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Rainfall Runoff Modelling of Panchaganga River Using HEC-HMS Software and it's Analysis.

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ABSTRACT
The present study of this project is intended on the formation of a working flood model of the river Panchaganga flood in the Kolhapur stretch which is in Maharashtra state in India. Using HEC-HMS the precipitation is used to estimate the run off along the watershed. The central aim of this project resides in the development of a calibrated working model of the 2019 floods. This model is later used to simulate the various possibilities of flood event. Rainfall Runoff Model which is a mathematical model which relates the rainfall and runoff with the use of catchment area or watershed area. Hydrological modeling can estimate for the runoff in the study area of the model by evaluating the precipitation and discharges inputs given to the HEC-HMS software. Hydrological models on the other hand estimates the surface runoff within the study area.
In recent decades, India has experienced an increase in the frequency of flood disasters. Flood is a flow that overtops either hydraulic structure or river bank along a stream resulting in damage to the adjoining property or life. The primary reason behind this is the Climate change and Immense urbanization, which has resulting in alteration of basin characteristics. The development projects near riverbanks have the worst effects on a reach's ability to drain, which increases the likelihood of flood-like conditions.
In this project an area of the Panchaganga river is to be taken and a flood mapping using HEC-HMS (Hydrological Modelling System) and GIS software is to be drawn. According to the drawn flood map there will be a suitable mitigation measure suggested and the effect of the suggested mitigation measure is to be modeled.

Keywords: Flood Modeling, Panchaganga River, DEM, GIS, HEC-HMS.

1.0 INTRODUCTION

Despite the fact that water covers 70% of the earth's surface, there is a severe water issue. This is due to the fact that 97.5 percent of all water on Earth is saltwater. Ninety-nine percent of the remaining water is trapped in subterranean sources and glaciers. Therefore, in actuality, less than 1% of freshwater is accessible to humans as rivers, lakes, streams, etc. Please be aware that even the last man on Earth may have his needs met by the less than 1% water availability. Because of human invasion at all levels, if appropriate precautions are not taken for the best possible utilization of water resources, human existence may soon be in jeopardy.
The eastern edge of the Sahyadri hills is home to the Panchaganga river basin. Situated at latitudes 15^{o}43

and 17°17' North, it lies in the northern region of Maharashtra's Kolhapur district'. It is made up of five streams that go northeast, including Bhogavati (83 km), Dhamani (41 km), Tulsi (30 km), Kumbi (48 km) and Kasari (69 km). The Bhogawati River is renamed Panchaganga from Prayag Chikhali. The river flows and meets Krishna River at Narsinhwadi, Tal: Shirol, Dist: Kolhapur.There are 174 villages, 2 municipal towns (Ichalkarnji and Kurundwad) and one city (Kolhapur) situated on the bank of the river.

In upcoming years there will be loss of area for people to live or populate. Hence there is a need to find safe and proper living areas for people. Flood mapping is a great idea for various reasons such as, due to flood mapping we can easily identify a mitigation measure for floods occurring in the floodplain. With careful planning and using such measures it is possible to reduce the threat area to allow for people to safely use the area which was thought to be hazardous in and around the floodplain. Also there may be illegal settlements in floodplains where there is a high hazard risk.

2.0 STUDY AREA & DATA USED

The Kolhapur city is placed along the banks of river Panchaganga. The Panchaganga river basin is to be mapped in HEC-HMS along with the use of GIS combined together. The data to be collected is through the Central Water Commission (CWC), Water Resource Department (WRD) and Sinchan Bhavan Irrigation Dept. Kolhapur. This will include mapping and referencing various already published papers and manuals.

