Increasing urban climate resilience by Installation of Internet of Things (IoT) based Early Warning System

to address flooding and water logging

Thane Municipal Corporation, India

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Increasing Urban Climate Resilience by Installation of Internet of Things (IoT) based Early Warning System to Address Flooding and Water Logging

Thane Municipal Corporation, India

Summary

Total geographic area: 128.23 km²
Total Population – 1.84 million
Population Density – 14349 persons per km²

Snapshot of the Case Study

Thane is a rapidly growing and heavily populated, low-lying city, prone to flooding, and waterlogging from high-intensity rainfall. Marked by its unique location with high hills on one side and submersible marshland along the Thane Creek and Ulhas riverbank, the city is highly vulnerable to floods and inundations. These floods mainly occur on account of the high runoff during short duration high-intensity rains and high tide conditions that blocks the outfalls in Ulhas River Estuary and Thane creek. The proximity of other urban/ peri-urban areas in the catchment such as Bhiwandi, Dhombivali, the limited water retention capacity exacerbates flooding in the region.

In Thane, an early warning system enabled by IoT was used for real-time monitoring of rainfall, the water level of creeks and drains, demarcation and tracking of tidal and flood levels, and updates to aid authorities to alert, plan and prepare during such events.

The project addressed the following critical needs:

- Non-structural flood mitigation measures by providing real-time information
- Easy medium for information dissemination across the city authorities and to the entire community
- Contribution towards improving the resilience of economy and society by providing real-time alerts for social safety, preparedness, reduced casualties and economic losses
- Contribution of the network of sensors at 6 locations that support the building of a database at the local level to inform urban planning and disaster management in the light of climate change

Introduction

Thane, is a rapidly urbanizing city of Maharashtra state, in the vicinity of Mumbai, the financial capital of India. Being one of the smart cities under the Smart Cities Mission of the Government of India, the Thane Municipal Corporation (TMC) has been spearheading several interventions proposed for clean, sustainable, and smart solutions for urban infrastructure and the environment while aiming to reduce GHG emissions. The project **Thane Urban Flood Alert Network (TUFAN),** deployed an IoT-based early warning system for flooding and water logging in Thane city under the Urban-LEDS II project.

Project Objectives

The project aimed towards;

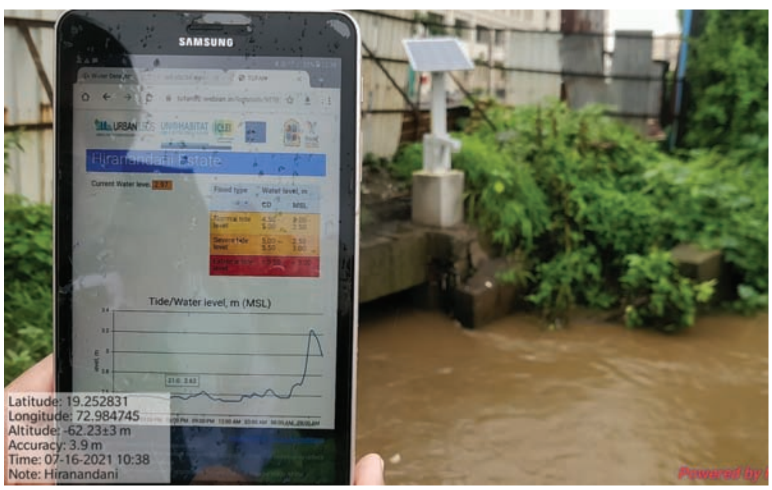
i) Developing real-time warning system to enable swift response of city administeration and citizens to incidences of urban flooding and water logging

ii) Enhancing resilience of Thane city for reducing the impacts of floods and the associated damage/loss of property, infrastructure, and human health and environment

iii) Using IoT based smart solutions for establishing the effectiveness of sensor-based systems in climate vulnerable urban areas

