

## Hydrological Simulation Study of Flood Disaster in Adyar and Cooum Rivers, Tamilnadu

### Introduction:

Chennai is a coastal city, where the two rivers, namely Adyar and Cooum, flow through. The Chennai Metropolitan Area (CMA) can broadly be divided into three parts. The northern part lies above the Cooum River, middle region is between Cooum and Adyar Rivers and the southern portion is below Adayar River (figure 1).

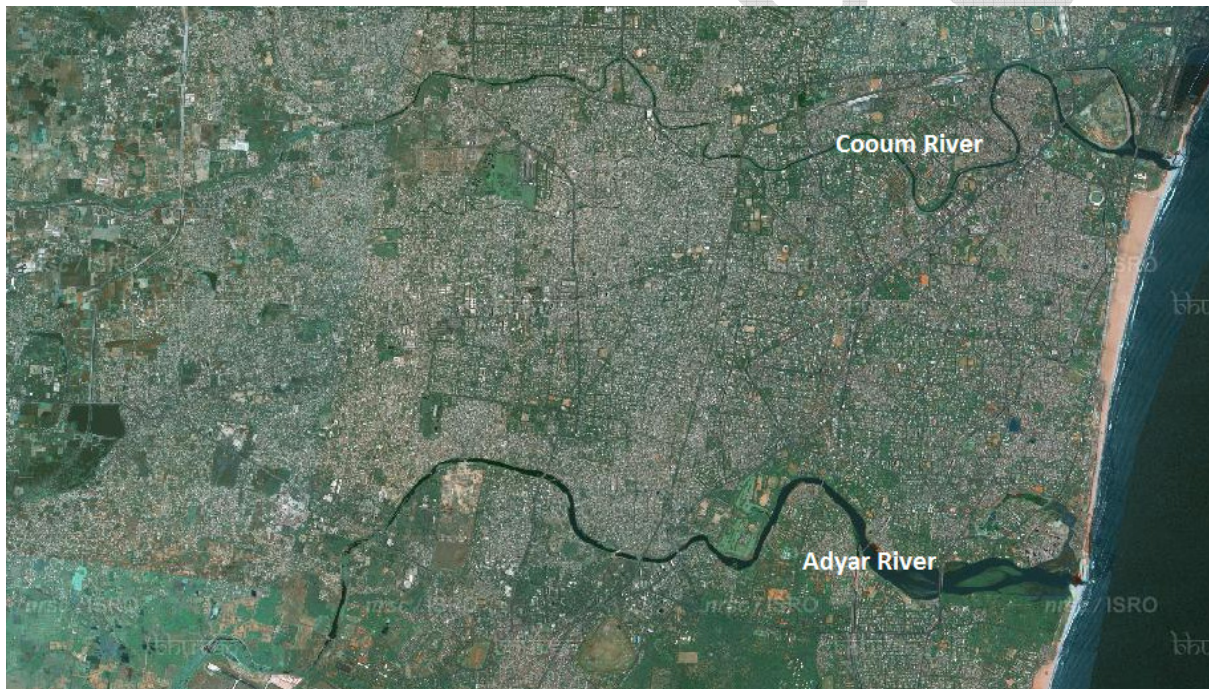


Fig 1. Adyar and Cooum Rivers in the Chennai City

Floods hit the Chennai City due to heavy rainfall in its environs in recent days. Adyar River (748 sq.km approx.) and Cooum River (1266 Sq.Km. approx.) that flows through the Chennai city caused floods due to high intensity of rainfall. These two river discharges are added to the urban floods (flood due to high intensity of rainfall within the city) and inundated the city. Initially there was a flood like situation in both the rivers during Nov 22 to 24 due to heavy rainfall and subsequently, there is an unprecedented rainfall in the catchment on 01 to 02 Dec, 2015, as a result heavy floods triggered in the Chennai City and in its surroundings. A brief hydrological

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and hydrodynamic modeling study has been carried out on the Adyar and Cooum rivers floods for approximate quantification of flood discharges and to forecast the flood discharges for next 2 days (up to 08 Dec 2015).