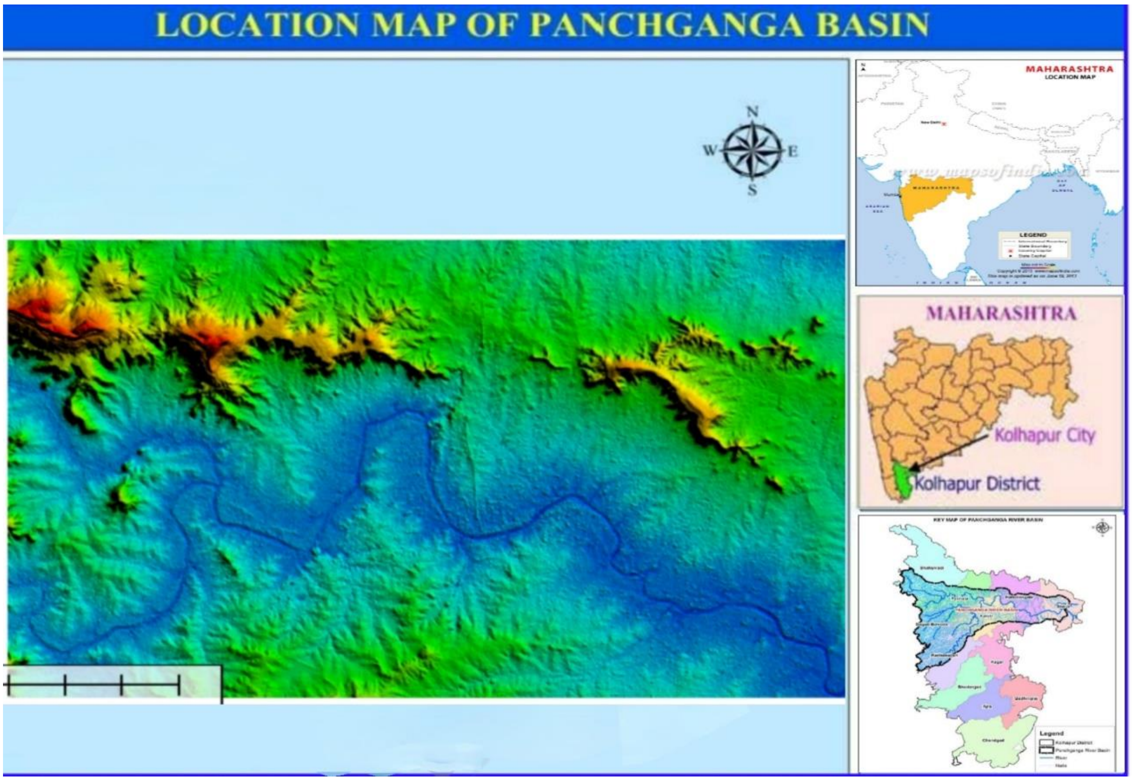

Fig. 1: Study Area Map for Kolhapur city, Maharashtra state, India.

