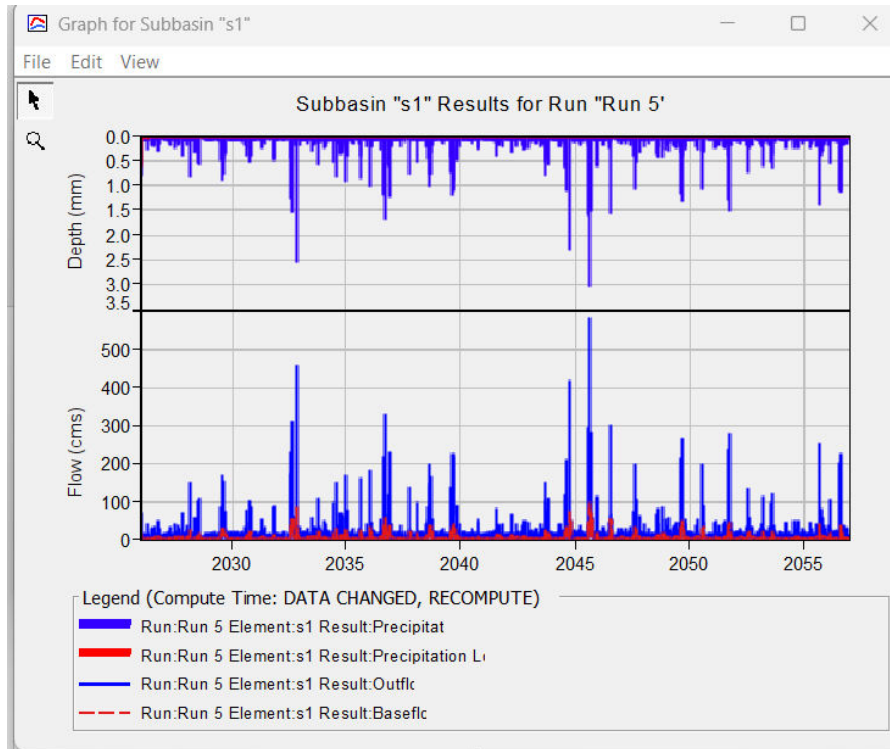


Fig.no.5:- Simulated runoff hydrograph of Sub-basin S1 for the future period

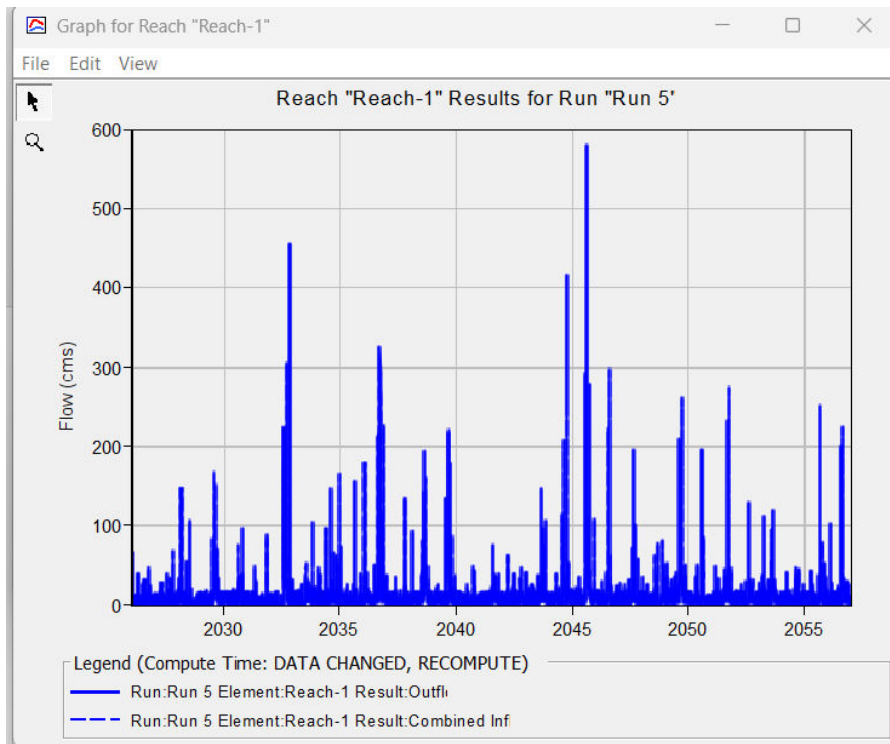


Fig.no.6:- Simulated discharge hydrograph of Reach-1 for the future period

V. RESULT

The HEC-HMS simulation showed a peak discharge of **843.7 m³/s** during the historical period (1995–2025) and **579.7 m³/s** during the future period (2026–2056). The results indicate changes in runoff generation and streamflow patterns under future climatic conditions