Rationale of interventions

Thane's Climate Risk and Vulnerability Assessment report projects extreme rainfall to increase by 10-14% in the city (ICLEI, 2021), consistent with the IPCC projections of the Sixth Assessment Report on rise in heavy rainfall/cyclones and flooding in South Asia (IPCC, 2021). The highly populated low-lying city is vulnerable to flooding posing a serious threat to the city's infrastructure, society, and



Maps of Thane City

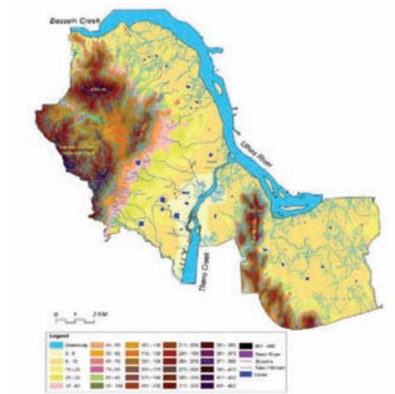


Figure 1. Ecological Base Map for lakes in Thane city (Pradhan and Latkar, 2009)

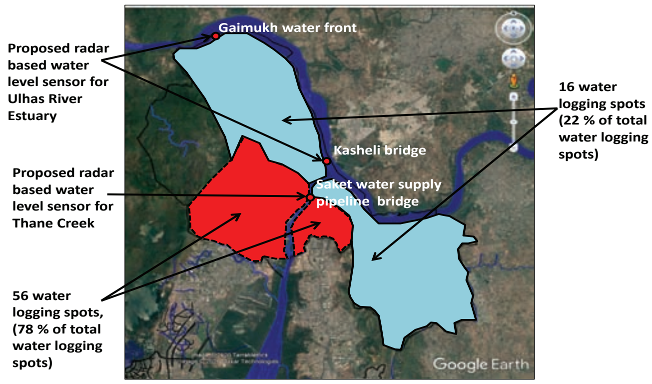


Figure 2. Situation of Water logging in Thane

economy. To reduce vulnerability to floods, several mitigation and adaptive measures were taken up including non-structural measures such as enhanced forecasting of heavy rains for alerting, preparing for risks, and managing floods. IoT architecture for flood data management has been successfully used in several other Indian cities for collecting, transmitting, and managing flood-related data. The feasibillity assessment undertaken in Thane city included a detailed study of the rainfall trend analysis, assessments of flooding, and waterlogging of nallahs that aided the identification of vulnerable hot spots (identifying 72 low lying waterlogged areas) in the city which has provided inputs to site selection for installing pilot water level sensors for early warning. The sensors enable the forecast of flooding & waterlogging and its management based on the real-time data on rainfal, water levels, and tidal ingress.

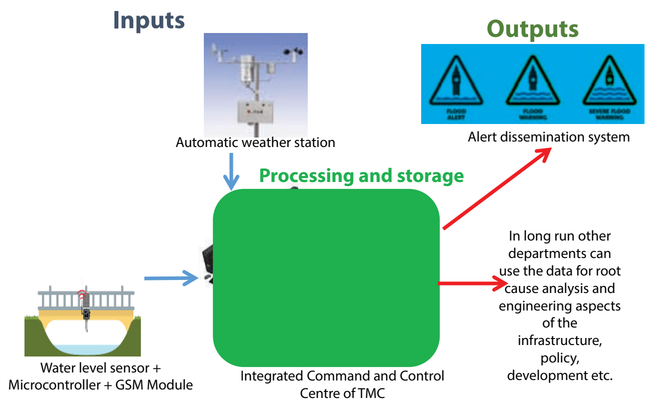


Figure 3. System Architecture

Organisations, Stakeholders, Location, period of implementation

The project TUFAN was conceptualized and implemented by TMC and ICLEI South Asia, under the Urban-LEDS II project (2017-2021), funded by the European Commission with support from the UN-Habitat. Expert consultant from M/s Enviro-con Urban Hydro Environment Centre was hired for the technical feasibillity study and the vendor/solution provider M/s 'Bulfro Monitech Pvt. Ltd.' for implementation of the solution. The pilot project encompassed technical feasibility study and identification of locations for pilot deployment, and supply, installation and testing of IoT-based early warning system for waterlogging using Water-level sensors and Automatic weather station with data loggers.