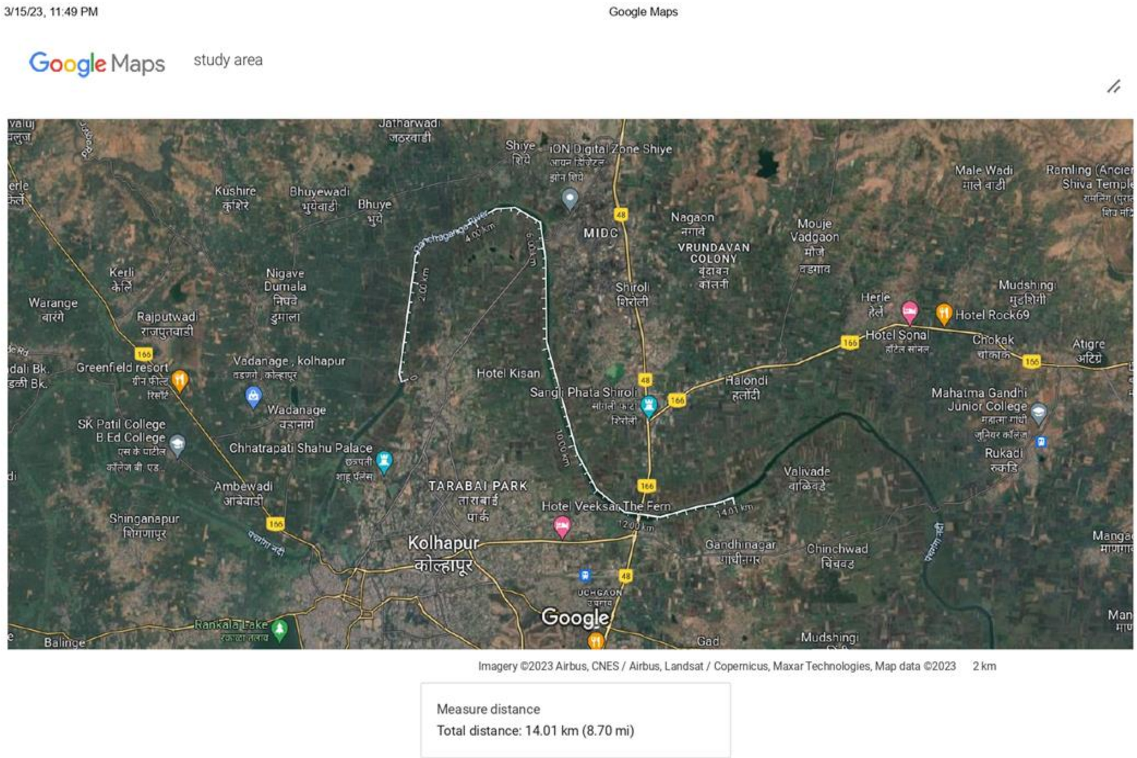

Fig. 2: Study Area Map for Kolhapur city, Maharashtra state, India

The total population of Kolhapur city is 7,57,000 (census of India, 2011).

1. Data collected from the Sinchan Bhavan, Irrigation Dept. Kolhapur.
2. Discharge of the water Rajaram, 2015 to 2023.

बं धारा पातळी नों दवही,

अ. क्र.	तारीख	राजाराम बं धारा		
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२	६/२/२०१५	१३'.६''	५३४.३	४००
३	६/३/२०१५	१२'.६''	५३३.९९	३५०
४	६/४/२०१५	१०'.६''	५३३.३८	४००
५	६/५/२०१५	१०'.६''	५३३.३८	४००
६	६/६/२०१५	१०'.४''	५३३.३३	३५०
७	६/७/२०१५	११'.००''	५३३.८४	६००
८	६/८/२०१५	१०'.००''	५३३.२३	४००
९	६/९/२०१५	८'.६''	५३२.७७	३००
१०	६/१०/२०१५	८'.००''	५३२.६२	२००
११	६/११/२०१५	७'.००''	५३२.३२	४४०
१२	६/१२/२०१५	७'.००''	५३२.३२	४४०
१३	६/१३/२०१५	७'.००''	५३२.३२	४४०

Table 1: Day wise discharge data at Rajaram weir

1) DEM model for 15km river section with the width of 10km.

Sr. No	Weir Name	Depth	Distance
1.	Rajaram Weir	4.57m	0
2.	Surve Weir	5.48m	16.94 km
3.	Rukadi Weir	6.00m	19.68 km
4.	Rui Weir	4.67m	30.61 km
5.	Ichalkaranji Weir	7.18m	41.39 km
6.	Tervad Weir	5.62m	53.99 km
7.	Shirol Weir	4.9m	64.26 km

Table 2: Depth and Distance of each weir

SUB Dn.- Hydrology Project Sub - Division, Kolhapur
STATEMENT SHOWING AVERAGE ANNUAL RAINFALL

Sr. No.	YEAR	WADANGE
1	2000	798.8
2	2001	676.0
3	2002	736.8
4	2003	563.4
5	2004	1023.8
6	2005	1913.0
7	2006	1468.0
8	2007	1031.4
9	2008	1286.2
10	2009	1007.1
11	2010	1079.9
12	2011	1053.3
13	2012	788.0
14	2013	1044.0
15	2014	1000.7
16	2015	736.1
17	2016	1171.3
18	2017	987.0
19	2018	1254.0
20	2019	1927.2
21	2020	1419.2
22	2021	1734.0
23	2022	1614.0
		26313.2
Average Annual rainfall in MM.		1144.05

Table 3: Annual rainfall data of Kolhapur city in MM.

In the last 20 years, the highest flood occurred in the years 2005, 2019 and 2021. In this, I have run the model for 2019 flood. It is highest flood.