VI. CONCLUSION

The present study demonstrated the applicability of HEC-HMS integrated with QGIS for hydrological modelling of the Karanja Reservoir watershed. The model effectively simulated rainfall-runoff processes and provided valuable information on streamflow behavior under both historical and future climatic conditions. Historical simulation identified a peak discharge of 843.7 m³/s, while future simulation projected a peak discharge of 579.7 m³/s. The results indicate that climate variability may influence future runoff patterns and water availability within the watershed. Therefore, proper reservoir operation, flood management strategies, and sustainable water resource planning are essential for adapting to future hydrological changes. The study confirms that HEC-HMS is a reliable tool for watershed analysis, runoff prediction, and climate change impact assessment in river basin management.

REFERENCES

1. U. Senatilleke et al.,(2025) “Modelling Capabilities of Two Physically Based Hydrologic Models for Streamflow Simulations,” *International Journal of Environmental Science and Development*, vol. 16, no. 2, pp. 103–110, 2025.
2. Razalee, N. I. H. M., & Hamidon, N. (2024). *Flood Warning Prediction Using HEC-HMS Software and GIS at Panchor Area*.
3. Vaddiraju, P., & Reshma, T. (2024). Geospatial and hydrological modeling of urban watershed runoff using HEC-HMS in Telangana, India. *International Journal of Hydrology Science and Technology*, 15(2), 101–118.
4. Sharma, P., Singh, R., & Kumar, V. (2023). Rainfall–runoff simulation using HEC-HMS in a semi-arid watershed of India. *Hydrological Sciences Journal*, 68(4), 521–536.
5. Ranjan, R., Kumar, A., Singh, V. P., & Mishra, S. K. (2022). HEC-HMS based rainfall–runoff modeling for Punpun River Basin, Bihar, India. *Water Practice and Technology*, 17(5), 986–1001.
6. Verma, A. K., Sharif, M., & Husain, I. (2022). Hydrological modeling of Upper Sabarmati River Basin using GIS integrated HEC-HMS. *Journal of Water and Climate Change*, 13(8), 2950–2965.
7. Mahadeva Prasad, A. C., Patil, R. H., Sumesh, K. G., & Bhat, J. (2022). *Historical and Projected Rainfall Analysis for North Interior Karnataka, India*. *Journal of Farm Sciences*, 35(4), 491–497.
8. Rajput, A., Rawat, U., Yadav, A., Pawar, P. S., & Vasht, D. (2021). *Hydrological Modelling of Banjar River Watershed using HEC-HMS*. *Chemical Science Review and Letters*.
9. Sahu, R. K., Khare, D., Mondal, A., & Srivastava, P. K. (2020). Hydrological response assessment of Shipra River Basin under land use and land cover change using HEC-HMS model. *Environmental Earth Sciences*, 79(3), 1–15.
10. Shaikh, N., Yadav, S. M., & Yadav, R. (2018). Simulation of rainfall–runoff event using HEC-HMS model for Rel Sub-basin, Gujarat, India. *International Journal of Advanced Engineering Research and Science*, 5(6), 145–151.
11. Patel, D. P., Srivastava, P. K., & Verma, P. K. (2015). Application of HEC-HMS for flood forecasting in Indian river basins using geospatial techniques. *Arabian Journal of Geosciences*, 8, 5709–5721.
12. Rathod, P. R., Khadse, G. K., Pagdhune, A. D., & Bhandari, M. M. (2015). Rainfall–runoff modeling using HEC-HMS for Tapi River Basin, Maharashtra, India. *International Journal of Engineering Research and Technology*, 4(5), 234–239.



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