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A Critical Review on Applicability of HEC-HMS Software for Hydrological Parameter Estimation: A Case Study of Hadamtala Basin

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Abstract— Hydrological Parameters estimation and their appropriate use to establish Rainfall-runoff Correlation and various hydrology projects on the particular study area. Various studies like silt, flood, utilization and reservoir operation are also to be done. In future with successful work by the project, increase yield of agricultural field and increase prosperity of the people of that area. Flow rates will be estimated for un-gauged basins. HEC-HMS system modeling gives great performance and it is highly sensitive to find basin parameters. Based on these findings it is suggested that HEC-HMS can be used as a tool for the present study area.

Key words: HEC-HMS, Hadamtala Basin

I. INTRODUCTION

Hydrological Parameter estimation and their appropriate use to establish Rainfall-runoff Correlation and various hydrology projects in the particular study area. Various studies, like silt, flood, utilization and reservoir operation are also to be done. In future with successful work by the project, increase yield of agricultural field and increase prosperity of the people of that area. It will be also noticed that use of particular HEC-HMS Software gives good performance and take less time for complicated calculation of dendritic watersheds. It will use to find flow rates at sites having no river gauging station and also used to find theoretical parameters of the same site that would not able to find practically them due to some reason.

II. OBJECTIVE OF STUDY

- To study HEC-HMS software and check its applicability to study area.
- To calculate flow rates at different element of watershed. I.e. Sub-basin, Reach, Junction and outlet.
- To estimate hydrological parameters and coefficients.

III. STUDY AREA

The proposed study area is located at relative latitude and longitude of 22° 03' 35"N and 70° 48' 35" E. The study area for which parameters should be estimated is located across river Semli, about 0.5 Km u/s of village Hadamtala of Kotdasangani tehsil in Rajkot district. River Semli is tributary to river Gondali, which itself is a tributary to main Bhadar River. The study area is approachable through Rajkot-Porbandar national highway 8B, which bifurcates at about 8Km away from Gondal town. Bhunva – Hadamtala village road crosses the national highway 8B and village Hadamtala is about 4 Km away from the crossing point. The study area can be approachable in any fair season.

The catchment of the study area shall intercept the catchment of the existing veri lake located d/s of proposed site area. The existing veri lake has net catchment of 122.79 Km^2. The net area of Veri Lake after hydrological evaluation of the project will be 80.57 Km^2. River Semli originates from the Sardhari ridge on u/s of Gundasara village of Gondal tehsil in Rajkot district. The River mostly flows north to South and passes near by the village Gundasara, Ardoi, Semla, etc... And it ultimately meets River Gondali near Panchiyavadar on u/s of existing Veri Lake.

Study area having average annual rainfall of 500 to 800 mm with relative normal humidity. Proportion and volume of rainfall is irregular, insufficient and unpredictable. The south west monsoon sets in by the middle of June and withdraws by the first week of October. About 90 % of total rainfall is received during July and August. Overall climate characteristics climate is variable. In winter temperature varies between 10°c to 25°c. The maximum Temperature varies between 40°c to 46°c.

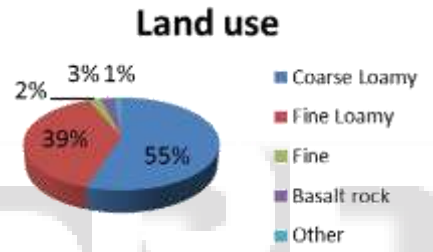


Fig. 1 Land use of study area

IV. HEC-HMSMODEL

Hydrology engineering concept – hydrology modeling system (HEC-HMS) - Version 4.0, is simulation software that determines behavior of watershed for predetermined rain events, developed by HEC-corps of engineers of U.S. army. This is single time event – deterministic model. The software has graphical user interface (GUI's), integrated with hydrological components and specific system of data storage system (DSS) and various management tools etc. In this model; infiltration, evaporation and interception processes determine from loss component while runoff processes are computed as the pure surface routing using transform component with various precipitation methods and their characteristics (Yusor et al, 2007). Mainly four components – Basin model, Meteorological component, Control specification and paired data manager.

In this study, HEC-HMS model is used to estimate flow rate of Hadamtala basin. Data required for simulation are rainfall, infiltration rate as well as topography and runoff (for calibration). Generally model components are used for simulation of the hydrological response in any catchment. A simulation calculates the rainfall-runoff response in the basin model given input from the meteorological model. The control specification defines the specific time period and time step of simulation run.

