

# Flood Modelling For Peri Urban Areas in Adyar River

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**ABSTRACT:** Water is essential for survival of all living organisms. It is the main constituent of Earth's streams, lakes, and oceans, and the fluids of most living organisms. A country's economy depends mostly on its wealth of water resources. Nowadays there are many pressures on water resources, including those arising from human activities. Water resources in India exhibit large scale variation in their occurrence. Many parts of the country are affected by severe flood and drought conditions. They are the extreme events in the hydrological cycle and helpful to describe how water moves throughout the earth in different ways and at different rates. Human activities like urbanization, industrialization and consolidation of agriculture land are the major driving force in altering the land use pattern and significantly affect the hydrologic processes. The effect of this land transformation is to increase the flood flows. The core objective of this study is to do the flood modelling for Peri-urban areas of Chennai, Tamil Nadu state for finding the depth and extent of flood inundation. In the study area, the rate of infiltration is low that causes frequent flooding. So the people living in vulnerable area suffer due to flood, resulting in loss of life and damage to properties. Chennai has only 855 km of storm water drains against 2,847 km of urban roads. The Hydrologic modelling is done by using HEC-HMS (Hydrologic Engineering Centre - Hydrologic Modelling System) model by giving the meteorological data and other necessary data as input and flood hydrograph is derived for specific rainfall event. The output from the HEC-HMS model is given as input to HEC-RAS (River Analysis System) along with the necessary geometric data and boundary conditions for generating the water surface profile. The output from the HEC-RAS is imported to HEC-GeoRAS for post processing from where the flood inundation map was prepared. From the flood inundation map, the flood vulnerable areas were identified. Based on the results, the flood mitigation measures have been suggested to reduce the damages caused due to flood in the study area. The findings from the study can be used to city planners, policy makers and environmental planners. Also it can be very useful to the government to control the flood during the monsoon season

**KEYWORDS:** Rainfall, Runoff, HEC-HMS, HEC RAS, Calibration, Validation

## I. INTRODUCTION

Water covers over 71% of the earth surface. Water on earth, moves continuously through the hydrological cycle. The two major drastic events of water are flood and drought. A flood is considered to be an unusually high stage of a river at which a stream channel becomes filled and above which it overflows its banks and floods nearby land. Chennai frequently experiences flooding due to heavy rain associated with depressions and cyclones. The last century records have shown that there were several catastrophic flooding in Chennai in 1943, 1978, 1985, 2002 and 2005 caused by heavy rain associated with cyclonic activity

## II. STUDY AREA

This chapter deals with study area description. The area of extended CMA is 1189 km<sup>2</sup>. The CMA falls in three districts of the Tamil Nadu state: Chennai district (area: 176 km<sup>2</sup>), and parts of Thiruvallur district (area: 637 km<sup>2</sup> out of 3427 km<sup>2</sup>) and Kancheepuram district (area: 376 km<sup>2</sup> out of 4433 km<sup>2</sup>). Adayar basin situated between Latitudes 12°47'6" N and 13°3'22" N and Longitudes 80° 17' 1" E and 79°52'36" E originating near the Chembarambakkam lake flows through Chennai and joins the Bay of Bengal at the Adayar estuary. The Adayar is a short river of about 42 km in

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length and enters the city limit near Nandambakkam Bridge (10 km upstream from the river mouth). The river consists of three arms. The northern arm comes from Chembarambakkam minor basin, the second arm comes from Guduvancheri and the third arm comes from Malaipattu tank near Manimangalam village

### III. METHODOLOGY

Initially DEM for the study area will be created by using ASTER in the ArcGIS. HEC-HMS consists of three modules such as basin, meteorological, control specifications. In HEC-GeoHMS is the pre-processor of HEC-HMS and it is an extension of Arc GIS aids for the basin module. In HEC-GeoHMS basin will be disaggregated into sub basins. Then the Physical characteristics of the watershed such as river length slope and longest flow path for each basin will be extracted. Then the weighted curve number for each basin will be created by giving land use information, soil type, rainfall data and curve number. After creating the basin module the meteorological data like rainfall data will be given and the control specification data will be given. Then the HEC-HMS model is runned and will get the output as peak discharge. The flow data from HEC-HMS is imported into the hydraulic model HEC-RAS along with geometry data to develop water surface profiles. Then the data is once again used in Arc-GIS with HEC GeoRAS extension from HEC-RAS to delineate flood plains. Suggestion of mitigation measures for the basin is given.

