IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 4, April 2024

DOI: 10.17148/IARJSET.2024.11446

"COMPARISON OF TWO RAINFALL-RUNOFF MODELS FOR STREAMFLOW PREDICATION IN A SEMI–ARID REGION: A CASE OF HIRAN RIVER BASIN"

Bhumika R. Mulasiya[1], Dr.V.R.Patel[2], Dr.N.K.Trambadia[3]

PG Student, Department of Civil Engineering, Lukhdhirji Engineering Collage, Morbi, India[1]

Asso.Professor and Head of Department, Department of Civil Engineering, Lukhdhirji Engineering Collage, Morbi, India[2]

Lecturer In Civil Engineering Department, Department of Civil Engineering, Sir Bhavsinhji Polytechnic Institute Bhavnagar, India[3]

Abstract: This paper describes a study carried out to estimate runoff for different rainfall events in 8 sub basin of Hiran river (Gujarat). This research emphasizes the western part of Gujarat for runoff prediction techniques. The Hiran River originates from the Gir forest, moves towards the river mouth, and meets the Arabian Sea near Somnath. The two hydrological models, HEC-HMS and IHACRES, have been simulated for runoff generation in this research. In addition, input parameters like rainfall, temperature, curve number, and DEM are utilized for modeling purposes. The discharges of both models are compared with the observed data acquired from the state water data center. In this regard, various statistics are calculated, like the coefficient of determination (R^2).This research enlightens the hydrological modeling for the ungauged river basins. The results help the global community decide to establish the new hydraulic structure, crop pattern, and hydrological monitoring.

Keywords: HEC-HMS, IHACRES, Rainfall-Runoff model, Co-efficient of determination.

I. INTRODUCTION

The hydrologic cycle, also known as the water cycle, involves the continuous movement of water through the earth's seas, atmosphere, and land. Water exists in three states: liquid, solid, and gas. Oceans make up most of the earth's water volume, with the rest found in ice caps, glaciers, groundwater, rivers, lakes, soils, and the atmosphere.

Evaporation and precipitation are key processes in the water cycle, where water evaporates from the earth's surface and returns as precipitation. Water can evaporate from land, seas, and plants, circulating through the atmosphere for about eleven days. Rainfall can then infiltrate the soil, recharge groundwater, flow into rivers and lakes, or evaporate again. Water spends varying lengths of time in rivers and lakes before eventually reaching deep groundwater or oceans.

Water, despite being a small portion of the earth's total supply, plays a vital role in sustaining ecosystems. Global patterns of precipitation and evaporation affect habitats like deserts and rainforests. Water transports minerals and pollutants across the landscape and influences global energy, carbon, and nitrogen cycles, essential for earth's ecology.

Surface stream discharge, or runoff, is water flowing across the ground surface and through channels to reach a stream. It includes interflow, where water infiltrates soil and moves towards a stream. Runoff also includes groundwater emptying into a watercourse. Base flow is fair-weather runoff made of groundwater at a stream channel's confluence with the water table.

Precipitation models are essential for decision-making in uncertain conditions. They represent watershed features and simulate hydrological processes. These mathematical models link inputs, factors, and properties to provide a better understanding of the hydrologic cycle.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁑ Peer-reviewed & Refereed journal ⁑ Vol. 11, Issue 4, April 2024

DOI: 10.17148/IARJSET.2024.11446

II. STUDY AREA

The Hiran River is located in Gujarat's Saurashtra region, namely the Gir-Somnath district. The river travels mostly through Gir's wooded sections, which are classified as semi-arid in this district. The surrounding land is predominantly used for cultivation. The geographic coordinates of Hiran River range between north and east. Its course concludes as it meets the Arabian Sea near Unava Bandar.

The Hiran River, situated in the western part of Gujarat's Saurashtra region, originates near the sasa hills in the Gir forest. This significant river, which spans 40 kilometres and has a catchment area of 518 kilometres, sustains varied wildlife ecosystems as well as human settlements. Notable dams, Hiran I and Hiran II, along its route contribute to water management. Major tributaries, including the Sarashwati River and Ambakhoi stream, converge near Talala Town. Kamleshwar Dam (Hiran I) and Umrethi Dam are key projects harnessing the River's flow. As it flows from the Gir Forest, the Hiran River significantly sustains the ecological balance and biodiversity of the region throughout the year.

The river originates from the Kansa hills of Gir, serving as the primary water source of the western Gir. Confluencing with the Sarashwati and Kapila rivers in Prabhashpatan, it eventually empties into the Arabian Sea.

The delineation of the Hiran watershed catchment was performed using AutoCAD. A GDS is located along the river near Sasan town, approximately 10km away from the Kamleshwar Dam site. The latitude of the sub basin is 70^0 32'30''E and its departure is 21^0 6'0''N.