The scope of work also included comprehensive maintenance of the sensors for five years. The Stormwater management department, Pollution Control Cell, Integrated Command and Control Centre, Regional Disaster Management Cell, Electricity department, Smart City Cell, and IT department of TMC were involved in the consultations, implementation, and post-implementation operation and maintenance.

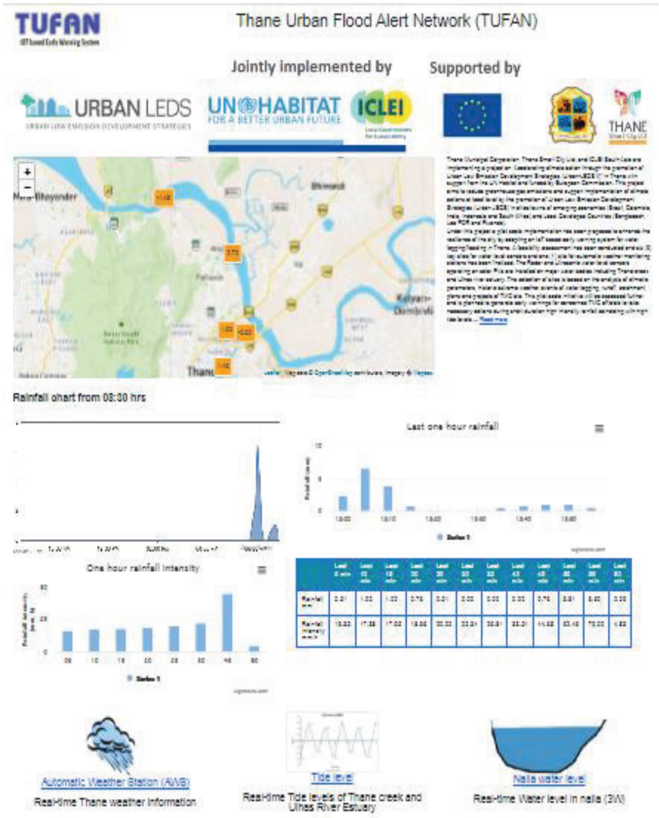
Project Activities

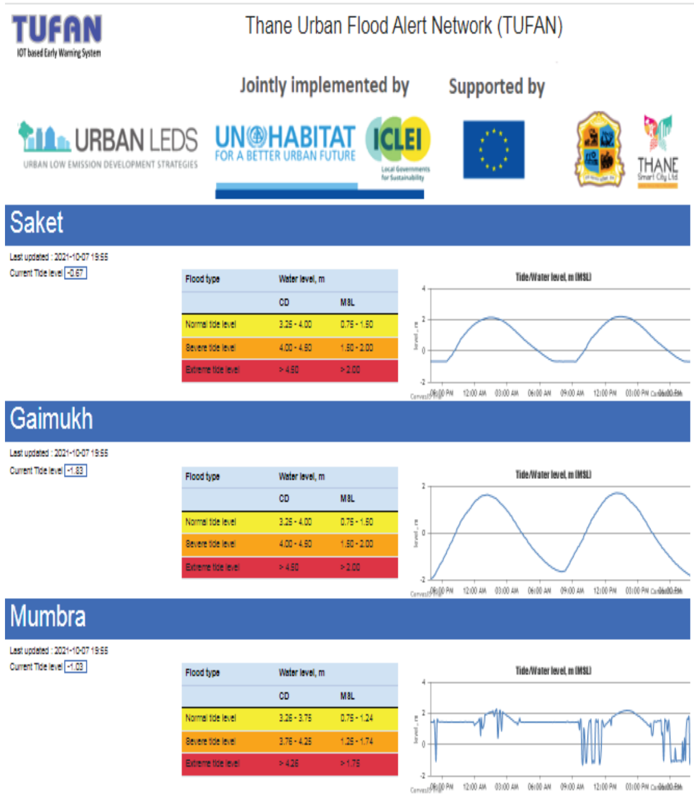
The project was divided into two main components:

i) Planning & Feasibility assessment for installing an early warning system for flooding/water logging through IoT measures and ii) supply and implementation of identified sensors and IoT system at the selected locations along with comprehensive O&M for 5 years.

Project activities included:

- Feasibility studies undertaken by the consultant comprised of data analysis for drain (nallah) catchments, rainfall trend analysis, and catchment delineation for selected vulnerable areas.
- Identification of six locations (Saket, Gaymukh, Hiranandani Estate, Thana College, Vrindavan Society, and Mumbra) by assessing prior waterlogging and flooding through the feasibility study. In addition, modelling and scenario building was undertaken for drain (nallah) no. 3 at the west side of the city. The detailed technical assessment ensured that the system is put in place at critical points/locations and it addresses a major portion of the city's areas prone to flooding and water logging.





- The technical assessments encompassing selection of the technology (suitability of the location to ultrasonic or radar-based technology) for the specific sites and understanding the threshold levels for flooding at each location.
- Supply and implementation of the pilot early warning system, including six IoT based sensors, which enabled forecasting of floods and waterlogging based on monitoring of real-time water levels at major water bodies such as the Ulhas River Estuary, Thane Creek, stormwater network (nallahs), and the tidal influence and their interconnections.
- In addition, modelling and scenario building was undertaken for drain (nallah) no. 3 at the west side of the city.
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- Analysis of water level data, tidal ingress, and rainfall data (from one automatic weather station procured and set up for recording the rainfall and other weather parameters) is used to alert the relevant authorities for planning and preparedness.
- Pilot tests successfully undertaken during the monsoon season of 2021.

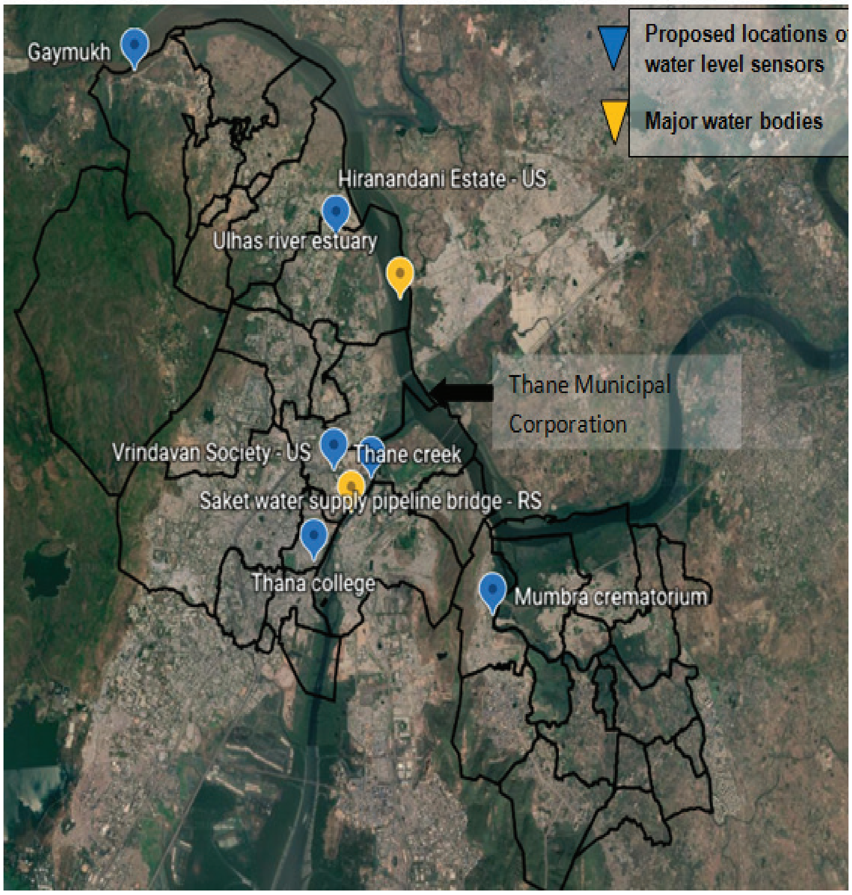
A key feature of this pilot is the integration of the sensors with the Integrated Command and Control Centre which hosts the ICT infrastructure for monitoring and effective management of the city. When water levels at the six locations exceed threshold flood levels, the concerned officials are informed through the TUFAN system. All data is communicated through the IoT platform and analysed at the Integrated Command and Control Centre. The main output of the project is the provision of crucial knowledge through monitoring and dissemination and communication of the same. The outcomes of the project are following the project objective, a particular highlight being effective communication of crucial knowledge for enhanced management of waterlogging, floods, and disasters.