## 2.0 Rainfall scenario during the flood event:

**In Adyar River Catchment:** Unfortunately neither rainfall data nor discharge data in the catchment is available from the field to quantify the runoff during the flood event. Hence, satellite based rainfall data products are used in the hydrological modeling. Daily rainfall data from Climate Prediction Centre (CPC), TRMM (Tropical Rainfall Measuring Mission), and IMD-forecast rainfall products for the period of 21<sup>st</sup> Nov to 8<sup>th</sup> Dec, 2015 were obtained, analysed and used in the hydrological model (CPC+TRMM rainfall is up to 05<sup>th</sup> Dec). Rainfall distribution in the Adyar catchment from 21<sup>st</sup> Nov to 8<sup>th</sup> Dec, 2015 is shown in the figure 2.

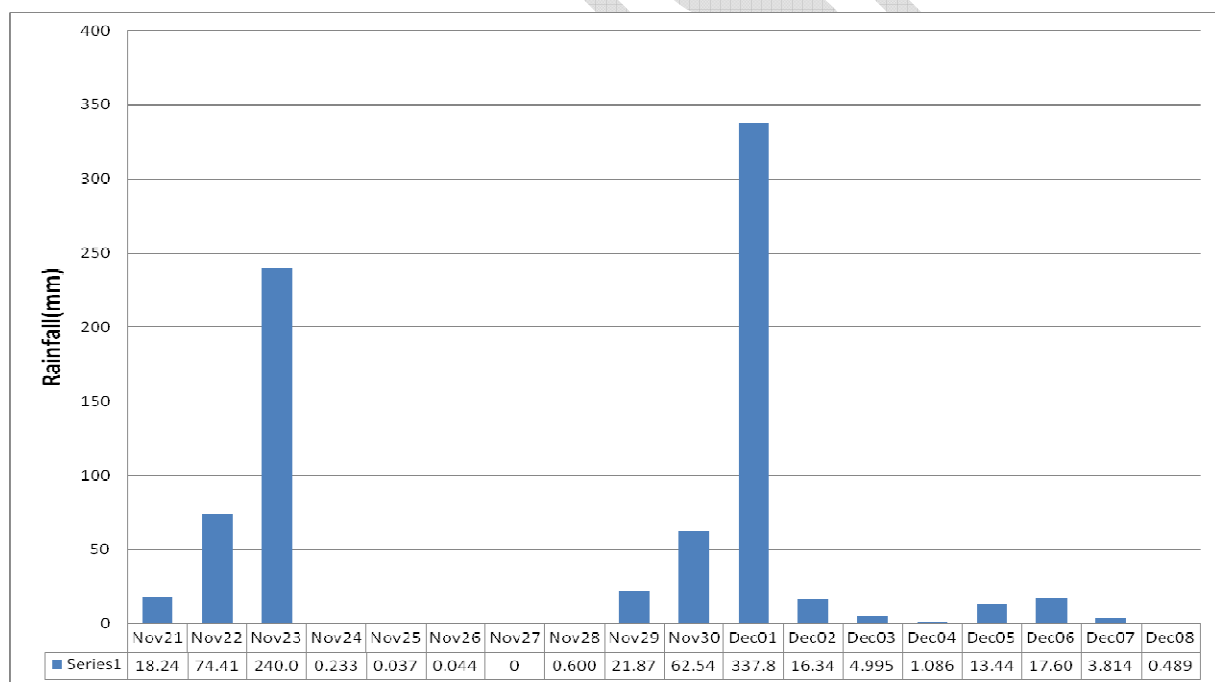


Fig. 2 Rainfall Pattern in the Adyar River Catchment

From this satellite based rainfall data, it can be understood that there was an average rainfall of 240 mm on 23<sup>rd</sup> November, 2015 in the river catchment and followed by high rainfall of 340 mm (average on catchment) on 01<sup>st</sup> December 2015. Due to proceeding day's rainfall, maximum part of 01<sup>st</sup> December rainfall has been converted into runoff. Rainfall of this magnitude is very

unusual in the catchment. From the forecast rainfall data of IMD, it can be inferred that there will be no significant rainfall in the next couple of days.