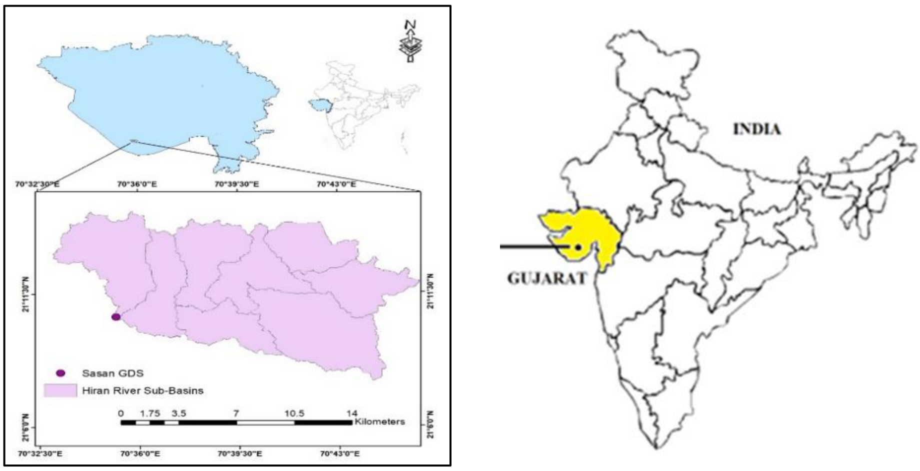

Fig: 1 Catchment of Hiran I River

III. DATA COLLECTION

Rainfall, Temperature and stream flow data:

The precipitation records, daily temperature data, and river gauge station information for the Hiran I river were obtained from the State Water Data Center (SWDC).

Catchment map:

The map of the Hiran catchment area was obtained from the irrigation divisional office in Junagadh, and subsequently, it was delineated in AutoCAD to encompass the necessary geographical details for the specified region.

Type Of Data	Details	Source Of Data	Use In Study
Digital Elevation Model	30m SRTM	USGS earth explorer	Terrain file creation

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 11, Issue 4, April 2024

DOI: 10.17148/IARJSET.2024.11446

Rainfall	5566m Grid	CHIRPS (Climate Hazard Group Infrared Precipitation with Station Data)	Input parameter of HEC – HMS
Curve Number	250m Spatial resolution	Global Curve Number	Input parameter of HEC – HMS
Runoff	2017 to 2021 Daily	SWDC	Comparative Analysis

Table 1 Data collection

IV. METHODOLOGY

(A)HEC-HMS: HEC-HMS is a hydrological modeling system that accurately replicates complex processes in watershed systems. It includes traditional tools like event intrusion and unit hydrographs, as well as continuous modeling techniques for evaporation and snowmelt. Advanced features like network flow simulation and model optimization make it a comprehensive tool for hydrological analysis.

HEC-HMS is known for its integrated work environment which includes a database, data entry utilities, computation engine, and results reporting capabilities. It has a user-friendly interface allowing easy navigation between components. Simulation results are saved in HEC-DSS for use in various water-related studies and investigations.

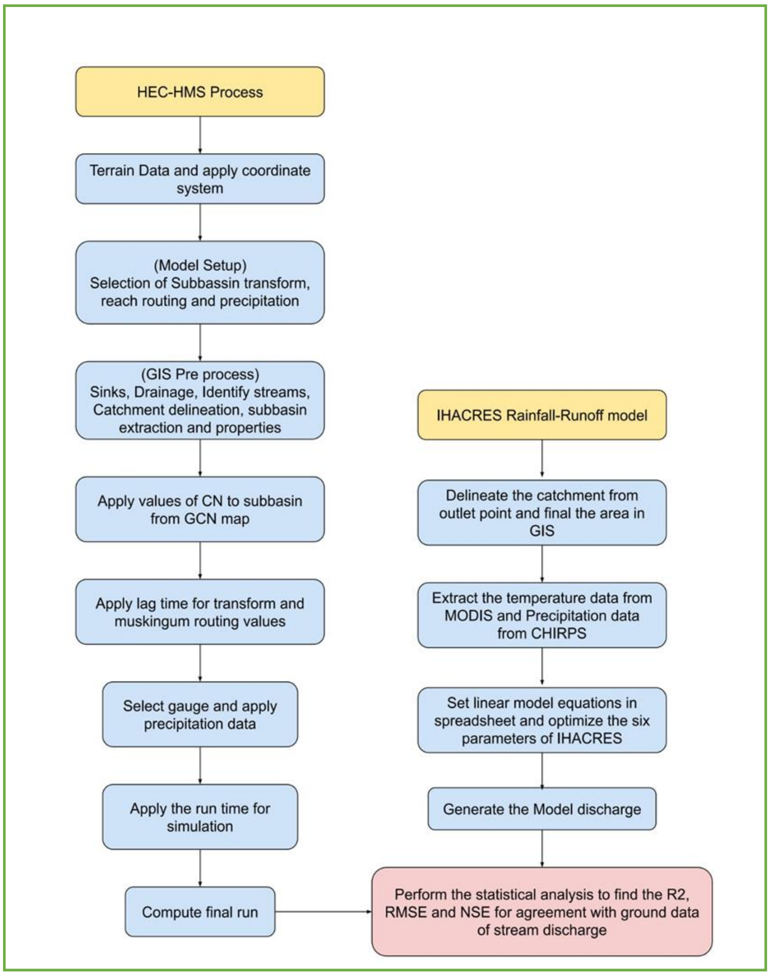

Fig: 2 flowchart of Methodology

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 11, Issue 4, April 2024

DOI: 10.17148/IARJSET.2024.11446

HEC-HMS is a superior hydrological model due to its comprehensive approaches for simulating watershed dynamics, forecasting flow and stage in hydrologic systems, and providing a detailed description of hydrological processes. It is suitable for various water resource and environmental applications, and has been tested for compliance with observed stream flow-data.