### IV. HYDROLOGIC MODELLING WITH HEC HMS

The Hydrologic Engineering Centre Hydrologic Modelling System (HEC HMS) simulates the precipitation runoff processes of watershed Systems. HMS uses deterministic mathematical modelling to compute various components of the Hydrological cycle.

The main input data used for HEC HMS are: Observed daily precipitation and different watershed characteristics obtained from terrain processing. HEC HMS simulation is defined by the three components: The basin model, the meteorological model, Control specification. The basin model consists of several components like Sub basins, Reservoirs, Junctions, Diversions, Reaches, and Sinks etc. The term loss refers to the amount of rainfall infiltrated into the Soil. For Loss determination NRCS Curve Number method is used. The basins parameters like Curve Number, Lag Time, Potential retention and Initial abstraction were calculated. Runoff transformation converts excess precipitation on a sub basin to direct runoff at the sub basin outlet. In the transform method, NRCS UH module is chosen. In routing method, Muskingum routing was used to route the channel for event hydrological modelling. The routing parameters are K and X values. The K values are the travel time of the flow which is calculated by dividing the reach length by the velocity of water in the reach. The weighting parameter X value can be in the range of 0-0.5.

The Meteorological model contains time series information consisting of Rainfall data. In Meteorological model, the Specified hyetograph was used to produce runoff from given precipitation data. Control Specifications are one of the main components in a model, Even though they do not contain much parameter data. The principle purpose is to control when simulations start and stop and what interval is used in the simulation. The time interval was about one day to run the model taken in this study

The time series data for discharge and rainfall are given in the model .Accordingly the required discharge gauge is to be selected for the corresponding sub basin in the options given under the particular element. Hydrologic model requires the use of paired data to describe inputs that are functional in form. Functional data defines dependent variables in terms of independent variable. The paired data in this study is storage discharge function.

### V. HEC-HMS MODEL RESULTS

HEC-HMS project requires five model data components: Basin Model, Precipitation Model, Control Specifications, Time Series Data and Paired Data. The basin boundary and drainage line layers prepared as background files for HEC

HMS are imported into the model from Arc GIS9.3. The downstream connections between the elements are checked before the initiation of meteorological file. For loss NRCS curve number was chosen. For transform NRCS Unit hydrograph was chosen. For routing Muskingum was chosen.

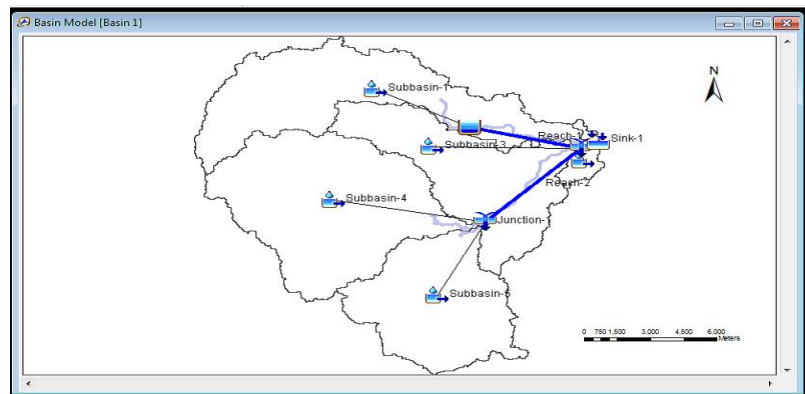


Figure 1-Basin Model of Adayar

Figure 1 shows the basin model of Adayar. It is divided into five sub-basins. The rain gauges were included in Meteorological file. For Adayar Meenambakkam rain gauge station was added

Once the basin model is setup, Rainfall data for each station, the Loss method, transform method and routing method for the sub basins were given and the parameters required for each of these methods along with storage discharge values for the reservoirs were given as input to the model. The control specifications are given for each time period and the simulation run was done. Results can be obtained as Hydrograph, Summary table and time series table. Model calibration is a process through the parameter optimization is done by comparing observed and calculated values. The value of the parameters should fall within the feasible region. In the present study, calibration for hydrologic model was done. The data which was chosen for this purpose is 2005 event. The calibration of rainfall –runoff model was carried out by comparing the observed and calculated data and the parameter values were corrected. In this study, the parameters that were optimized were curve number, Lag time as they would influence the volume of flow and peak flow respectively. After Computing the parameter values during the calibration model parameters were tested for another set of field observations to estimate the model accuracy.