**In Cooum River Catchment:** Similarly rainfall in the Cooum River catchment also has been analysed. From this satellite based rainfall data, it can be understood that there was an average rainfall of 227 mm on 23<sup>rd</sup> November, 2015 in the river catchment and followed by high rainfall of 248 mm (average on catchment) on 01<sup>st</sup> December 2015 (figure 3) . From the forecast rainfall data of IMD, it can be inferred that there will be no significant rainfall in the next couple of days. Rainfall distribution in the Cooum River catchment from 21<sup>st</sup> Nov to 8<sup>th</sup> Dec, 2015 is shown in the figure 3.

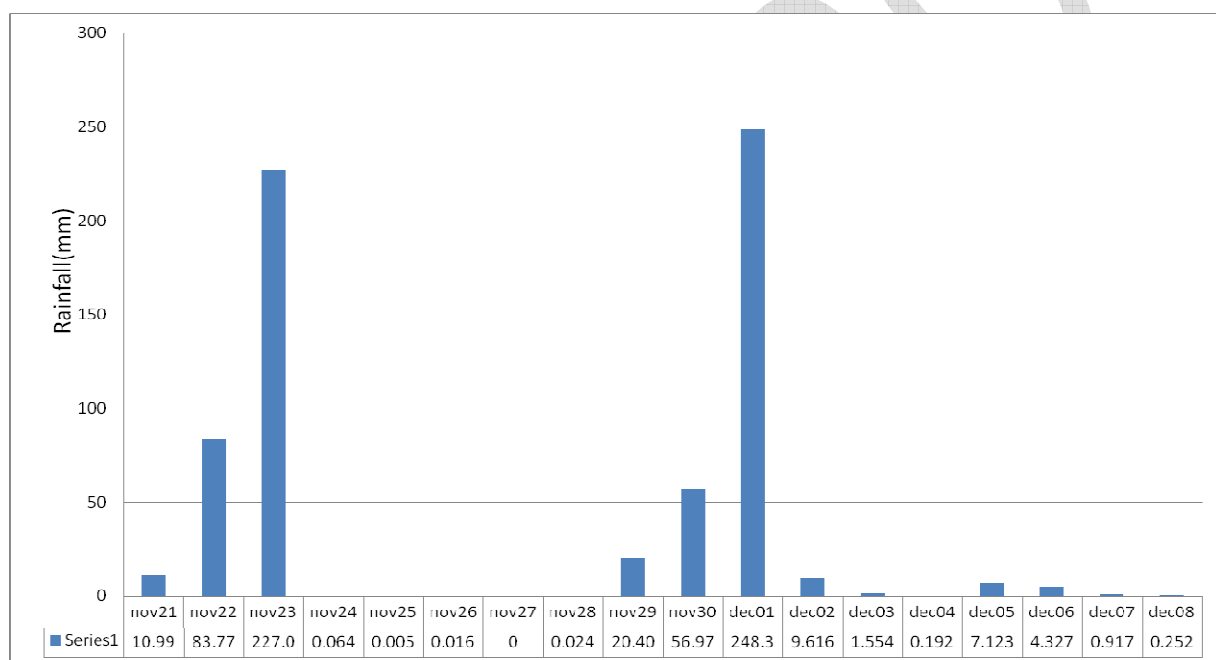


Fig. 3 Rainfall Pattern in the Cooum River Catchment

### 3.0 The Hydrological Model

Hydrological modeling was done to compute the runoff using space based inputs. CARTO DEM, landuse land cover grid (derived from IRS P6 satellite data) of the study area, soil textural maps were used in deriving the input parameters for the study. All the topographic and hydraulic parameters like; catchment slopes, lag-time, channel slopes, roughness parameters are computed (Boundaries of the river catchments are approximate near coast). Rainfall during the mentioned period was extracted from the rainfall images and fed in to the hydrological model. Basin model setup of the Adyar and Cooum Rivers are shown in the figure 4 and 5 respectively.