HEC-HMS offers various loss algorithms like SCS-CN for event-based modelling and Soil Moisture Accounting for continuous modelling. It assists in selecting suitable hydrological models and supports water resource management and sustainable development.

(B)IHACRES: IHACRES is a tool for modeling rainfall-stream flow interactions at catchment scale. It uses rainfall and temperature data to anticipate stream flow patterns on different scales. It can be used to fill data gaps, extend stream flow records, and study the impacts of climate change and land use changes. IHACRES helps in understanding hydrological processes and predicting stream flow dynamics.

V RESULT AND DISCUSSION

Analysis of meteorological data of the Hiran River Basin for the periods of 2017 to 2021 differs during during this period. Estimation of Runoff was done using HEC-HMS model and IHACRES model and correlated with the Rainfall data. The discharge hydrograph obtained using two Rainfall-Runoff models for stream flow predication. Simulation and observations of discharge data are critical for understanding and managing water resources.

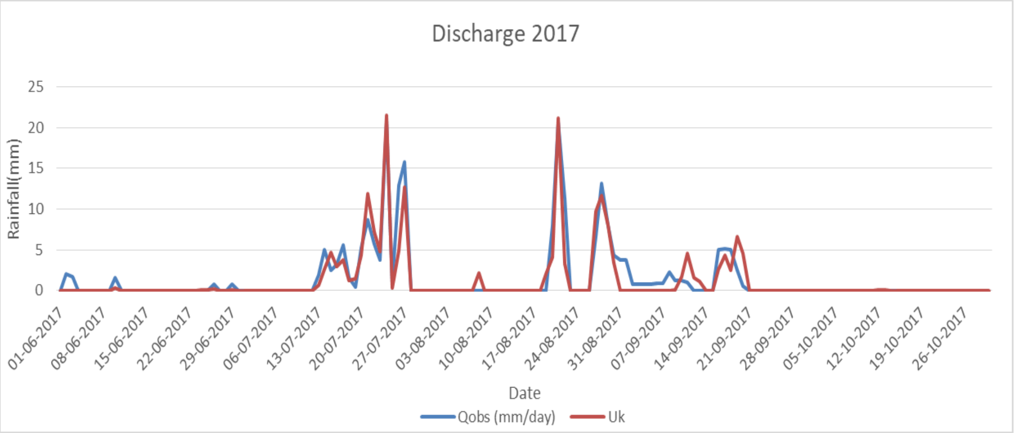

Fig: 3 Discharge Hydrograph of 2017 (IHACRES Model)

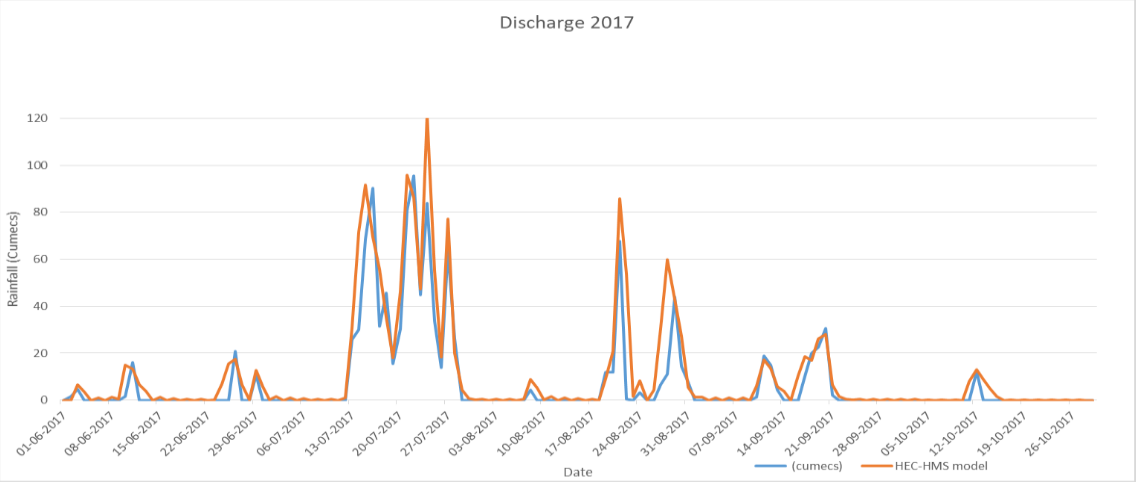

Fig: 4 Discharge Hydrograph of 2017 (HEC-HMS Model)