Project Benefits

The project aligns with the **Smart Cities Mission** in India and also supports the climate action-related schemes of Maharashtra State and the Nation. Thane City has already implemented several smart city concepts such as *Integrated City Data Center & Command and Control Room Facility* (ICDCF), smart water metering, etc, for integration of information communication and technology (ICT) for effective and sustainable urban infrastructure and service delivery.

Studies predict that and waterlogging events, that have caused extensive damage and economic losses such as the floods of 2005 are expected to double by 2080 (Dhiman et al, 2018). Changes in precipitation and increase in short-duration high-intensity rainfall events, and sea-level rise on account of the proximity to the Ulhas river estuary, and Thane creek are identified as the main climate change risks for Thane city. The project contributes towards building climate resilience by the application of IoT for capturing the real-time data for early warning of flooding/waterlogging.

Cities like Thane are important drivers of the region's and country's socioeconomic and industrial development. The pilot solution helps to better manage urban flooding, which poses a threat to socio-economic well-being through material damage, business interruption, environmental damage, and other socio-economic consequences.



No.	Location	Water body
1	Saket water pipe line bridge	Tidal water level in Thane creek
2	Gaymuch riverfront	Tidal water level in Ulhas river estuary
3	Thana College -N. G.Bedekar	Water level in Nalla no. 3 (runoff from Navpada area) and tidal impact
4	Vrindavan society	Water level in Nalla no. 6 (runoff from Wagle, Vartak Nagar, Uthalsar)
5	Hiranandani estate	Water level in Nalla no. 11 (runoff from Patlipada, Hiranandani area).
6	Mumbra crematorium	Water level in Mumbra nalla

Figure 4. Location of real-time water level sensors

Challenges

Monitoring & analysis of data and prediction: One of the main challenges in flood management is the lack of accurate information. Monitoring, analysis, and data prediction are effectively addressed with IoT where accurate and reliable real-time data is made available to enable city administration and citizens for a prompt and adequate response.

Dissemination of data and communication: Effective communication of data requires that the information is received and understood by all the relevant stakeholders. The Central Water Commission's colour codes of yellow, orange, and red are used to communicate the intensity of the tides /floods as normal, moderate, and high. Automatically generated emails/SMS alert messages are effective communication strategies.

Challenges associated with the use of new technology are overcome through adequate participation and effective capacity-building which was an important component of this project. On finalization of the technology and the sites through the study, the installation was undertaken in close coordination with the relevant departments such as Storm Water and Disaster Management Cell. The integeration was done in close colaboration with the IT department (that manages the Command & Control Centre's ICT infrastructure) to link/integrate the sensor and their datasets with ICT infrastructure such as servers. Since the IOT based pilot aligns well with the technical expertise and purview of the IT Department, their involvement during the project execution helped them comprehend and get familiar with the early warning system and its outputs, boosting their management and operation capabilities.

