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Rainfall Runoff Modelling of Gambhir Sub-basin Using HEC-HMS

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ABSTRACT: Rainfall runoff modelling is critical for a wide range of applications, including water resource evaluation, engineering channel design, flood forecasting, population incident prediction, and more. The goal of this study is to use HEC-HMS to quantify runoff depth for the Gambhir River Subbasin in the Indore District of Madhya Pradesh. Rainfall data from three rain gauge sites was collected during a 21-year period, from 2000 to 2020. The basin model is created in ArcGIS utilising a DEM of the study area and various Arc Hydro and Hec Geo HMS tools. The Curve Number model of the Soil Conservation Service was used to anticipate rainfall losses, while the Unit Hydrograph model of the Soil Conservation Service was employed to transform excess rainfall into a direct rainfall hydrograph. The whole runoff from the sub-basin outflow to the basin's outlet was routed using the Lag model.

KEYWORDS: HEC-HMS, ArcGIS, Rainfall Runoff modelling

I. INTRODUCTION

Water is a precious natural resource that needs to be protected, managed, and controlled. Engineering methods that are implemented and improved can aid in the management of water resources. Throughout the planning and development of water resources, it is vital to measure available water resources in the river system. In India, the river gauging network is insufficient, and data is unavailable. Rainfall is converted to runoff in these circumstances by creating a relationship between rainfall and runoff or by using a suitable rainfall runoff model. When precipitation is given as an input, a rainfall runoff model generates the surface runoff hydrograph (Das, 2012). Rainfall runoff modelling is important for a variety of practical issues, including water resource evaluation, engineering channel design, flood forecasting, and population incident prediction, among others. Most places have rainfall data, but discharge or runoff data is either unavailable or incomplete. Rainfall runoff modelling uses rainfall and catchment characteristics to anticipate long-term runoff (Chander S, 2014). Researchers have spent a long time trying to create and assess several rainfall runoff models in order to identify one that is suitable for the river basin in question and can be used effectively in the area.

HEC-HMS, which stands for Hydrologic Engineering Centre Hydrologic Modeling System, is a hydrologic model that may be used to predict runoff in response to precipitation watersheds. It was developed by the Hydrologic Engineering Centre (HEC) and the US Army Corps of Engineers. The HEC-HMS uses a number of models to represent various aspects of the rainfall runoff process, including the Loss model for calculating precipitation losses, the Transform model for converting excess precipitation into direct surface runoff, the Base flow model for estimating base flow, and the Routing model for routing the reach. The basin model is a representation of the basin in physical form. The rainfall and evapotranspiration data required to replicate the watershed process are stored in the meteorological model, while the control specification defines the model's run time. To generate the runoff data, the model uses a Basin model, a Meteorological model, a Control specification, and Time series data.

II. STUDY AREA

The Gambhir River Catchment in Indore District, Madhya Pradesh, India, is the subject of this research. It originates in Janapav, 45 kilometres from Indore, and runs from 75°40'0"E, 22°30'0"N to 75°50'0"E, 22°50'0"N. (Figure 1). It passes through Mhow, Indore, and parts of Depalpur before arriving at the Yashwant Sagar Dam, which supplies water to Indore. Janapav is a sacred site since it is where Lord Parshurama was born, and a fair is held there every year on Kartik Purnima (first full moon after Diwali)

The river flows from Yashwant Sagar Dam to Ujjain, where it merges with the Kshipra river, which flows north across the Malwa plateau until merging with the Chambale river. The river has lost its perennial nature over time

and now only flows during the monsoon season. The research area receives between 900 and 1000 mm of rainfall per year.

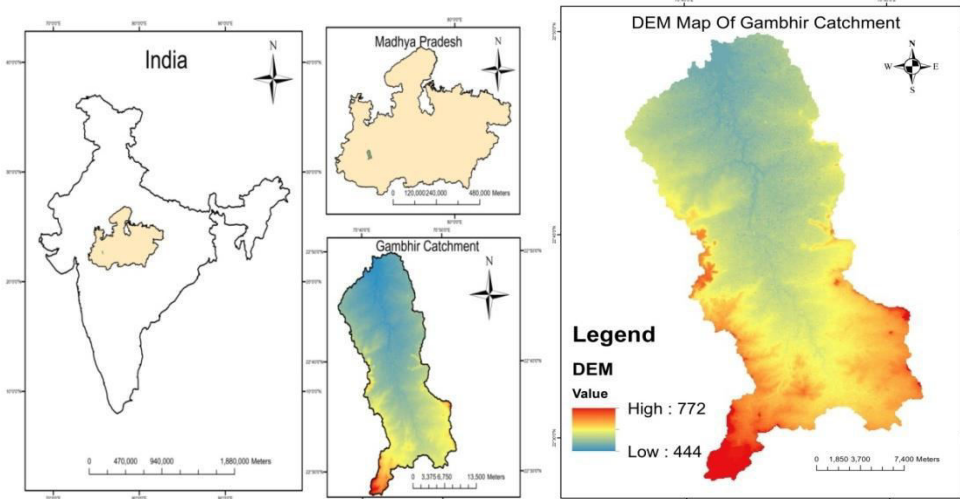


Figure 1. Location Map of Study Area Figure 2. DEM Map of Study Area Location

III. METHODOLOGY

The daily rainfall data of 2000 to 2020 i.e., last 21 years is collected from Mhow, Indore and Depalpur tehsil office respectively.