DOI: 10.17148/IARJSET.2024.11446

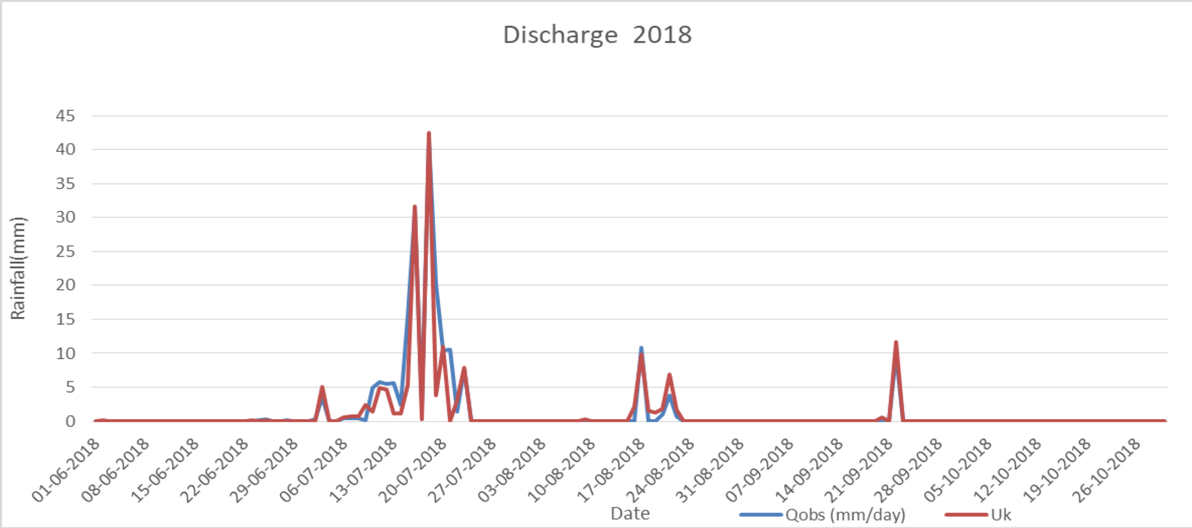

Fig: 5 Discharge Hydrograph of 2018 (IHACRES Model)

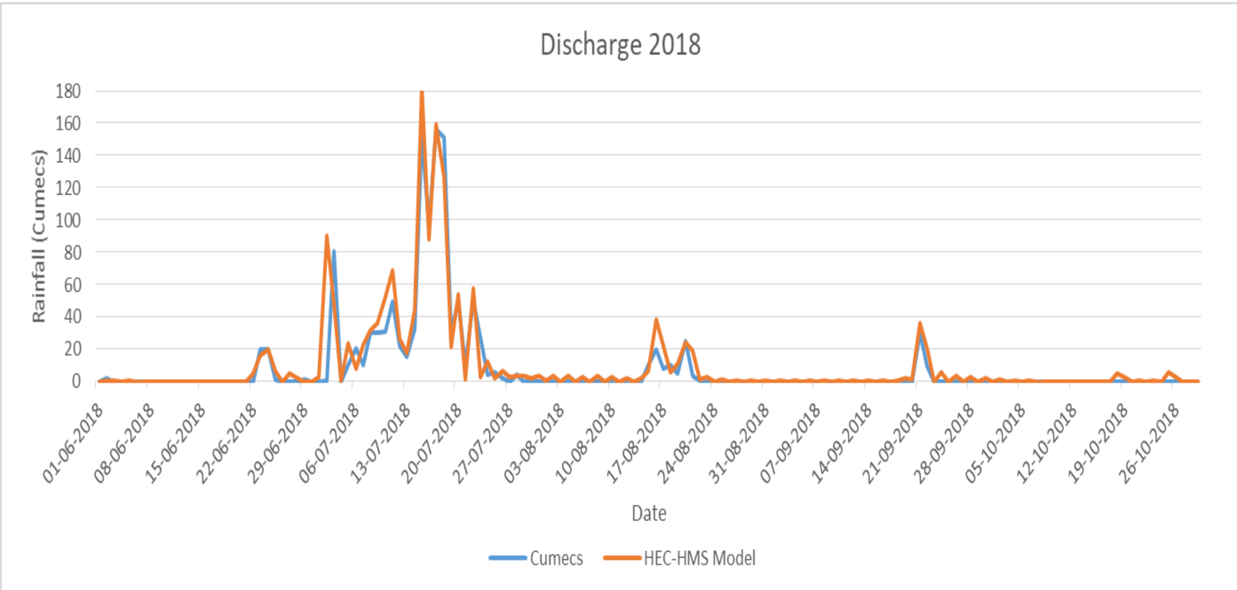

Fig: 6 Discharge Hydrograph of 2018 (HEC-HMS Model)

IARJSET
ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 11, Issue 4, April 2024
DOI: 10.17148/IARJSET.2024.11446