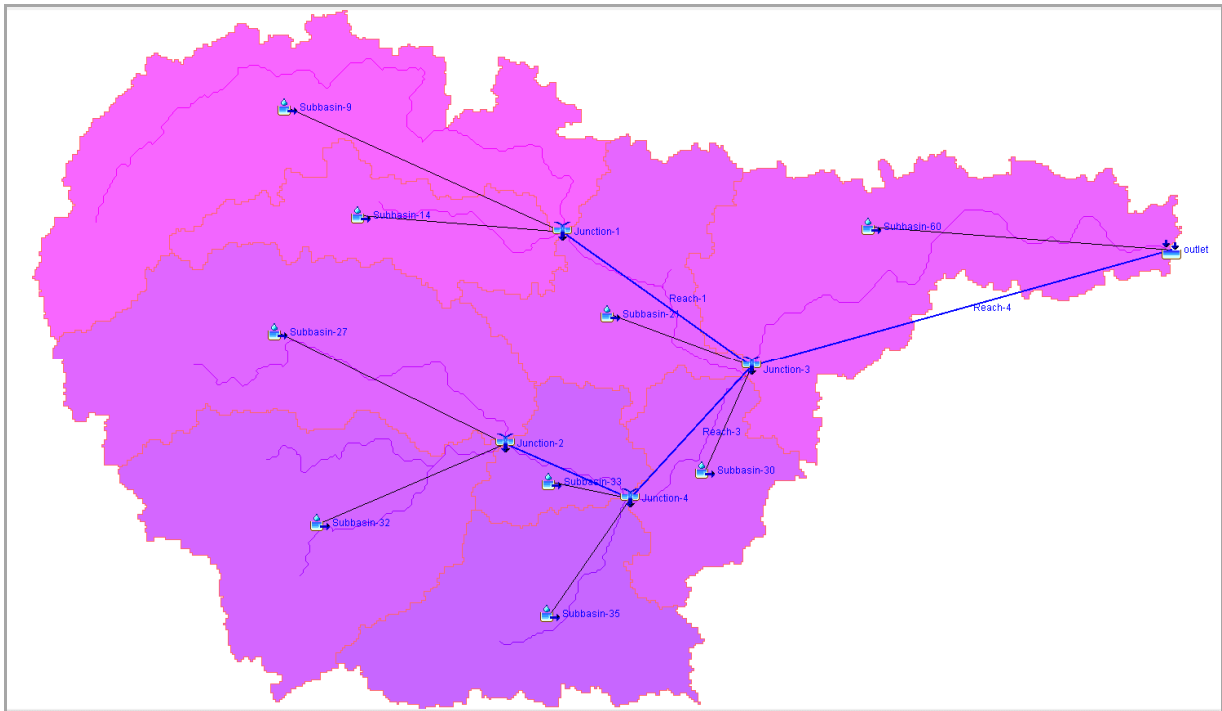


Fig. 4 Basin Model Setup of the Adyar River Catchment

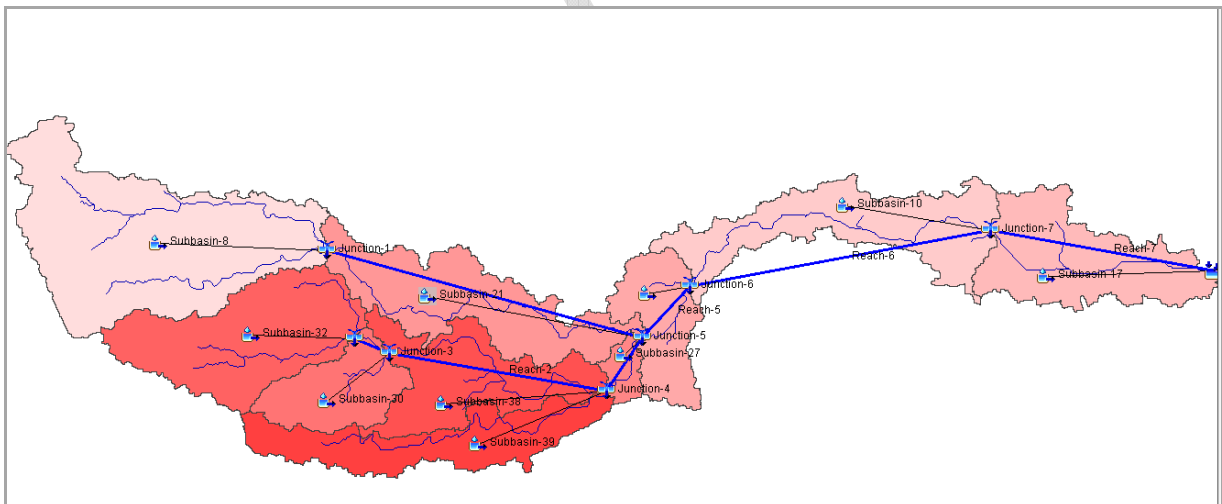


Fig. 5 Basin Model Setup of the Cooum River Catchment

Flood hydrograph at the outlet was computed using the developed models for both the Adyar and Cooum Rivers for the period 21<sup>st</sup> Nov to 08 Dec 2015 and shown in the figures 6 and 7 respectively. As there is no discharge data available in the downstream side, calibration could not be done in the modelling.

