

1.0 State of art flood warning system - An overview

As an excellent example of a G2G initiative in building a disaster resilient India, a state of art flood warning system has been developed for Mumbai, by the Ministry of Earth Sciences (MoES), Government of India in Collaboration with Disaster Management Department, Municipal Corporation of Greater Mumbai (MCGM), Govt of Maharashtra. This Integrated Flood Warning system for Mumbai referred to as iFLOWS-MUMBAI, was launched through video conference jointly by Chief Minister of Maharashtra, Shri Uddhav Thackeray and Union Earth Sciences Minister Dr. Harsh Vardhan on 12th June 2020.

2.0 Genesis and development of the iFLOWS-Mumbai

Mumbai, the capital of the state of Maharashtra, a megapolis and the financial capital of India has been experiencing floods with increased periodicity and almost every monsoon, Mumbai struggles to cope with the chaos caused by the rains. The suburban trains which serve as the city's lifeline gets affected, low-lying areas get flooded, traffic jams and water logged streets add to the woes of the Mumbaikars. The Mumbai flood during 26th July 2005, is probably etched in the memory of every Mumbai citizen, when the city received a rainfall of 94cm, a 100 year high in a span of 24 hours paralyzing the city completely. Anticipating floods before they occur, facilitates precautions to be taken so as to protect property and save lives.

In a bid to aid in the mitigation activities of the flood prone city, Disaster Management Department, of MCGM, Govt. of Maharashtra approached the MoES to develop iFLOWS-Mumbai, as similar system was already developed by MoES and put into operation in Chennai. MoES initiated the development of flood warning system in July 2019 through National Centre for Coastal Research(NCCR), an attached office using the in-house expertise available within the Ministry (India Meteorological Department (IMD), Nation Centre for Medium Range Weather Forecasting (NCMRWF) and Indian Institute of Tropical Meteorology (IITM)), in close coordination with Disaster Management Department of MCGM. iFLOWS-Mumbai is a state of art webGIS based decision support system to enhance the resilience of Mumbai city by providing early warning for flooding specially during high rainfall events and cyclones. NCCR has put the system in pilot mode through Disaster Management Department of MCGM and coordinated by IMD-Mumbai.

3.0 Architecture of iFLOWS-Mumbai

iFLOWS is a webGIS based decision support system built on a modular structure and comprises following modules namely Data Assimilation module, Flood module, Inundation module, Vulnerability module, Risk module and Dissemination module as shown in Fig.1.

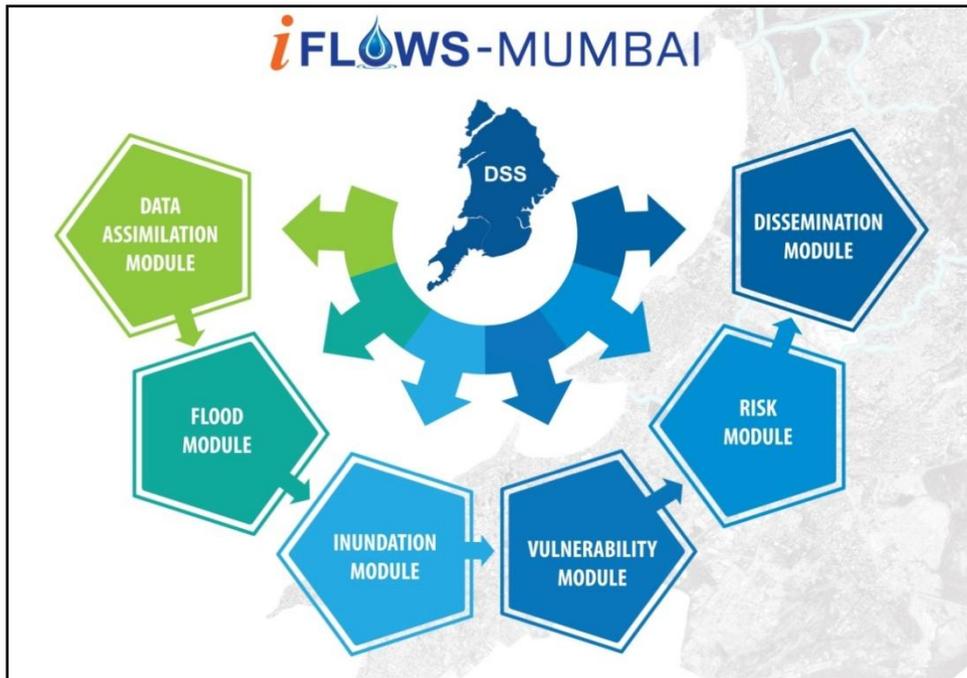


Fig 1: Architecture of iFLOWS-Mumbai

The Data Assimilation Module incorporates the following datasets namely;