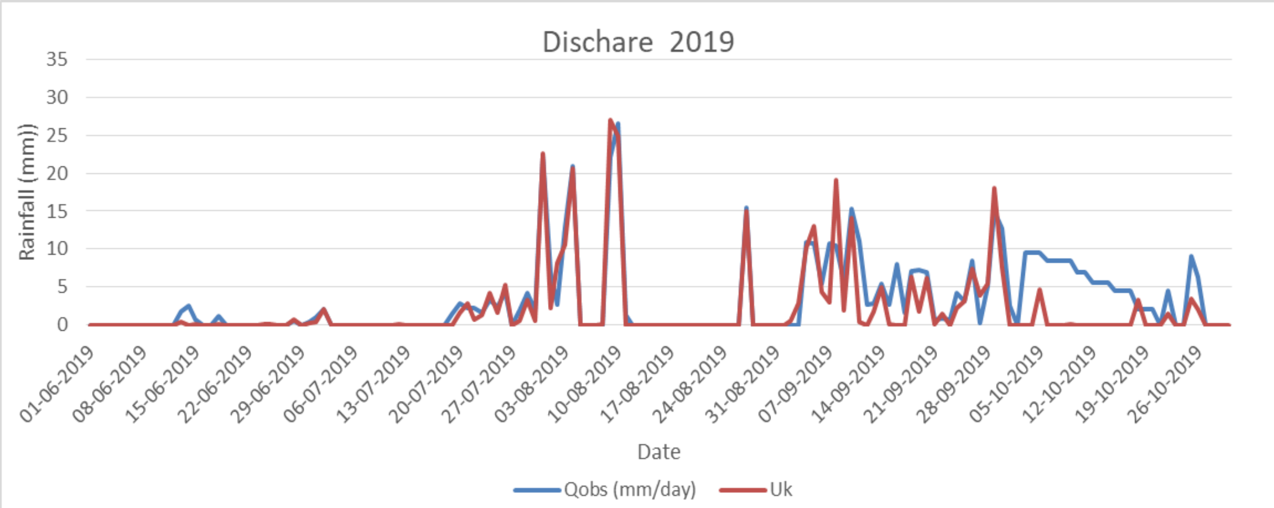

Fig: 7 Discharge Hydrograph of 2019 (IHACRES)

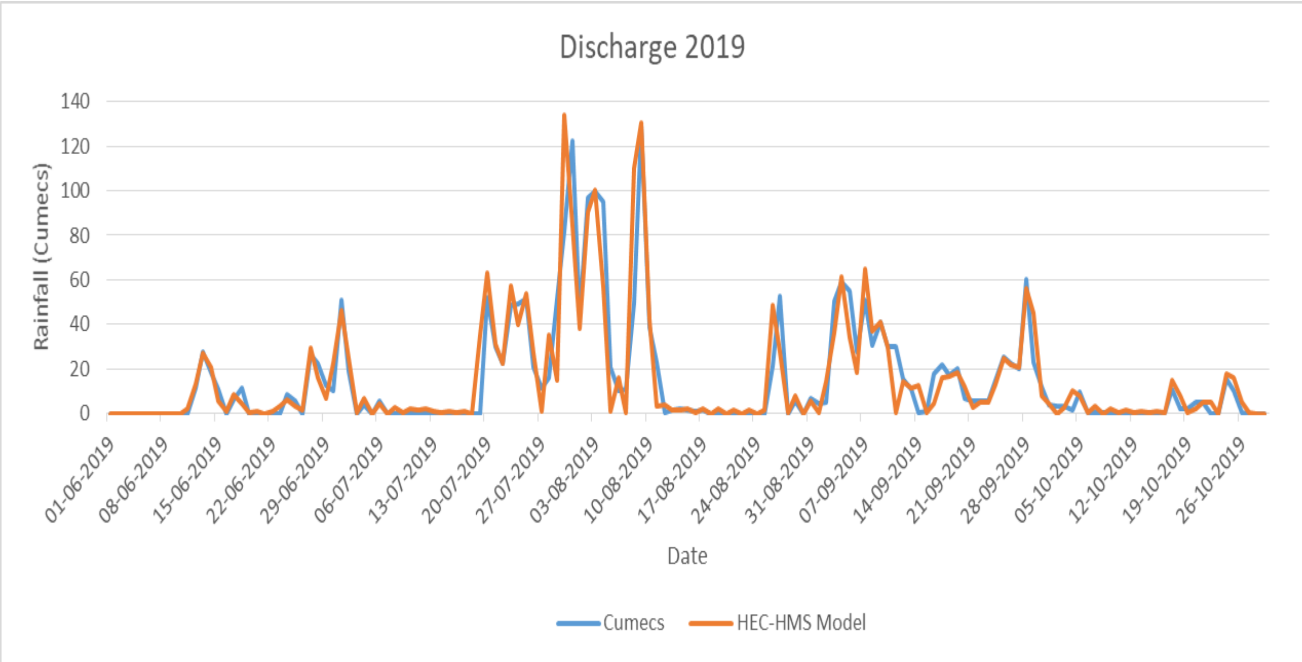

Fig: 8 Discharge Hydrograph of 2019 (HEC-HMS)

