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Rainfall-Runoff Modelling of a River Basin Using HEC HMS: A Review Study

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Abstract: ***A hydrological model helps in understanding of the hydrological processes and useful to measure water resources for effective water resources management. Hydrological cycle describes evaporation, condensation, precipitation and collection of earth water and on again.***
Hydrological models have been used in different watersheds across the world. The runoff estimation process is the most complex in nature that depends on the meteorological data and also on the various watershed physical parameters. To generate runoff data for a particular watershed it is needed to find out various parameters related to precipitation models. The HEC HMS (a Centre for Hydrological Engineering and Hydrological Modelling Systems introduced by the US Army Corps of Engineers) is a popularly used watershed model to simulate rainfall runoff process.
The input variables used by hydrological models are rainfall data, runoff data, wind speed, relative humidity, soil type, catchment properties, hydrogeology and other properties. The Hydrological Modeling can also be an event based or may be continuous.
This model is used to predict future impacts of the climate changes on the runoff of River basin and it is used to simulate runoff in ungauged watershed. This literature review represents that application of rainfall runoff modelling using HEC HMS is helpful in prediction of flood, water management and socio-economic development as well as food security.
Keywords: HEC-HMS, hydrological modeling, rainfall-runoff simulation, soil type.

I. INTRODUCTION

Water is a precious commodity and is critical for socio-economic development, healthy ecosystem. Climate change threatening the hydrologic cycle of watershed, due to global warming temperature rises and which effects the precipitation. Poor water management of water resources can lead to soil infertility and erosion; destroy natural ecosystem and overall growth of region.
For better management of water resources, through understanding of hydrologic behaviour of a watershed is known. Hydrological models have been developed across the world to study and understand the hydrologic response of a catchment (Sintayehu, 2015). To assess and forecast the water availability of river catchment so, it is important to use hydrological models. The HEC HMS is a popularly used watershed model to simulate rainfall runoff process. The input variables used by hydrological models are rainfall data, runoff data, wind speed, relative humidity, soil type, catchment properties, hydrogeology and other properties.
Watershed hydrological response with data limitations, rainfall-runoff modeling is complex and also time consuming process to manual mathematical form. Many users have been challenged in converting precipitation runoff into mathematical equation. Now a day's computer-aided hydrological modelling is being used for estimation of runoff become solution for such difficulties. One of the Rainfall runoff modeling tools is Hydrologic Engineering Centre-Hydrologic Modeling System (HEC-HMS) (USAC 2001). The U.S. Army Corps of Engineers developed Hydrologic Engineering Centre (HEC) software. HEC-1 is first software program and called version 1.0. It was written in the FORTRAN language. The second launch was called Version 2.0. In this version, the Soil moisture accounting method was added. The third launch was called Version 3.0. The new graphics interface was designed. The fourth and last program launch was called Version 4.0. In this version, surface erosion, sediment transport and real-time forecasting processes is also added.
HEC-HMS model has been used to simulate precipitation-runoff process with geo-informatics and atmospheric models like evapotranspiration data for flood forecasting and early warnings in different regions of the world (Abed et al., 2005, Azmat.M et al., 2017, Derdour, A.et al., 2018, Bennett, T. H., & Peters, J. C. 2000). It is used for watershed management in different parts of India (Putty and Prasad, 2000).This paper represents the reviews of work done with HEC-HMS software (Hydrologic Engineering Centre Hydrologic Modeling System).

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II. LITERATURE REVIEW

H.K. Nandalal and U.R. Ratnayake (2010) has performed the Event Based Modeling of a Watershed by Using HEC-HMS. Study Area in the region of Kalu-Ganga River watershed. Rainfall-runoff modelling for this basin is developed by using HEC-HMS software. The total area of the basin is 2658 km2. There are two different models, one model having four sub basins and the other model having ten sub basins.Used initial and constant method was utilized for loss estimation, Clark's model method for transformation, Exponential Recession for base flow and both lag model and Muskingum model are used for routing because lag model is used for steeper reaches and Muskingum model is used for gradual slope. The results have shown that HEC HMS software is suitable in modeling of the Kalu-Ganga watershed. It can be concluded that there is no impact of the number of sub basins considered in modeling the Kalu-Ganga River basin using HEC-HMS for flood prediction.