PLANNING PROCESS 01

i) Climate vulnerability and risk assessments

ii) Feasibility assessment, hydro-geological study, analysis of extreme weather events and waterlogging areas, review of existing plans

iii) Identification of vulnerable areas and selection of key sites for monitoring water levels in stormwater networks and major water bodies

METHODOLOGY 02

i) Solar powered ultrasonic and radar-based sensors to record data and transmit to the central server through the internet

ii) Automatic weather monitoring system to record weather parameters. Rainfall intensity computed and displayed on a graphical user interface

iii) Automatic generation of alerts if rainfall is more than 10 mm in 15 min. Automatic communications

OPPORTUNITIES 03

i) Enhancing climate resilience in the city

ii) Reducing climate risks and possible damage to lives and infrastructure

iii) Improving planning, IoT based monitoring, and precautionary measures

iv) Success of IoT techniques for real-time monitoring and management of floods

Lessons Learnt

- **Combining structural (engineering solutions) and non-structural (social measures such as early warning systems) enhances urban resilience.** TMC has undertaken structural measures (such as widening of drains, augmenting of storm water network infrastructure, etc) with nonstructural measures encompassing monitoring of water levels, training etc. Implementation of the early warning system provides adequate opportunity to enhance capabilities of the city administration and citizens to effectively manage and respond to flooding and water logging, given projected climate change impacts. TMC has undertaken structural measures (such as widening of drains, augmenting of storm water network infrastructure, etc) with non-structural measures encompassing monitoring of water levels, training etc. Implementation of the early warning system provides adequate opportunity to enhance capabilities of the city administration and citizens to effectively manage and respond to flooding and water logging, given projected climate change impacts.
- **Multi-stakeholder coordination:** Implementation of the program in close coordination with key TMC departments such as Smart City Cell, Disaster Management Cell, State Pollution Control Board, IT department highlights partnership as a key element of successful implementation of cross-cutting programs and actions. Such an approach also enables to tap into local expertise and long-term sustenance of new solutions. For instance, drawing on the IT department and Smart City cell's expertise on sensors and integration of IoT ensured that the pilot project is well-embedded into the city management systems and contributes effectively in day-to-day operations of departments such as Disaster Management Cell and Storm Water Management.
- **Innovative solutions with local-level strategic planning and implementation:** Using a comprehensive approach for assessing issues, finding solutions, finalizing locations for application of technological interventions, methodology, the approach together enables efficient implementation of measures. Based on the analysis of climatic parameters, previous events of waterlogging, and other vital factors in the feasibility study, six strategic locations (Saket, Gaymukh, Hiranandani Estate, Thana College, Vrindavan Society, and Mumbra) were shortlisted for water level This helped to address a large part of the urban area vulnerable to water logging and flooding.
- **Enabling Policy Environment:** Supportive policies and programs such as the Smart Cities Mission of India launched in June 2015, for developing smart infrastructure and systems towards clean and sustainable urban development, have supported the IoT-based TUFAN project. Efficient, data-driven decision-making in the TUFAN project has enhanced the program objectives of building climate-resilient cities. Bilateral funds and programs can play a key role towards facilitating initial adoption of sustainable and innovative solutions with replication and scalability for strengthening climate resilience.

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MU GAMMA Consultants Pvt. Ltd

Case Study authored by Mu Gamma Consultants Pvt. Ltd. with contributions from ICLEI South Asia

For more information, please contact:

ICLEI- Local Governments for Sustainability, South Asia

C-3 Lower Ground Floor, Green Park Extension, New Delhi 110 016, Tel: +91-11-4974 7200, Fax: +91-11-4974 7201, Email: iclei-southasia@iclei.org