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 4, April 2024

DOI: 10.17148/IARJSET.2024.11446

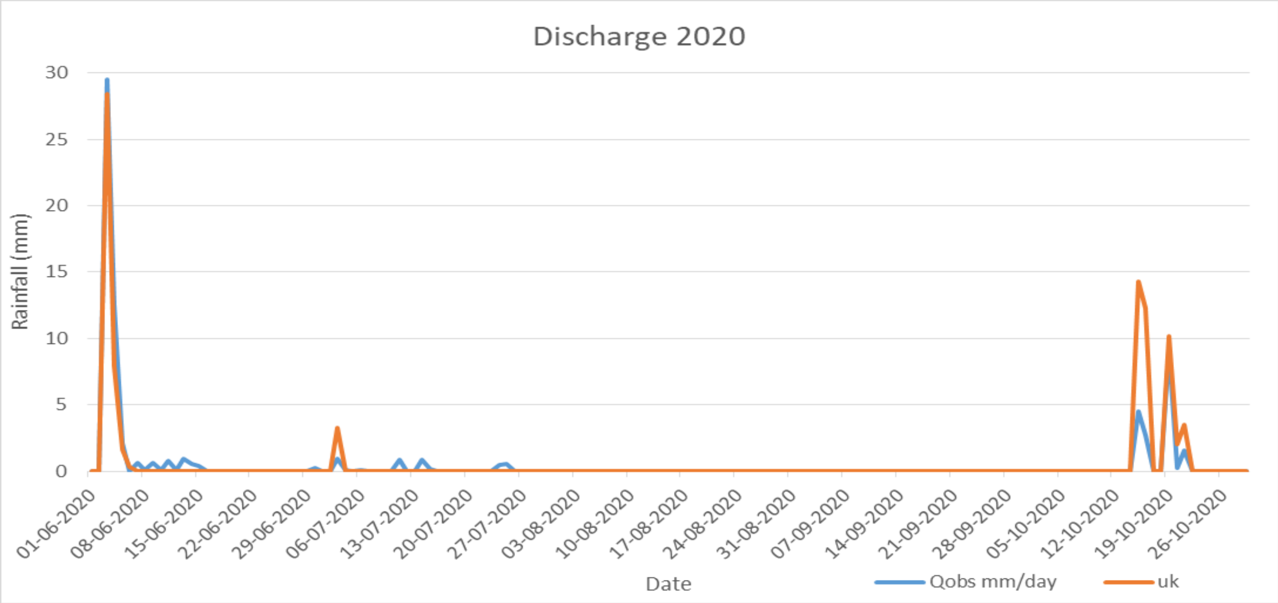

Fig: 9 Discharge Hydrograph of 2020 (IHACRES)

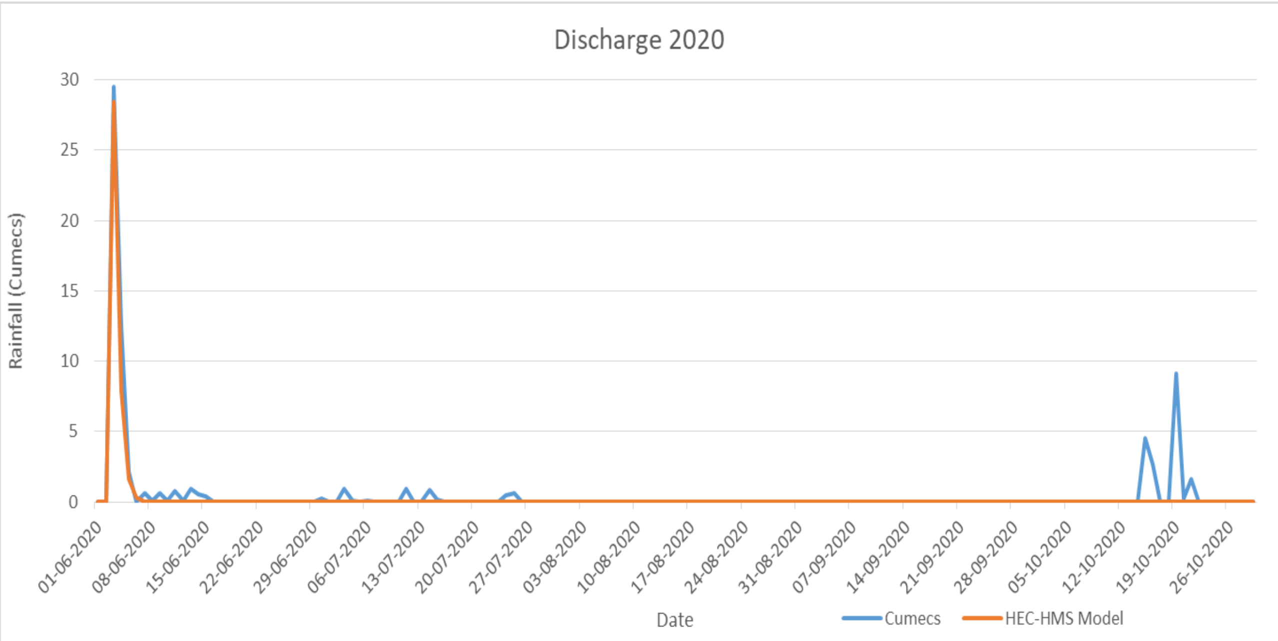

Fig:10 Discharge Hydrograph of 2020 (HEC-HMS)