A Sarminingsih, A Rezagama, and Ridwan in 2018 has performed the Simulation of Rainfall runoff process by using HEC HMS model for the Garang Watershed, Semarang of Indonesia. They used SCS (Soil Conservation Service) unit hydrograph method was utilized for loss estimation, SCS's UH method for transformation, Exponential Recession for base flow and lag for routing. For the calibration, observational discharge data is utilized from the AWLR Kreo. HEC HMS 4.2 software is used. Rainfall-runoff conversion is a very complex process. Basing the optimization analysis, hydrological parameter were obtained CN composite is 66.4, and the groundwater content is 128.48 mm, with Initial Abstraction as 25.7 mm and lastly the imperviousness is 9.27%. The validity of the model is quite satisfactory, from the correlation values, RMSE and Nash. It is concluded that the HEC-HMS model is good enough to be used to model rain-runoff in the Garang watershed.

Abdessamed D, Abderrazak B, Kamila B in 2018 used HEC-HMS Model for the rainfall runoff relations in a semi-arid region: Case study in Ain Sefra watershed, Ksour Mountains (SW Algeria). The precipitation excess was estimated using SCS curve number method and SCS unit hydrograph method was used for effective rainfall transformation. After calibration and validation, the simulated peak discharges are close with the observed values. The efficiency coefficient of Nash Sutcliffe was 0.95, and it indicates that the hydrological modeling results obtained were very satisfactory and accepted. Also, the peak discharges that were obtained for the periods of 1000, 100, 50, 10 year storms respectively are 1328.3, 904.3, 750.5, 425.8 m3·s–1.

Kishanlal Darji, Vidhi Khokhani, Dr.Indra Prakash, Khalid Mehmood, Binh Thai Pham (2019) performed Rainfall-Runoff Modelling Using HEC-HMS Model: An Application of Regression Analysis. Regression analysis method is applied for the forecast the runoff and also helped in the estimation of flood frequency in the catchment area. 12 Rain gauge stations are used. Used Initial and Constant Rate Method was utilized for loss estimation. Regression analysis gave the coefficient of determination R 2 value is 0.85. Model is evaluated by regression analysis which gave R2 value is 0.89. There is a good approximation between observed rainfall and estimated runoff.

Wana G N, Dr. Ing. Tamane A D and Fayera G T (2020) utilised HEC-HMS Hydrological Model for Rainfall Runoff Modeling: The Case of Awash Bello Sub-Catchment, Upper Awash Basin, Ethiopia. The loss rate was estimated utilizing SCS CN method , the runoff rate was estimated using SCS unit Hydrograph method. Flood routing was estimated utilizing Muskingum and base flow modeling was estimated utilizing monthly constant method. The rainfall-runoff model has shown good performance during calibration and also validation with Nash Sutcliffe efficiency coefficient is 0.855, R2 estimation of 0.867 for calibration and Nash Sutcliffe efficiency coefficient is 0.739, R2 estimation of 0.863 for validation respectively. The peak flood from the model is 573.7m3/s was compared with direct observed flow is 546.4m3/s. It is concluded that HEC-HMS can be applicable for rainfall runoff modeling for the specified sub-catchment.

Salil Sahu, S. K. Pyasi, R. V. Galkate and R. N. Shrivastava (2020) used HEC-HMS Model for rainfall runoff modelling for Shipra River Basin in Madhya Pradesh, India. This study is carried out in Shipra river basin of area 5679 sq. km. The daily rainfall data of two rain gauge stations from 2000-2003 was used for calibration purposes. Validation was performed for the period from 2004 to 2006.

Methodology used in this study is shown in the following table as:

Table 1 : Methodology used in this study

Serial no.	Calculation type	Method used
1	Loss	SCS Curve Number
2	Transform	SCS-unit hydrograph
3	Base Flow	Lag

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The results are obtained during the calibration are Coefficient of Determination (R2) = 0.85, Nash-Sutcliffe Efficiency (NSE) = 0.72, Root Mean Square Error (RMSE) was 14.4(m3/s), and Mean Absolute Error was 53.9 (m3/s). Other side the results are obtained during validation are R2= 0.88, NSE =69, RMSE= 13.9 (m3/s) and Mean Absolute Error = 63.9 (m3/s). It is concluded that HEC-HMS can be applicable for rainfall runoff modeling for Shipra basin.

III. CONCLUSION

The application and selection of hydrological modeling methods according to the availability of data and other hydrological parameters of the watershed in HEC-HMS. Event-based hydrologic modelling, the rainfall losses due to infiltration are determined. Continuous hydrologic modelling, the rainfall losses due to evapotranspiration are mainly determined which have long-term monitoring data and continuous data.