- Downscaled weather models for Mumbai from NCMRWF, IMD & IITM
- Weather forecast from IMD
- Rainfall data from a network of automatic rain gauges (120 stations) from IITM, IMD and MCGM. (Fig.2)
- Digital elevation model with a resolution of 20 cm from Disaster Management Department of MCGM
- Water level data across rivers from DMD, MCGM
- Landuse, infrastructure and other thematic datasets were provided by Disaster Management Department of MCGM.
- Bathymetry data for rivers and lakes across Mumbai city, extensive field survey conducted by NCCR, Disaster Management Department of MCGM and IMD, Mumbai.

The Flood Module simulates the combined effects due to river flow, inundation in floodplains, flooding in streets, collection through drainage networks, inundation due to storm surge in coastal areas and breach discharges from reservoirs. For the study area an integrated hydraulic and 2D hydrodynamic model is created which simulates the flow of runoff from precipitation over the study area, the flow of water that breaches the river banks (river model), effects of overflowing from drainages (1d hydraulic model) and the effect of the coastal boundary on

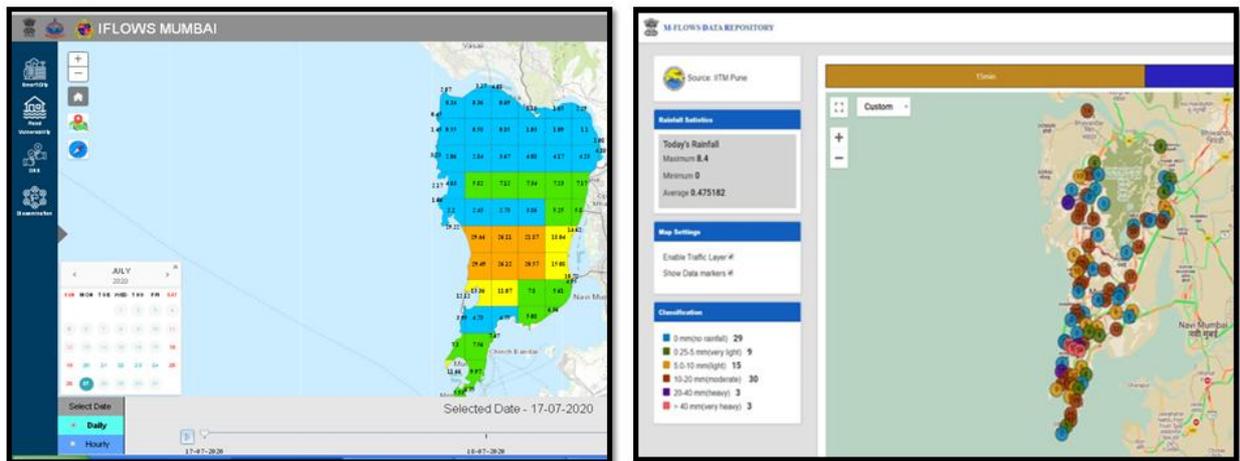


Fig.2. Meteorological forecast Models and Observation datasets in iFLOWS-Mumbai

inundation in the study area. The 2D hydrodynamic model also has the sea bathymetry integrated with it and considers water levels of the sea at the coast as the offshore boundary condition. The inundation model translates the model outputs to inundation maps and stored in the Geodatabase. Spatial analysis are carried out in a GIS environment and vulnerability and risk are calculated. Flood reports incorporating the water depths are generated at city and ward level to enable the administration to take smart decisions to manage the situation based on a scientific and holistic assessment of flooding risks. The Dissemination Module makes information available to field officials through various communication channels, enabling them to take prompt and informed field action.

4.0 iFLOWS-Mumbai-workflow

The primary source for the system is the amount of rainfall, but with Mumbai being a coastal city, the system also factors in tidal waves and storm tides for its flood assessments. Based on inputs from weather models, Hydrologic models are used to transform rainfall into runoff and provide inflow inputs into the river systems. Hydraulic models are used to solve equations of fluid motion to replicate the movement of water to assess flooding in the study area. The hydro dynamic models and storm surge model are used to calculate the tide and storm surge impacts into the model domain.