The Digital Elevation Map with a resolution of 30mX30m can be obtained from the ISRO Bhuvan website (ISRO, 2020). The DEM is then retrieved, trimmed, and projected to fit the shape of our study area (Figure 2).

We delineated the stream and generated a sub-catchment of the basin (Figure 3) using this DEM, Arc Hydro tools, and HecGeoHMS tools, and developed a basin model file that was imported into HEC-HMS Software (Figure 4)

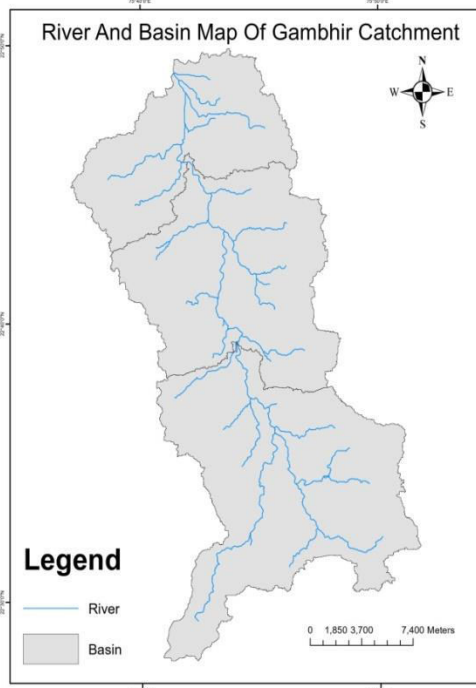


Figure 3. Delineated Stream & Catchment Map

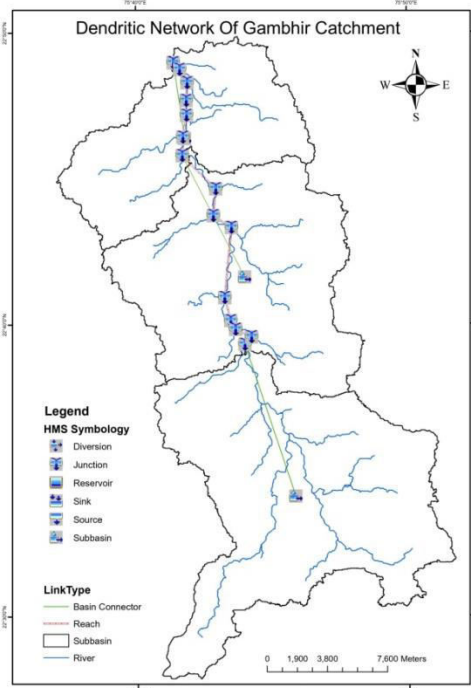


Figure 4. Basin Model of HEC-HMS Model

After importing the basin model into HEC-HMS, we must choose different model parameters; for the loss model, we used the SCS Curve Number approach in this study. We needed curve number, beginning abstraction, and percentage



of imperviousness for the SCS Curve Number approach. The SCS Unit Hydrograph model is utilised for the Transform model. The only input parameter required for the SCS Unit Hydrograph model is the lag time of each sub basin, which is calculated using ArcGIS HecGeoHMS tools. We chose the Lag model as our routing model, which requires us to calculate the lag routing time for all reaches.