The results of these studies from the HEC HMS model are very good enough to be used to model rainfall-runoff by changing the sensitive parameters. The model is very sensitive for time of concentration. Selection of model depends on type of data available. In order to predict the surface runoff, the HEC-HMS hydrologic modeling software was applied to the watershed and can be applied to the other catchments with similar hydro meteorological and land use characteristics.

It is concluded that, HEC-HMS model can be used for projection of the future impacts of the climate changes on the runoff of River basin. It is concluded that, it is used to simulate runoff in ungauged watershed.

It is concluded that application of rainfall runoff modelling using HEC HMS is helpful in prediction of flood, water management and socio-economic development as well as food security

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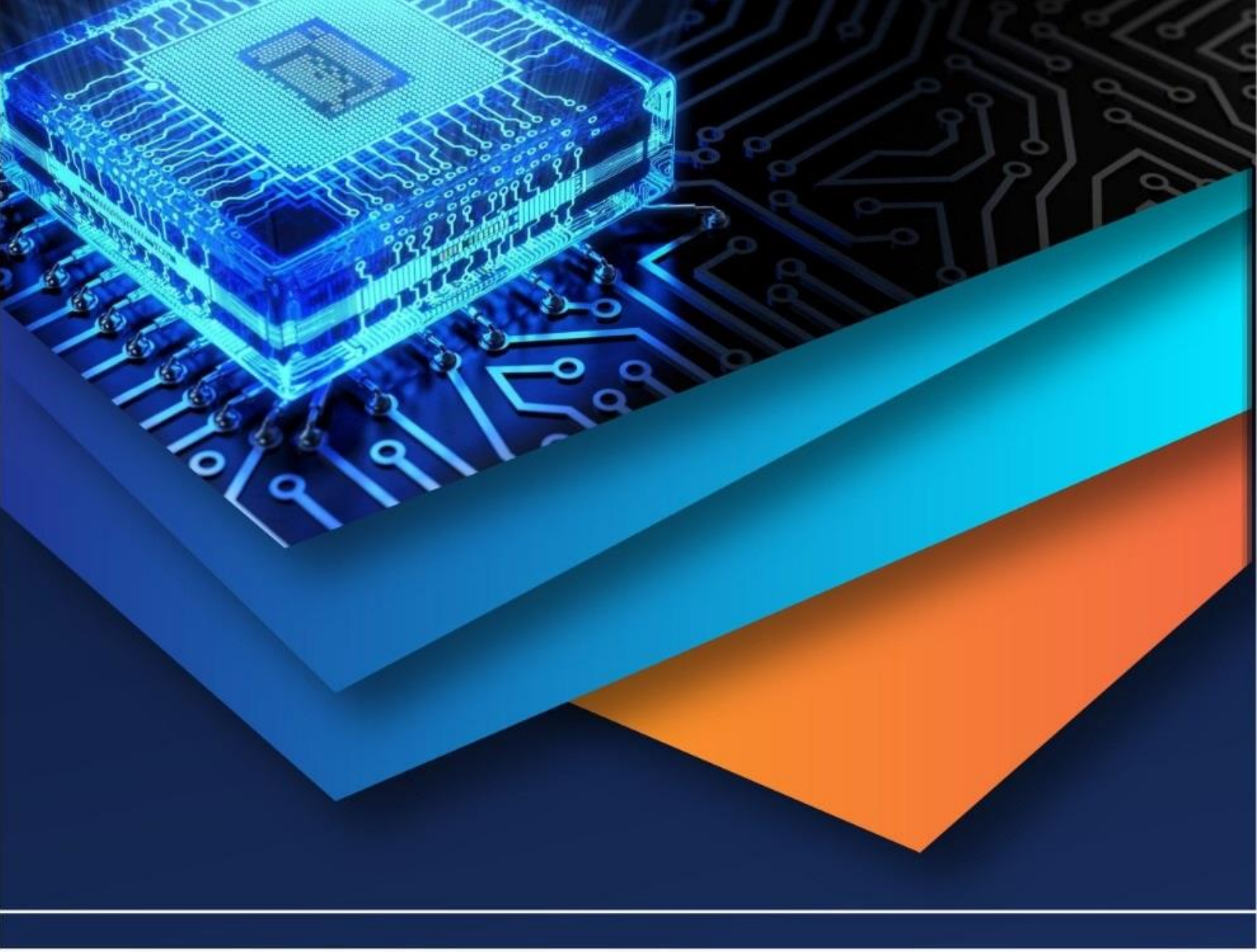

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