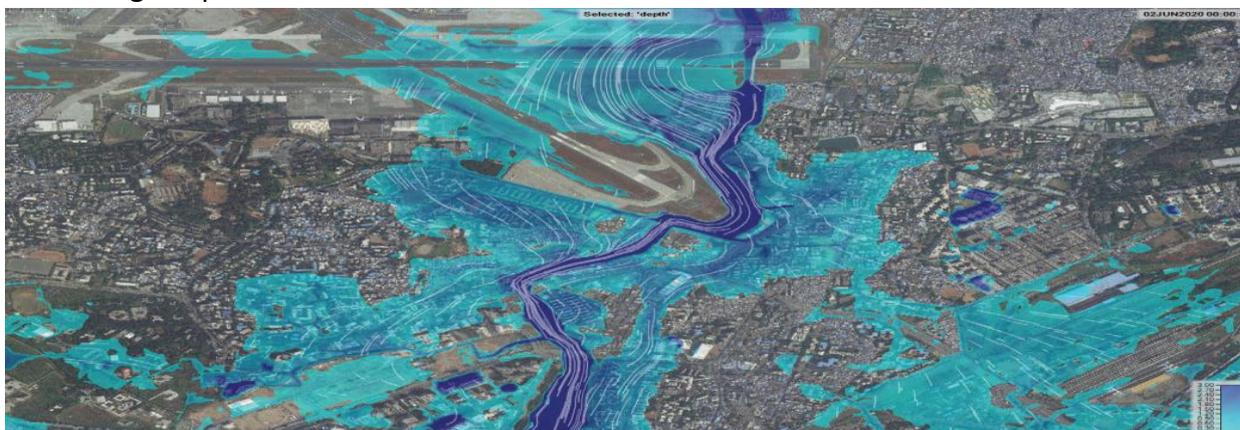


Fig 3: Flood Inundation Modelling

The system will use forecasted rainfall from the numerical weather models and Flood inundation will be estimated for Mumbai three days in advance. The system will also work in now cast mode using precipitation data available from the dense network of rain gauges and radars established by Ministry. A web GIS based decision support system is build to calculate the vulnerability and risk of elements exposed to flood. The infographics of the system is shown as fig.4.



Fig.4 Infographics on the workflow in iFLOWS-Mumbai

5.0 Utility of iFLOWS-Mumbai

iFLOWS-Mumbai is a monitoring and flood warning system that will be able to relay alerts of possible flood-prone areas between six to 72 hours in advance. The system can provide all information regarding possible flood-prone areas, likely water depth, location-wise problem areas across all 24 wards and calculate the vulnerability and risk of elements exposed to flood. This data will be useful to the administration to plan evacuation from low lying areas atleast 12 hours in advance. iFLOWS-Mumbai will address the flood inundation due to rainfall, river bank breach, storm surge, obstruction of flow due to roads, buildings, rail lines, high tides and sea level rise. The system will help make the city become more resilient, by providing early warning for flooding especially during high rainfall events and cyclones. The dashboard of iFLOWS-Mumbai is shown as Fig.5.



Fig 5: iFLOWS-Mumbai WebGIS dashboard

Based on weather forecast models, flood models are run and water level reports are generated at ward level to help identify the most vulnerable areas and dynamic charts help the decision makers in their flood mitigation operation. All outputs including the model and vulnerability reports are uploaded in the server and made available at realtime to IMD-Mumbai and DMD-MCGM (Fig 6).



Fig. 6: iFLOWS-Mumbai Flood Reports at Ward level

Apart from the Dashboard a “Flood Atlas” has been prepared depicting areas prone for flooding using various flood scenarios to serve as a ready reckoner to help plan mitigation operation well ahead of the monsoon season.