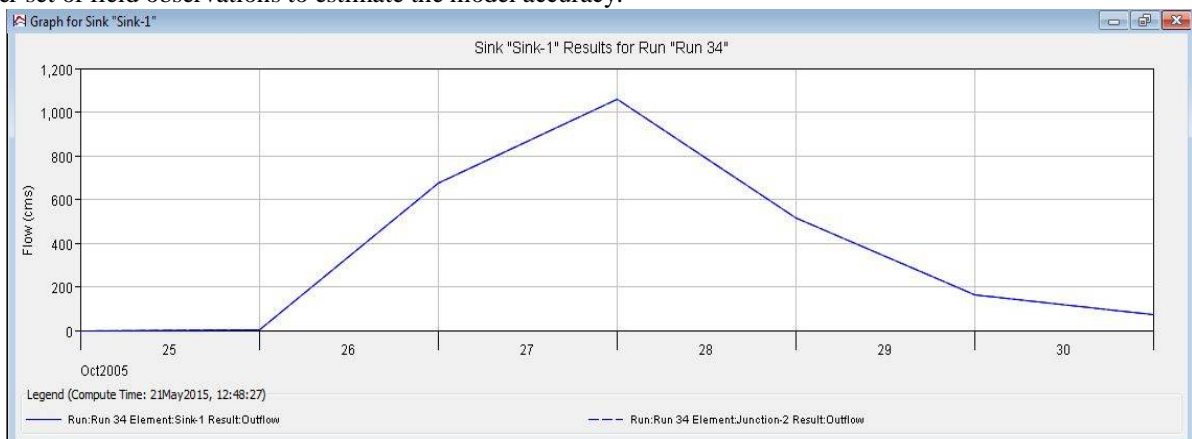


Figure 2 Hydrograph for Adyar (2005 Event)

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Vol. 6, Issue 3, March 2017

Figure 2 shows model validation was carried out for the 1996 event. In this process, if the calibrated parameters do not fix the data of validation, the required parameters have to be calibrated again

### VI. HECRAS OUTPUT

Delineation of flood extent and depth within the floodplain in the three rivers was carried out based on the integration of hydraulic simulation results and GIS analysis using the HEC-GeoRAS extension of ArcView HEC-RAS requires flow and topographic data as channel and flood plain cross section. In the present study, steady flow analysis was done. For Adayar, the river stretch was about 25km taken from nearer to Thundalkalani to Madanandapuram. The steady flow data consist of flow regime, boundary conditions and peak discharge. For Adayar River the flow regime was considered as mixed flow regime and the boundary condition chosen is the normal depth with an upstream slope of 0.0018 and downstream slope of 0.0009. The peak discharge for the study area is taken from HEC HMS output. The peak discharge at each cross section is given as in HEC-RAS to compute the water surface profile. Thus the model inputs are given for the study area and run using steady flow analysis. The model gives the flood plain water surface in 2D View. Areas inundated by flood occur wherever the elevation of the floodwater exceeds that of the land. HEC RAS represents the floodplain as a computed water surface elevation at each cross section. During the data import step, these elevations were brought into ArcGIS, along with the distance from the stream centreline to the left and right floodplain boundaries. Hence two things are known about the floodplain at each cross section, water surface elevation and width on each side of the centreline. With the bounding polygon created, water surface TIN was created from given profiles and underlying DTM/TIN. The water surface TIN consequently gives rise to floodplain delineation.