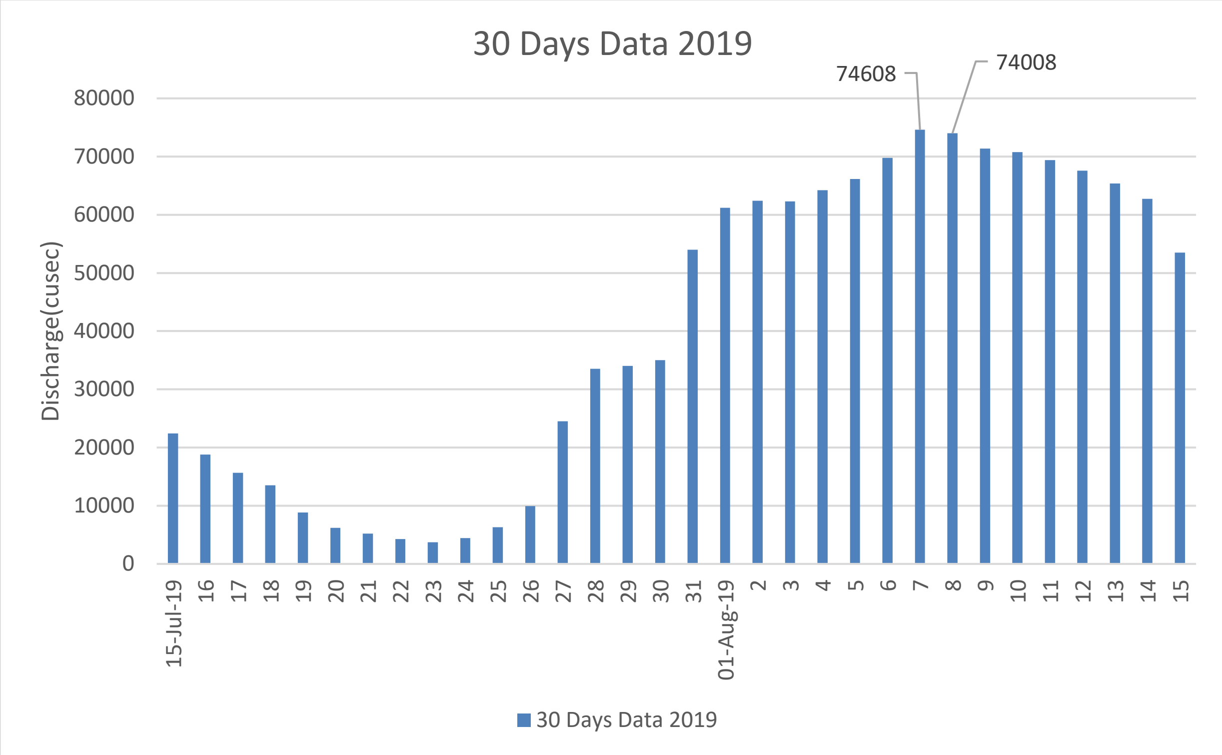

Fig. 3: 30 days rainfall data

From the above graph we can see that the highest discharge was 74,608 mm on 7 August 2019 and 74,008 mm on 8 August 2019.

3.0 METHODOLOGY

The procedure followed for the study is enlighten in the following figure 4.

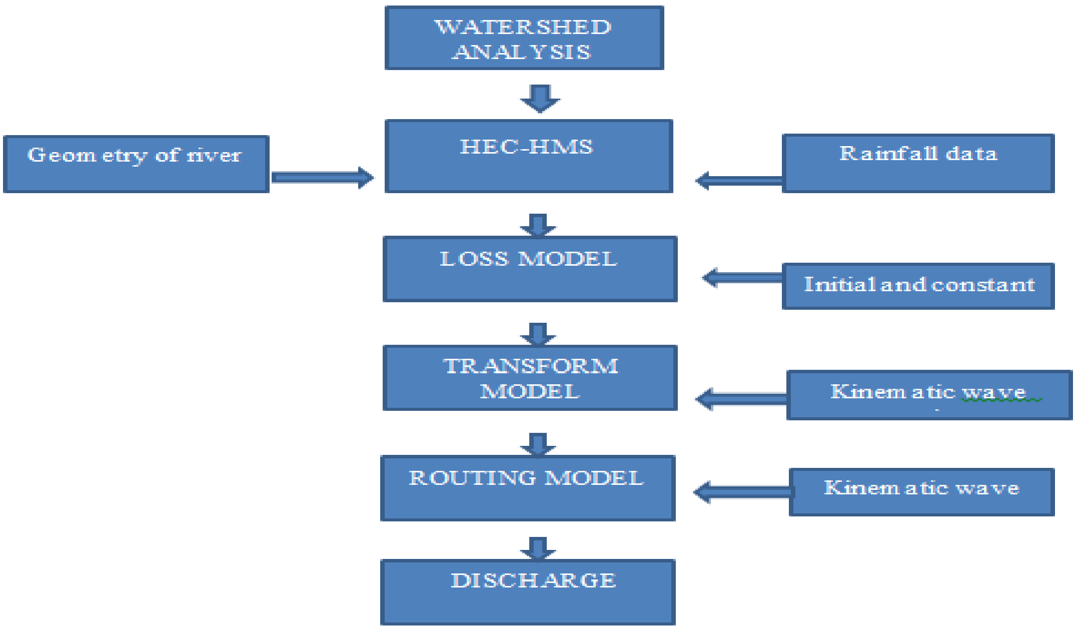

Fig. 4 : Methodological Flow Chart.