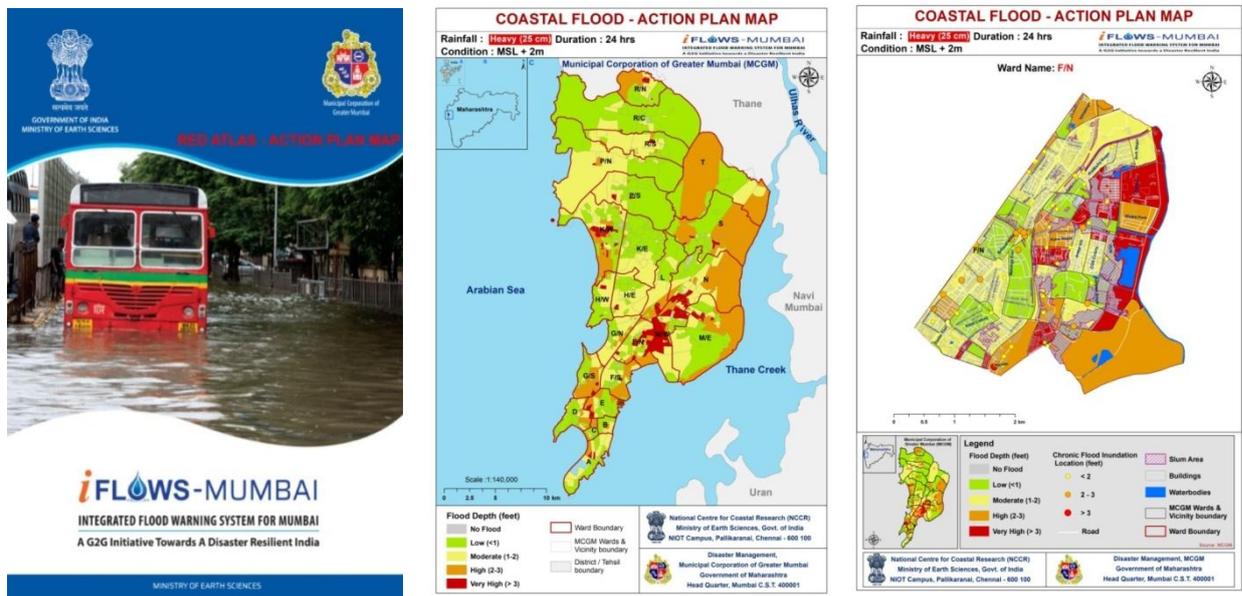
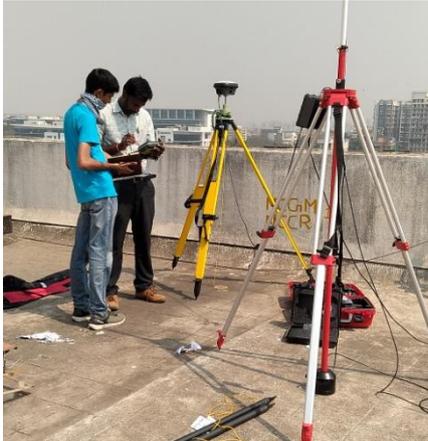


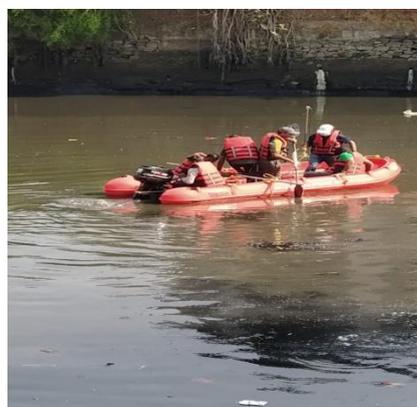
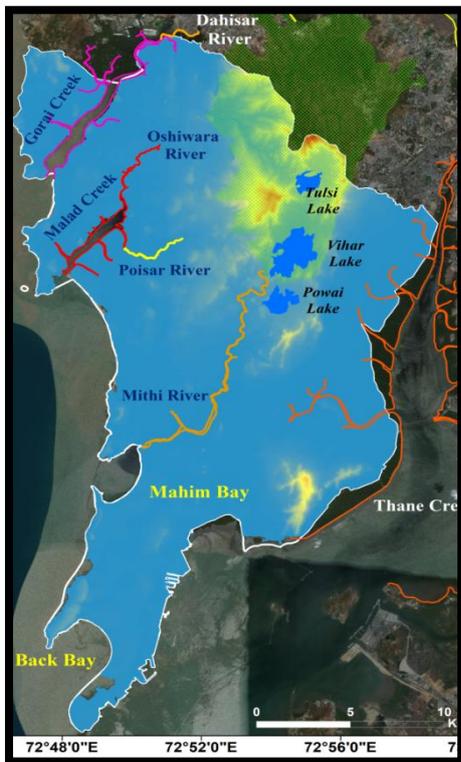
Fig. 7: iFLOWS-Mumbai Flood Atlas

iFLOWS-Mumbai is presently in testing phase (Monsoon 2020) and the operational system will be handed over to DMD-MCGM and it will be maintained with support of IMD-Mumbai

Topographic Survey



Bathymetric Survey



Extensive bathymetry data collection across all major river and lakes of Mumbai (Feb 2020), by NCCR, DMD-MCGM and IMD-Mumbai

PERIODIC REVIEW MEETINGS



VIDEOS

[IFLOWS-MUMBAI-VIDEO](#)

[IFLOWS-MUMBAI-LAUNCH](#)