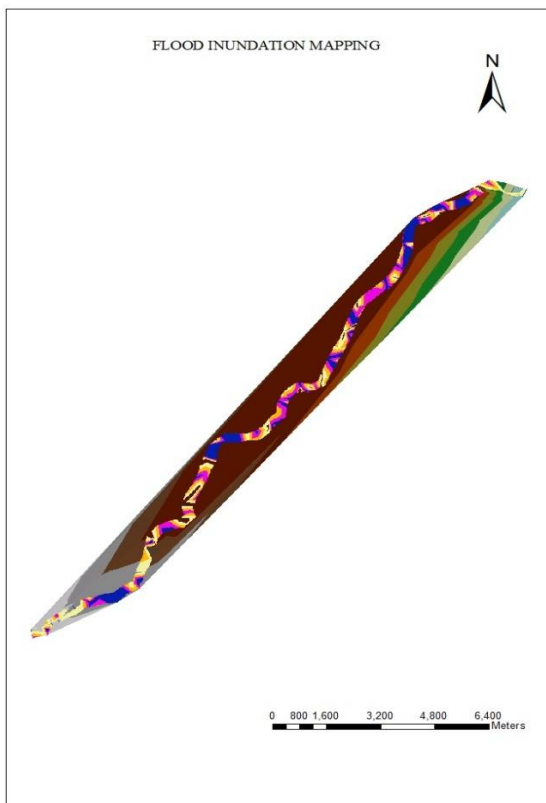


Figure 3 Flood inundation mapping for Adayar river

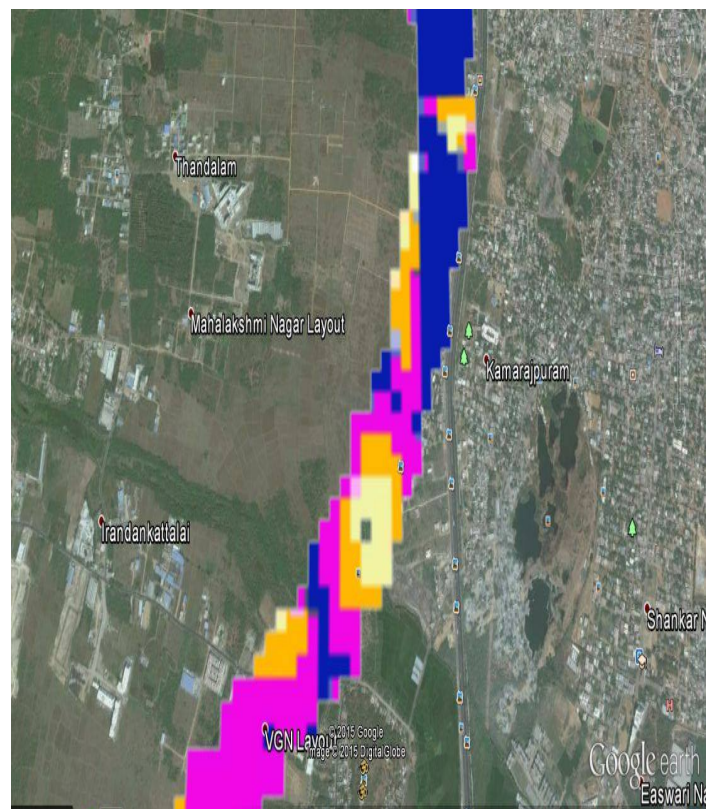


Figure 4 Areas affected in flood -Adayar river

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Vol. 6, Issue 3, March 2017

Figure 3 shows the flood inundation map of adyar after exporting the HEC RAS output to ARCGIS and then by post processing this map was created. Figure 4 shows the areas affected by flood classified as least, less, moderate and high, very high hazard zones

## VII. CONCLUSION

The data requirement for the study includes Rainfall data and discharge data. Rainfall data was collected from Department of Statistics, discharge data was collected from Public Works Department, Chepauk. Toposheet were collected from Survey of India. Event simulation studies generates a record of stream flow from records of precipitation and climatic and basin parameters. The model was calibrated and the parameters lag time and curve number was optimized and validation was done. Flood zone mapping forms the foundation for flood risk and disaster management by providing essential information about the nature and characteristic of flooding. From the hydraulic model results indicate that the flood depth 6.30m, and water spread extent for Adyar 238-274m. This also helps to identify the area that is affected by the flood and to suggest conservation measures. Finally the use of remote sensing and GIS techniques in combination with hydraulic and hydrologic modelling approaches have helped in better simulation results

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