Hydrological Model Development

HEC-HMS was used to perform rainfall runoff simulation. Rainfall Runoff modeling approach may be summarized by categorizing it into three components, which are as follows:

1. Creating Basin Model
2. Developing Hydrological Parameters
3. Hydrological Modeling

Digital Elevation Model :

The Digital Elevation Model (DEM) of the study area is an important necessity for the determination of the watershed's physical characteristics such as the land data, the elevations of the land, etc. For the proposed project DEM file of Maharashtra region is downloaded from Bhuvan website https://bhuvan-app3.nrsc.gov.in/data/download/index.php.

A topographic map's most unique feature is its contour lines. Contour lines are lines drawn on a map that link places of equal elevation, which means that if you practically traced a contour Flood modeling of Panchaganga River by using HEC-HMS, your elevation would remain constant. Contour lines depict elevation and landscape form. They are useful because they depict the contour of the ground surface, or topography, on a map.

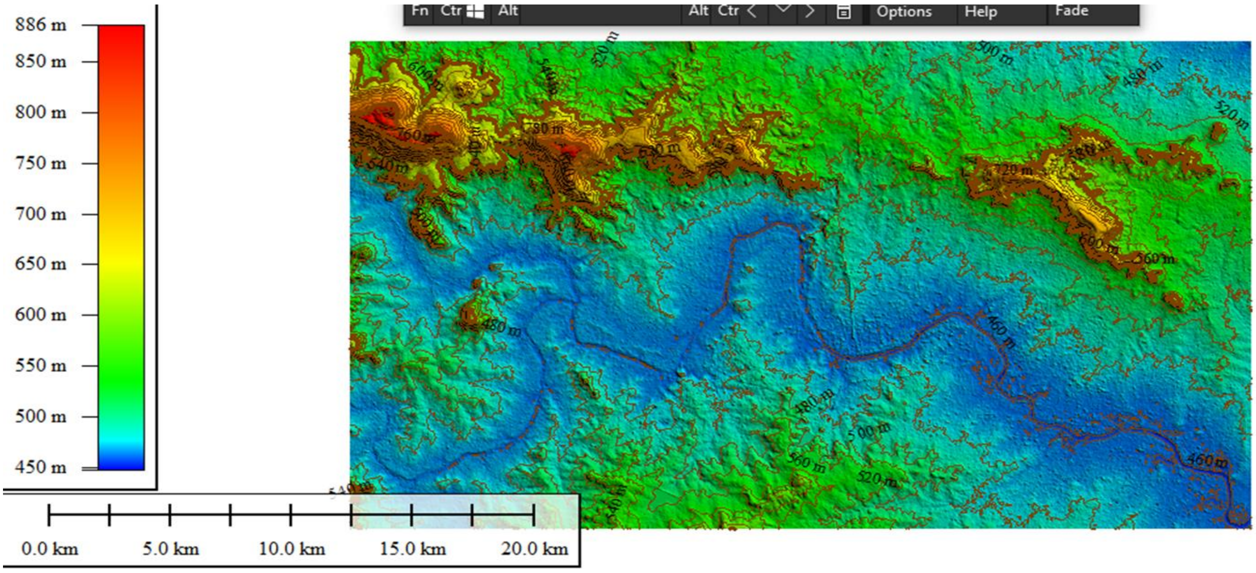

Fig. 5: DEM with Contour Map

Watershed analysis is a useful tool which is used to map out the boundary of the hydrological model of the study area. After determining the study area the watershed boundary as well as the contours of the area were determined. The Figure 4. lists out the watershed area of the study area.