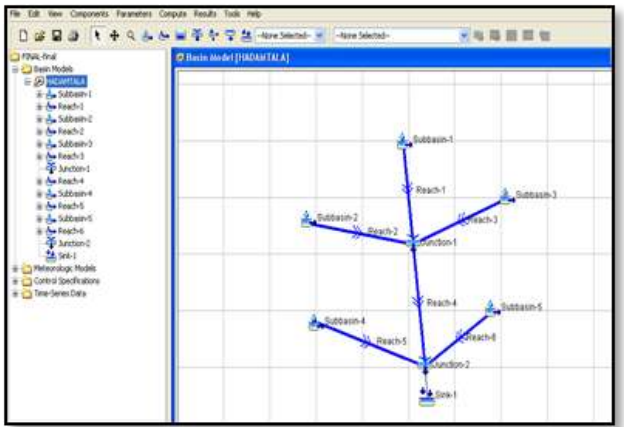


Fig. 2 Main Screen of HEC-HMS Software

V. METHODOLOGY

In HEC-HMS model, same parameters are required as input to simulate runoff hydrographs and other required results parameters can be estimated through observation and measurement of stream and ban characteristics (Yener et al, 2006).

For simulation and calibration processes, initial and constant loss method, synthetic snyder unit hydrograph method, transform method with smaller base flow and canopy method used as sub-basin inputs. As a meteorology model data, specified hyetograph is used as input. In addition, precipitation data are main data to run simulation.

After application of HEC-HMS on study area, obtained results are compared with the actual observed data of flow rates. The model parameters are calibrated until the results are favorable with close proximity of the observed and the simulated-hydrographs. .

In HEC-HMS, there are so many methods available for the Precipitation, Transform, Loss, Base flow and surface and canopy methods. Most of parameters for methods included in sub basin and reach elements can be estimated automatically using optimization trials. Seven different objective functions are available to estimate the goodness-of-fit between the computed results and observed results.

Parameter estimation is the trial and error type methods to adjust the value of variables. Optimization trails are one of the components that can compute results. Each trial is also included data regarding basin model, meteorological model and control specification. This process also included selection of the objective function, search methods and parameters to be adjusted in order to find a optimized model. Different types of results graph and tables are available from the watershed explorer for evaluation of preciseness of the results.

VI. RESULT AND DISCUSSION

Calibration of the model is process to adjust parameters of model to get simulated results to as same the observation results on field. Calibration is trail and error type process. For model calibration, simulated results were compared with actual observed results. For that known rainfall and runoff values are used to prepare hydrograph and that hydrograph used for the finding of parametric values. Successful application of the hydrologic watershed model depends upon how well they are calibrated with given situation and its technical dependability on input data. HEC-HMS model is calibrated for the event based simulation. The objective of the model calibration is to match observed and simulated runoff volumes, runoff peaks with same time of events.

Sr. no.	Parameter	Initial value	Optimized value
1	Infiltration constant rate (mm/HR)	0.96	0.6
2	Lag time (HR)	10	8
3	Muskingum (K), Hr	0.68	0.8
4	Muskingum (X)	0.35	0.2

Table-1 Calculated initial and optimized parameters for the watershed

Simulation results were obtained for the year 2010 and 2013 for the peak season of rainfall of July and August months. Results were divided into sub basin and junction graphs of flow rate and excess precipitation.