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 4, April 2024

DOI: 10.17148/IARJSET.2024.11446

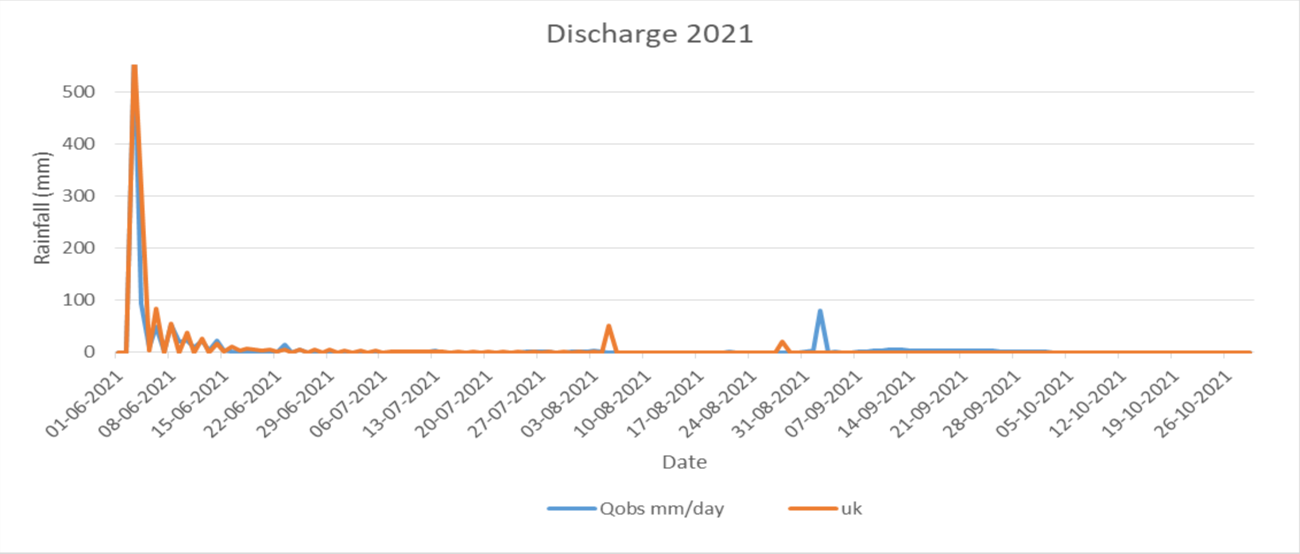

Fig: 11 Discharge Hydrograph of 2021 (IHACRES)

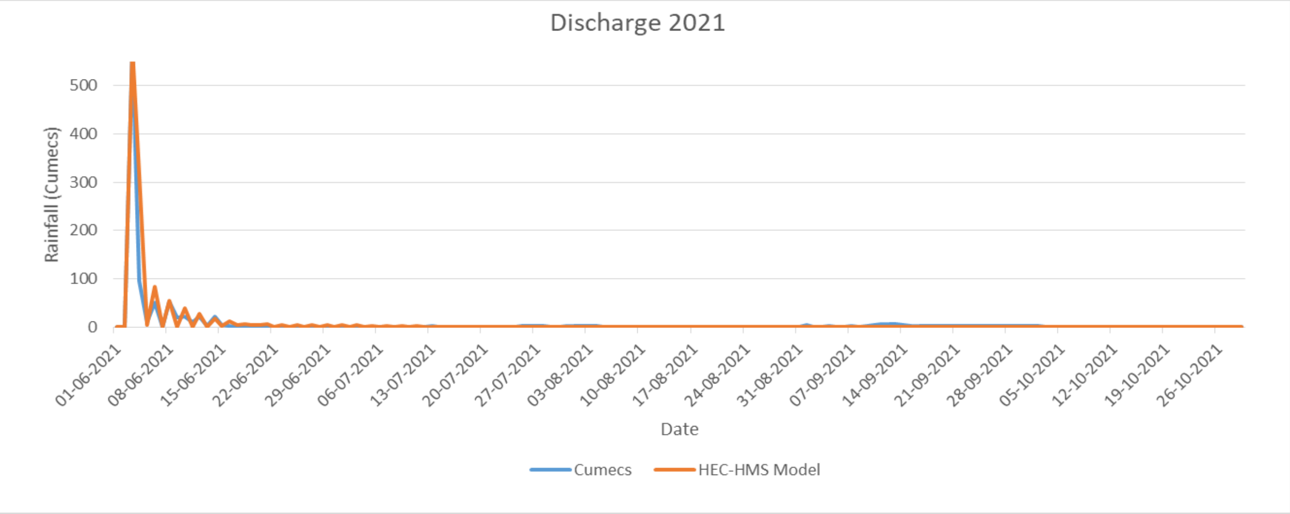

Fig:12 Discharge Hydrograph of 2021 (HEC-HMS)

In the present study HEC-HMS model and IHACRES model has been used for the predication of annual runoff based on the yearly rainfall data of the Hiran River basin for the period 2017-2021. A regression analysis was utilized for runoff predication, aiding in flood frequency estimation within the catchment.