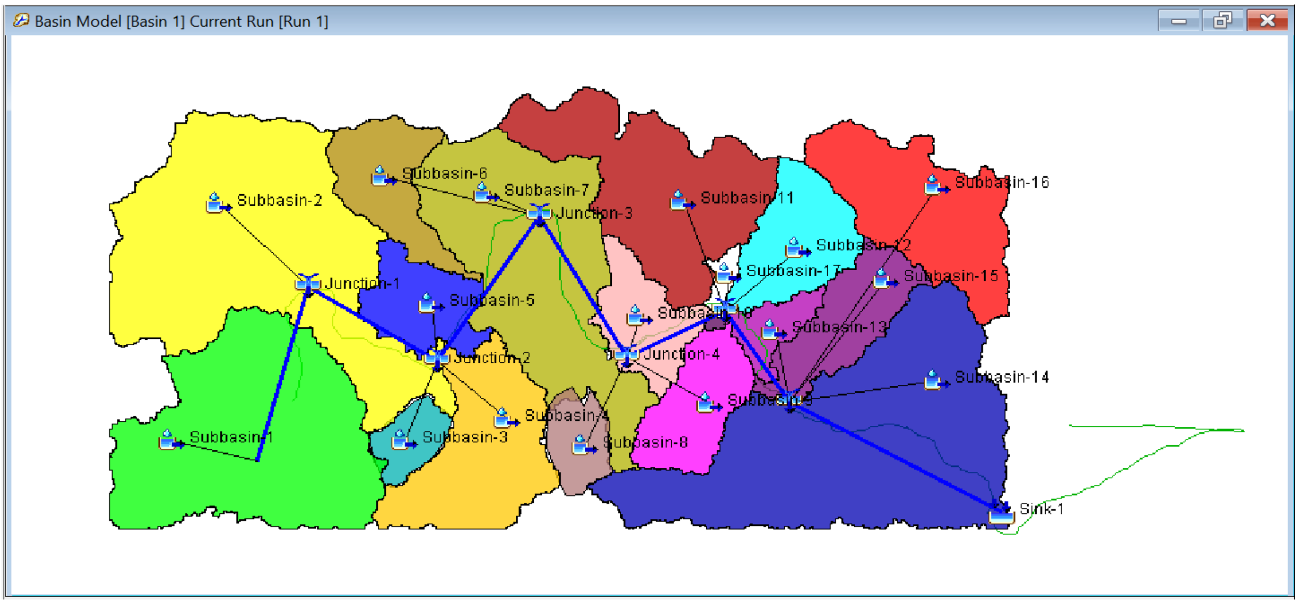

Fig. 6: Output of catchment polygon generation.

Once all the processes are carried out, the model is converted to HEC-HMS format and further Processing is carried out in HEC-HMS.

5.0 RESULTS AND DISCUSSION

The results of hydrologic routing show that the peak discharges for the enter model has been observed on 7th August 2019.On the same day Kolhapur has faced the flood. The peak dischargesat various reaches and junctions are as below.

The observed discharge flow is shown by the black line in this graph and the computed discharge flow is shown by the blue line. From this, we may conclude that due to the higher backwater input, the observed discharge is six times more than the computed discharge.