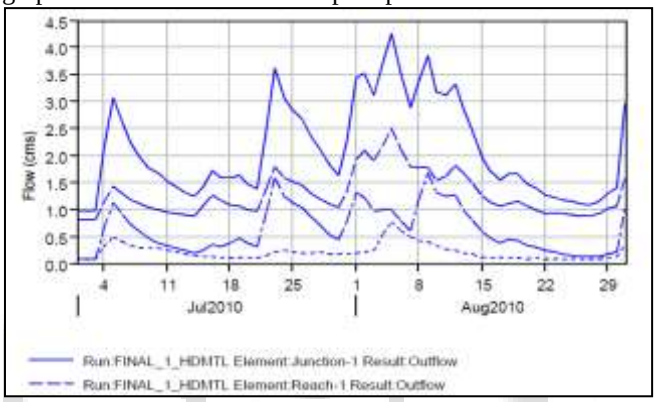


Fig. 3 Results of Junction 1 for year 2010

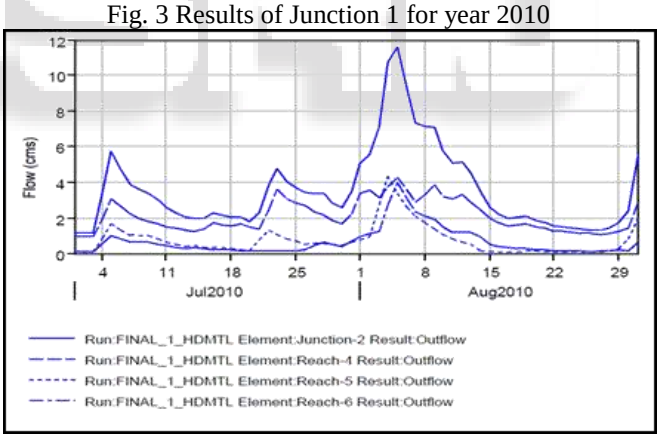


Fig. 4 Results of Junction 2 for year 2010

A. Discussion of results of year 2010:

1) Total simulation period was taken from1st July 2010 to 31st August 2010, having high rainfall days in a year. The peak discharge for the computation is found out 11.6 m^3/s as well as runoff volume of at sub basin-1 of 1018.6 mm.
2) Out of 61 rainfall events, 5 events of Aug-4 to Aug-9 having large flow rates at time of observation.
3) Coefficient of determination for the event is 0.809 which indicates good calibration of model. Total flow rate depends on the reach characteristic and the no. of reach connected at the junction.
4) By observation of simulation result of peak discharge from all events is 11.6 m^3/s with runoff volume of 1018.6 mm on duration of 1stJuly to 31staugust, 2010.

5) For same duration observed flow is 13.9 m^3/s with runoff volume of 1200 mm. so, validation and calibration of model done on the basis of this event duration and all the parameters are self calibrated by actual data collection.

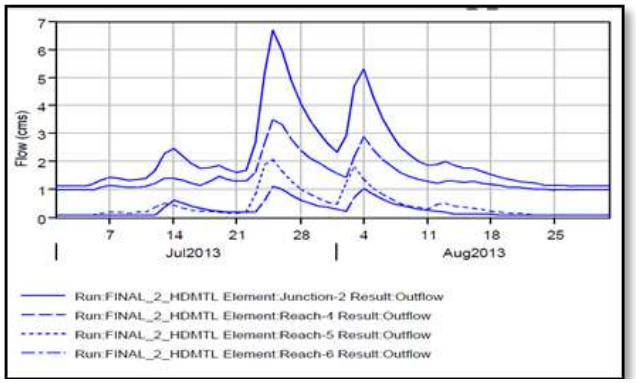
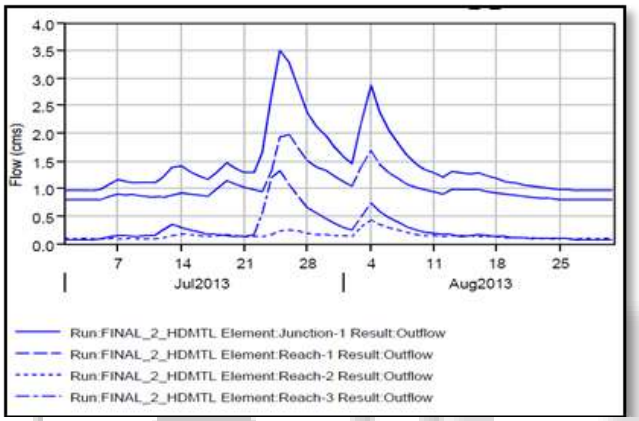


Fig. 5 Results of Junction 1&2 for year 2013



B. Discussion of results of year 2013:

1) Total simulation period was taken from1st July 2013 to 31st August 2013, having high rainfall days in a year. The peak discharge for the computation is found out 6.7 m^3/s as well as runoff volume of at sub basin-1 of 1018.6 mm.
2) Out of 61 rainfall events, 2 events of July-25and July-26 having large flow rates at time of observation.
3) Coefficient of determination for the event is 0.809 which indicates good calibration of model. Total flow rate depends on the reach characteristic and the no. of reach connected at the junction.
4) From the analysis of figures it is concluded that the optimized parameter in HEC-HMS model gave values of different runoff hydrograph parameter close to the observed ones than when un-optimized parameters are considered.

A calibrated model should be validated before it is recommended for use. For validation, the simulated data as predicted by the model must be compared with the observed data and statistical tests of error functions must be carried on. If the values of error functions are very small then the model is validated.

For Validation	RMSE		MARE	
	Run off depth	Peak discharge	Runoff depth	Peak discharge
Before calibration	-	-	-	-
After	0.805	0.111	0.23	0.15
Calibration				

Table 2: Error function computed for Validation

The derived model also all over efficiency by using NASH-SUTCLIFFE criterion. The value of efficiency is 0.79 (>0.7), which is consider as good simulation of model over selected watershed.

VII. Conclusion

Based on the results and data confirmation, HEC-HMS can be reliable to modeling flow rates for the study area (HADAMTALA BASIN) and it can be applicable for the other basins having same Geomorphologic condition. The Sensitivity analysis for the flow rate of study area calculated using Snyder method which shows high sensitivity of parameters in range of 0 to 28 % means that the basin discharge is more sensitive to smaller value of lag time and peaking coefficient for basin as well as Muskingum X-parameter for routing. In other words underestimate of lag time will cause more error on prediction of flow rate in comparison Overestimate this parameter. Model is also highly sensitive to base flow and infiltration rate to obtained total flow rate.

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