As per above figure show the comparison of both models when using produces similar results obtained.

The given table is comparison of two rainfall runoff modeling use and obtained value of coefficient of determination (R^2)

DOI: 10.17148/IARJSET.2024.11446

Sr. No	Year	Model	
		IHACRES (R^2)	HEC-HMS (R^2)
1	2017	0.829	0.843
2	2018	0.850	0.865
3	2019	0.706	0.808
4	2020	0.805	0.882
5	2021	0.859	0.883
Total Average		0.8098	0.8562

Compared to HEC-HMS, IHACRES usually requires fewer input data. Precipitation, temperature, and fundamental catchment parameters like area, elevation and land use are main source of information. IHACRES can be appropriate option if data availability is restricted or performing analysis for smaller catchments where comprehensive data may be hard to come by. It is perfect for basic hydrological assessments because of its efficiency & simplicity.

In general, HEC-HMS requires more extensive input data such as precipitation, temperature, humidity, wind speed, land use, soil parameters, and specific hydrological features like channel geometry and soil moisture retention curves. More flexibility and sophisticated capabilities are available with HEC-HMS if need to simulate larger or more complicated watershed and have access to a lot of data. It is appropriate for through hydrological modelling because it can support a variety of hydrological processes.

V CONCLUSION

The current research emphasis on the comparative study of rainfall-runoff modelling using the linear model parameter in HEC-HMS and IHACRES. This case study is benchmark for global researchers for selecting the open-source rainfall-runoff models

As a part of regression analysis, the coefficient of determination has been employed for the comparative study and its outcomes as 0.8562 and 0.8098 respectively for HEC-HMS and IHACRES

The HEC-HMS model simulated with the SCS-CN method, whereas the many options are available for runoff prediction. The outcomes were satisfied with the observed data set with this methodology.

In this IHACRES, the linear model has been employed for runoff generation whereas the six parameters of IHACRES directly employed from the pas studies which gives the satisfacthec-ory result with the observed dataset.

The HEC-HMS models gives the more close agreement with the ground data as compared to IHJACRES model; however, the peak flow moments does not predict by both the models precisely.

The more precision in the HEC-HMS is occurred because of simulation was software based whereas in the IHACRES the simulations was spreadsheet based.

In IHACRES model was user friendly because of the simulation does not require any installation whereas in the HEC-HMS the professional training and tutorial needs for the simulations.

REFERENCES

[1]. Croke, B. F., & Jakeman, A. J. (2007). Use of the IHACRES rainfall-runoff model in arid and semi-arid regions. Hydrological Modelling in Arid and Semi-Arid Areas, 41–48.
[2]. Darji, K., Pham, B. T., Mehmood, K., Prakash, I., & Khokhani, V. (2019). Rainfall-runoff Technologies and Innovative Research (JETIR), 6(5), 226–234. Modeling using HEC-HMS model: An application of regression Analysis. Journal of Emerging
[3]. Derdour, A., Bouanani, A., & Babahamed, K. (2018). Modelling rainfall runoff relations using HEC-HMS in a semi-arid region: Case study in Ain Sefra watershed, Ksour Mountains (SW Algeria). Journal of Water and Land Development, 36(1), 45–55.

DOI: 10.17148/IARJSET.2024.11446

[4]. Prabha, J. A., & Tapas, M. R. (2020). Event based rainfall runoff modeling using HEC-HMS. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 17(4), 41–59.

[5]. Raman, S., & Singh, V. (2022). HEC-HMS based rainfall-runoff model for Pun pun River Basin. Water Practice and Technology, 17(5), 986–1001.

[6]. Sarminingsih, A., Rezagama, A., & Ridwan. (2019). Simulation of rainfall-runoff process using HEC-HMS model for Garang watershed, Semarang, Indonesia. Journal of Physics: Conference Series, 1217(1).

[7]. Shaikh, M. P., Yadav, V. G., & Yadav, S. M. (2018). Simulation of Rainfall-Runoff Event Using HEC-HMS Model for Rel Sub-Basin, Gujarat, India. Journal of Emerging Technologies and Innovative Research (JETIR) , 5(4), 402–40

[8]. Halwatura, D., & Najim, M. M. “Application of the HEC-HMS model for runoff simulation in a tropical catchment”. Environmental Modelling & Software, 46, 155–162.

[9]. Hrissanthouh, K. K. “Application of a continuous rainfall-runoff model to the basin of Kosynthos River using the hydrological software HEC-HMS”. Issue 1, 16(1), 188–203.

[10]. Abushandi, E., & Merkel, B. “Modelling rainfall runoff relations using HEC Abushandi, E., & Merkel, B”. Modelling rainfall runoff relations using HEC-HMS and IHACRES for a single rain event in an arid region of Jordan. Water Resources Management, 27(7), 2391–2409.