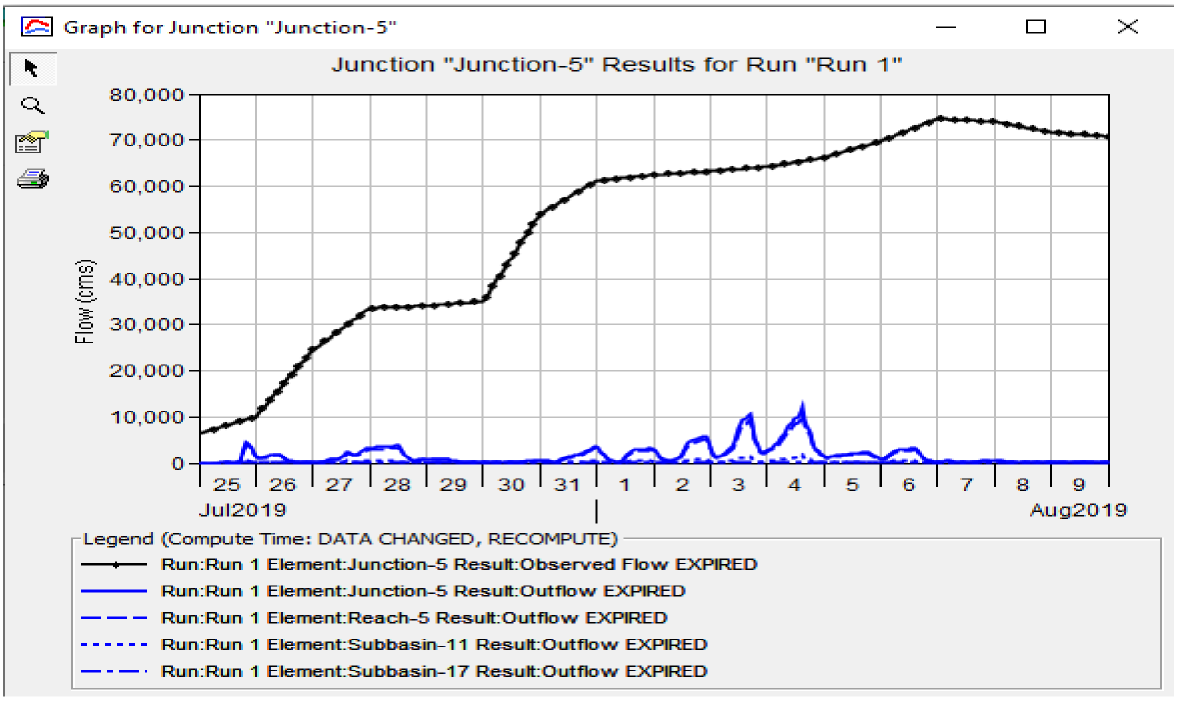

Fig. 7: HEC-HMS Junction 5 Results

Summary Results for Junction "Junction-5"

Project: anant kit Simulation Run: Run 1
Junction: Junction-5

Start of Run:	25Jul2019, 00:00	Basin Model:	Basin 1
End of Run:	10Aug2019, 00:00	Meteorologic Model:	Met 1
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	Control 1

Volume Units: (●) MM ( ) 1000 M3

Computed Results

Peak Discharge:	12076.4 (M3/S)	Date/Time of Peak Discharge:	04Aug2019, 15:00
Volume:	5830.48 (MM)		

Observed Flow Gage Gage 1

Peak Discharge:	74608.0 (M3/S)	Date/Time of Peak Discharge:	07Aug2019, 00:00
Volume:	179415.88 (MM)		
RMSE Std Dev:	2.4	Nash-Sutcliffe:	-4.650
Percent Bias:	-96.36 %		

Fig. 7.b: HEC-HMS Junction 5 summery report.

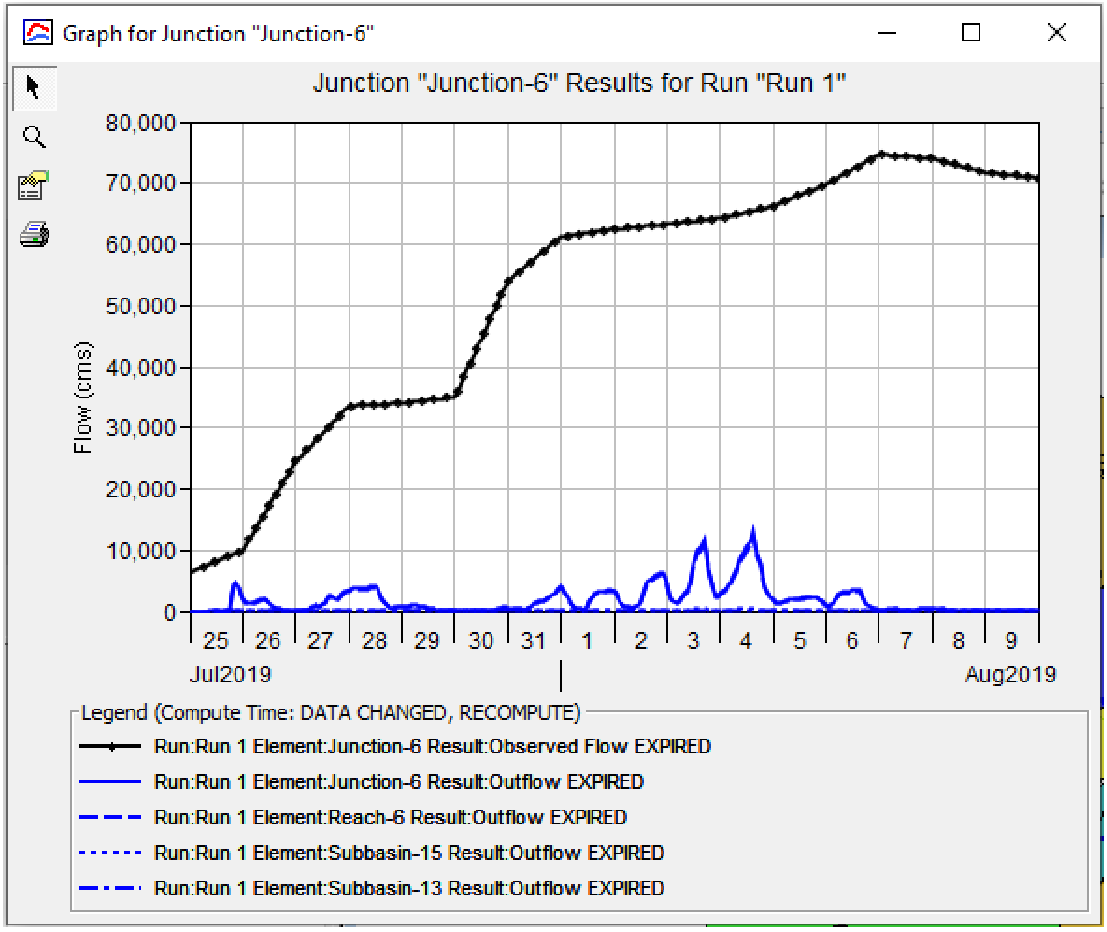

Fig. 8: HEC-HMS Junction 6 Result.