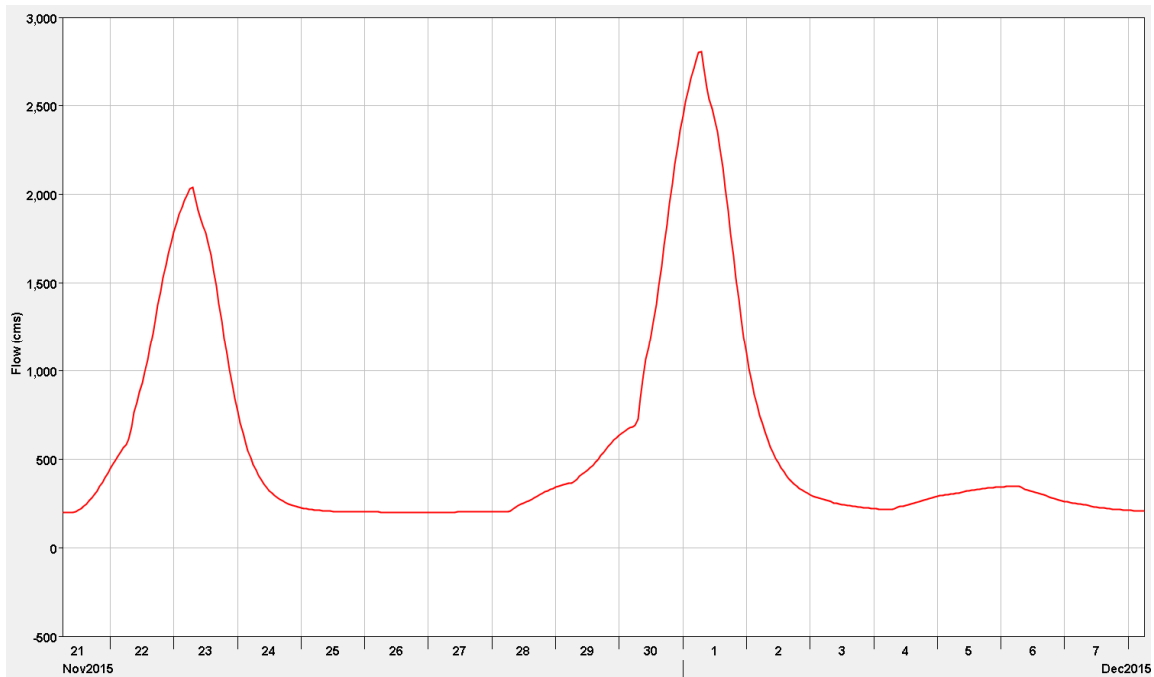


Fig. 6 Computed flood hydrograph of Adyar River

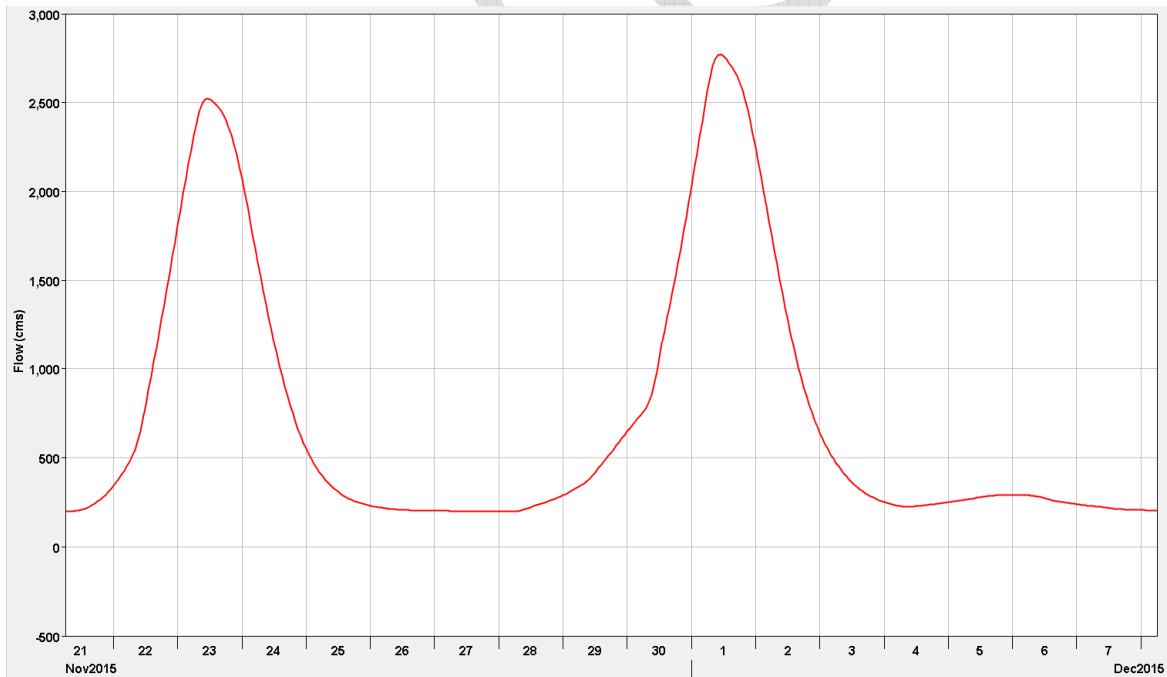


Fig. 7 Computed flood hydrograph of Cooum River

Computed peak flood in Adyar and Cooum Rivers at final outlets are found to be 2850 and 2800 m<sup>3</sup>/sec (approximately). The computed discharge could not be validated with the field discharge as there is no discharge sites are available. As the Rivers are narrow n its cross section, it could not accommodate the flow and caused the flooding. From the forecast rainfall data received from IMD, it is found that flood situation due to rainfall in the catchment will not be there in next couple of days from the present status. From the computed flood hydrographs it is found that river floods have receded completely. As the terrain in the city is very flat, flood like situation may continue till flood water drains out completely. These simulations are to give the flood situation in these two rivers in absence of any field rainfall and discharge data hence, these are approximate.

#### **4.0 Flood Inundation Simulations**

Flood inundation simulations were done using high resolution processed Digital Terrain Model (CARTO DTM of 10 m resolution, msl datum with height accuracy of 3 to 4 m) in the northern part of Chennai upto 20 km stretch from the coast. River cross sections profiles were extracted at regular intervals along Adyar and Cooum Rivers, river longitudinal profile, and other topographic parameters were extracted using the DEM and landuse. The above computed flood hydrographs of both the rivers were used in simulating the approximate flood inundation and in computing the dynamics of flow. Simulated flood inundation during the maximum flood due to these two river floods is shown in the figure 8.

Bare earth elevation model is used to approximate ground level inundation scenario without considering urban infrastructure. Hence, the simulation results are approximate and can give overall picture of flood scenario.