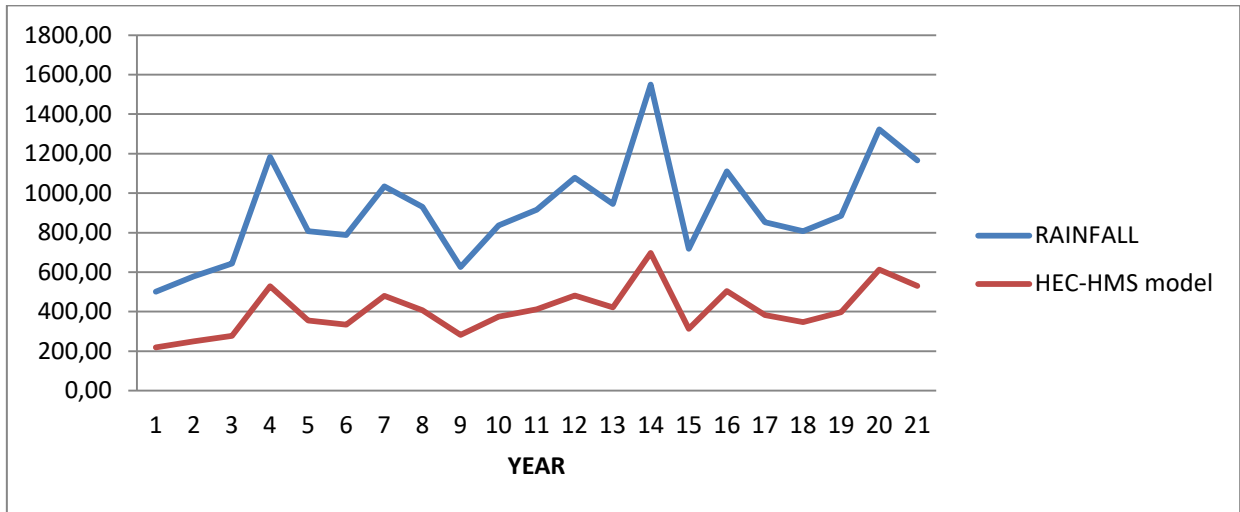
We imported rainfall time series data for all of the rain gauge stations after selecting all of the model parameters. The time series data only includes 5 months of rainfall data, i.e. June to October for each subsequent year. The control specification component is the next stage. Control requirements are one of the most critical components of a project, despite the fact that they do not contain much parameter data. Their main job is to control when simulations start and stop. It's time to start the simulation after you've finished generating all of the components. It is possible to do so by first picking the compute option, then the run simulation option. Graphs and tables are used to display the results.

IV. EXPERIMENTAL RESULTS

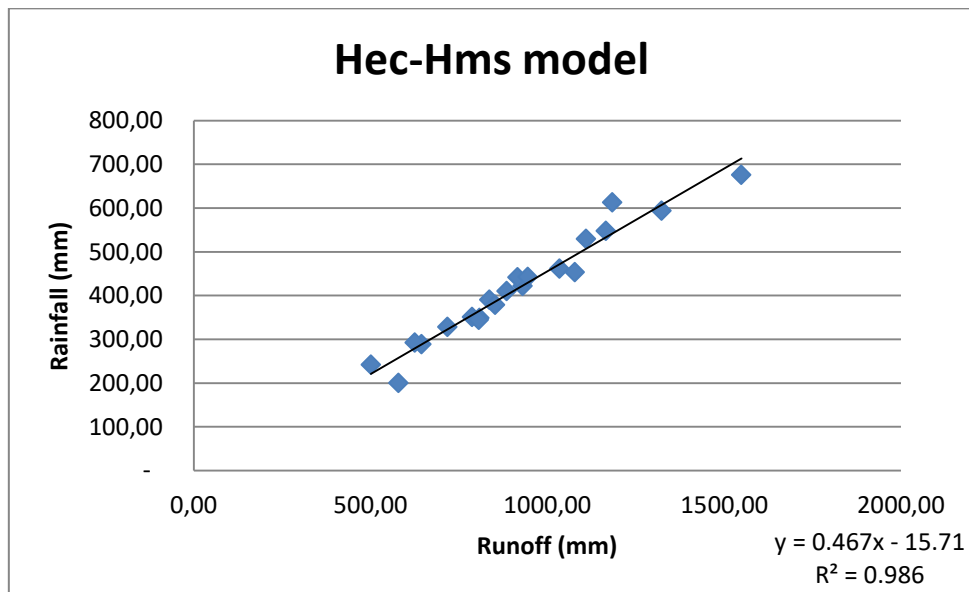
Following are the results generated from HEC-HMS method. The results are tabulated as follows:

Table 1. Value of Discharge Generated from HEC-HMS (in mm)

Year	Rainfall (mm)	Runoff Generated from HEC-HMS (mm)
2000	501.17	241.54
2001	579.46	200.23
2002	644.39	288.60
2003	1183.78	613.00
2004	807.91	348.60
2005	787.68	351.22
2006	1034.67	461.67
2007	930.20	421.97
2008	625.70	292.35
2009	836.68	390.42
2010	916.26	441.88
2011	1078.10	453.10
2012	944.76	442.15
2013	1549.23	675.86
2014	717.66	328.14
2015	1110.06	529.33
2016	852.79	378.98
2017	806.82	344.11
2018	885.16	409.91
2019	1323.22	593.59
2020	1166.20	547.45



Graph 1. Relation between rainfall and runoff generated from HEC-HMS model



Graph 2 Relation of rainfall vs. runoff for HEC-HMS model

V. CONCLUSION

In this study we have focused entirely upon rainfall runoff relationship and succeeded in establishing the same for our study area. Graph 2 shows the relationship between rainfall and runoff for HEC-HMS as the coefficient of determining (R2) is 0.986 which is good as the range of R2 is 0 to 1.

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