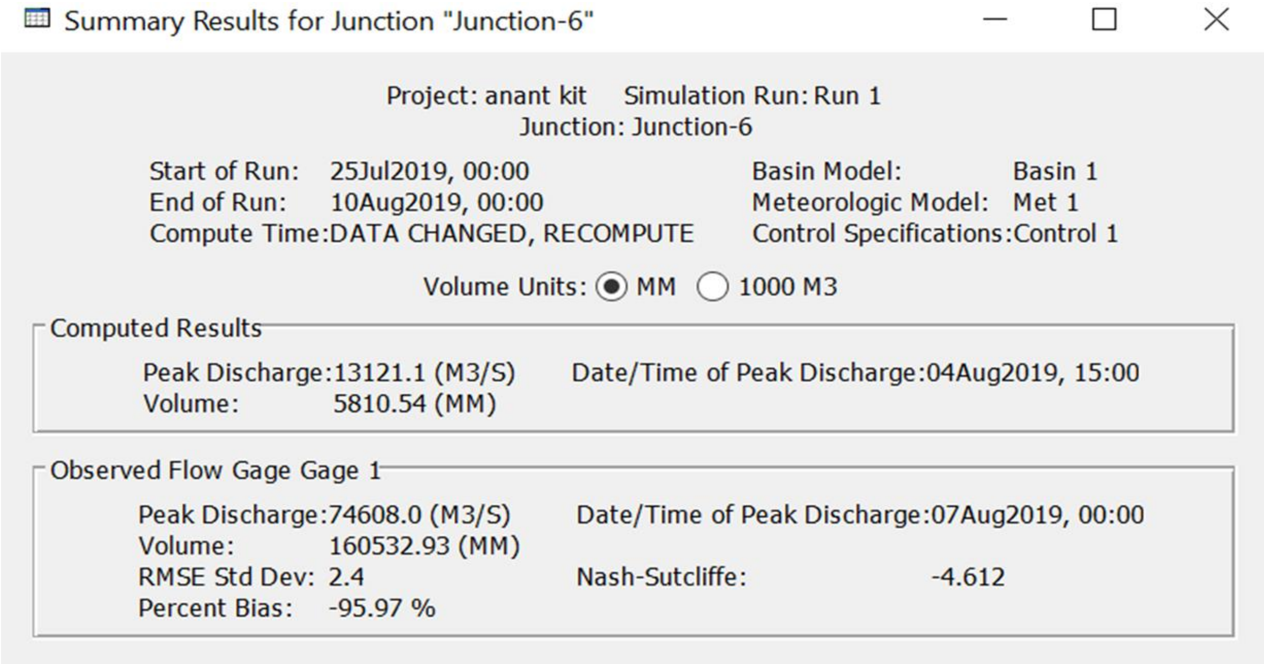

Fig. 9: HEC-HMS Junction 6 summery report

6. CONCLUSION

The hydrologic model has been successfully setup for simulating the 2019 floods. The methodology used for the simulation of the model is suitable for the hydrological model.

The River level is expected to rise due to continuous rainfall and water discharge from Radhanagari Dam The observed discharge is 6 times more than the cumulative discharge because of the inflow at the Rajaram weir is high.

Construction area increased 46% to 60%. Thus, there is 14% increase in construction area from 2001 to 2022. Consequently, This reduced water infiltration into the soil & increased runoff resulting in an increase in river water level.

The rapid population growth and the change in land-use are also one of the reason for occurrence of flooding.

Peak discharges in accordance with precipitation are found to have adequate levels. Thus, it can be said that the suggested methodology is appropriate for catchment flood modelling. The flood inundation maps can be used for identifying the areas that are affected during the flood event.Spread of flood water beyond banks of river can be identified by cross section profile and preventive measure like construction of levees or embankment can be suggested. With further modifications the model can be used for real time flood simulation.

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