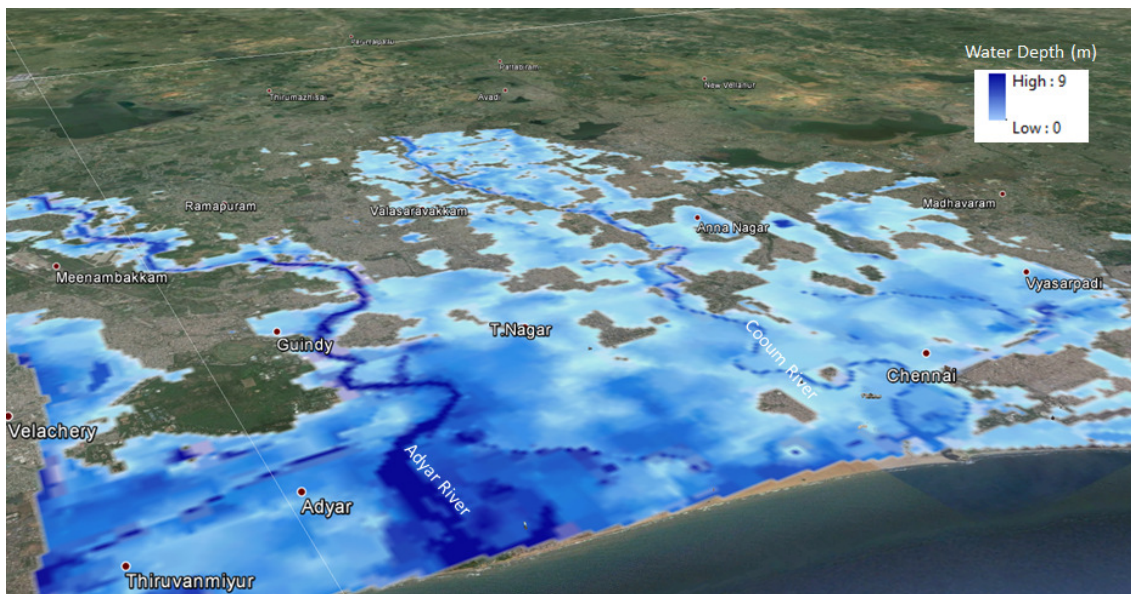


Fig.8 Flood inundation simulations (Northern part of Chennai , up to 20 km from the coast)

## 5.0 Flood Analysis:

**Adyar River:** Total rainfall of 335 mm took place between 21 to 23 Nov 2015 with highest magnitude of 240 mm on 23<sup>rd</sup> Nov 2015. Immediately after this event, unprecedented rainfall of 445 mm took place between Nov 29 to 03 Dec with the highest magnitude of 340 mm on 01 Dec 2015. As a result, peak flood discharges of 2000 m<sup>3</sup>/sec and 2850 m<sup>3</sup>/sec occurred on 23<sup>rd</sup> and 01<sup>st</sup> Dec 2015 respectively. Due to immediate consecutive two peak flood discharges, the floodplains of the river got submerged heavily and created huge damage in the floodplains of the city.

Depths of flood in the Adyar River floodplains are found to vary between 0.5 to 5 m. velocities of flow in the main channel are found to be 0.25 to 2.25 m/sec, and along the flood banks it is found to be 0.1 to 0.9 m/sec.

**Cooum River:** Total rainfall of 330 mm took place between 21 to 23 Nov 2015 with highest magnitude of 225 mm on 23<sup>rd</sup> Nov 2015. Immediately after this event, unprecedented rainfall of 335 mm took place between Nov 29 to 03 Dec with the highest magnitude of 250 mm on 01 Dec 2015. As a result, peak flood discharges of 2500 m<sup>3</sup>/sec and 2800 m<sup>3</sup>/sec occurred on 23<sup>rd</sup> and 01<sup>st</sup> Dec 2015 respectively. Due to immediate consecutive two peak flood discharges, the floodplains of the river got submerged heavily and created huge damage in the floodplains of the city.

Depth of flood in the Cooum River floodplains is found to vary between 0.5 to 2.5 m. Velocity of flow in the main channel is found to be 0.2 to 1.6 m/sec, and along the flood banks it is found to be 0.1 to 0.6 m/sec.

Due to sudden change in velocity of flow from upstream to downstream (floodplains) velocity head has been converted into static head and inundated its floodplains. Due to heavy rainfall in the city area also, storm water flooding got added to the river floods and created havoc in the city. From the satellite images it is found that both the rivers are very narrow in its cross sections. Adyar River width varies from 40 m to 100 m within the city limits, with maximum width of 500 m at coast. River Cooum is further more narrow river compared to Adyar River. Cooum width varies from 30 to 80 m with maximum width of 150 m at coast. These narrow channels could not accommodate the peak flows and caused floods. From the literature it is found that highest floods took place in these two rivers was in 1943 ([https://en.wikipedia.org/wiki/1943\\_Madras\\_floods](https://en.wikipedia.org/wiki/1943_Madras_floods)) it is reported that the present floods are much severe than the floods of 1943 in these two rivers.