Visioning Workshop Report

Resilient HydroTwin: Participatory Integrated Digital Twin for Adaptive Urban Resilience to Water Extremities

28 January, 2026
IIT Madras Research Park

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Background and Objectives

The Resilient HydroTwin (RHT) project, funded by the Department of Science & Technology, GOI aims to build a participatory and integrated digital twin (DT) platform to support adaptive urban resilience to water extremes such as floods. This Indo-Dutch project focuses on Tambaram City Municipal Corporation and is led by IIT Madras in partnership with Okapi Research & Advisory and Care Earth Trust and in collaboration with partners from TU Delft and TU Eindhoven.

The Visioning Workshop is the second in a series of workshops planned under the Resilient Hydrotwin project. The two key objectives of the workshop were to engage stakeholders to share learnings and perspectives on grey infrastructure, Blue Green Infrastructure (BGI), and soft measures for flood resilience through participatory methods and to develop a dynamic threshold definition for road transport resilience under flood hazards. The discussions and knowledge exchange during the workshop would help come up with strategies reflecting multi-stakeholder priorities that foster a sense of ownership and collaboration for future policy and planning processes.

The workshop brought together key stakeholders from government, academia, NGOs, and private organizations working on the city's flood resilience. Participants included representatives from Tambaram City Municipal Corporation (TCMC), Tamil Nadu Water Resources Department (WRD), Infrastructure Fund Management Corporation Limited (IFMC), Chennai Unified Metropolitan Transport Authority (CUMTA), Directorate of Municipal Administration (DMA), Institute for Transport and Development Policy (ITDP), Care Earth Trust, IITM Pravartak INSPAN project, SECON, Sponge Collaborative, Shreya Krishnan Design Office (SKDO) , Madras Terrace Architects, TU Delft and TU Eindhoven.

Prof. Balaji Narasimhan welcoming the participants to the RHT Visioning workshop

Overview of Technical Presentations and Conceptual Frameworks

The session began with a brief round of participant introductions. This was followed by technical presentations on Digital Twin (DT) based approaches for urban flood resilience by Dr. Balaji Narasimhan, Professor at IIT Madras, Principal Investigator of the Resilient Hydro Twin project, and member of the Flood Advisory Committee and Dr. Ranjith K Soman, Assistant Professor of Digital Construction, TU Delft and Principal Investigator of the Resilient Hydro Twin project.

The presentations focussed on the integration of behavioural models, decision support systems, visualisation dashboards, and output modules. The importance of preparatory and iterative workshops was highlighted as part of the resilience planning process. These include policy adaptation, resilience assessment and testing, and implementation as iterative learning processes to continuously refine strategies and interventions.

Prof. Balaji Narasimhan presenting on the overview of the project

A multi-domain framework for resilience assessment was proposed, integrating the flood hazard domain (flood depth), operational domain (road capacity and traffic simulation), and physical domain (building and infrastructure characteristics). The interaction of these domains collectively would inform the behavioural dynamic domain, particularly evacuation system dynamics, which incorporates stakeholder criteria to support resilience assessment and the identification of appropriate adaptation measures.

Prof. Ranjith K Soman presenting on the capabilities of the Digital Twin

As part of the modelling demonstrations, Dr. Balaji. L, Senior Research Associate, IIT Madras presented flood depth maps for the worst-case scenario (Making an assumption of 75% release from the Chembarambakkam lake). These maps illustrated the spatial extent and severity of inundation under extreme conditions, supporting risk identification and prioritisation of mitigation measures. Dr. Parama Roy, Executive Director of Okapi, further elaborated on TCMC's current monsoon management practices and expanded on the role of Blue-Green Infrastructure (BGI) as a sustainable, adaptive urban flood management approach.

Dr. Balaji.L presenting on development of flood depth maps

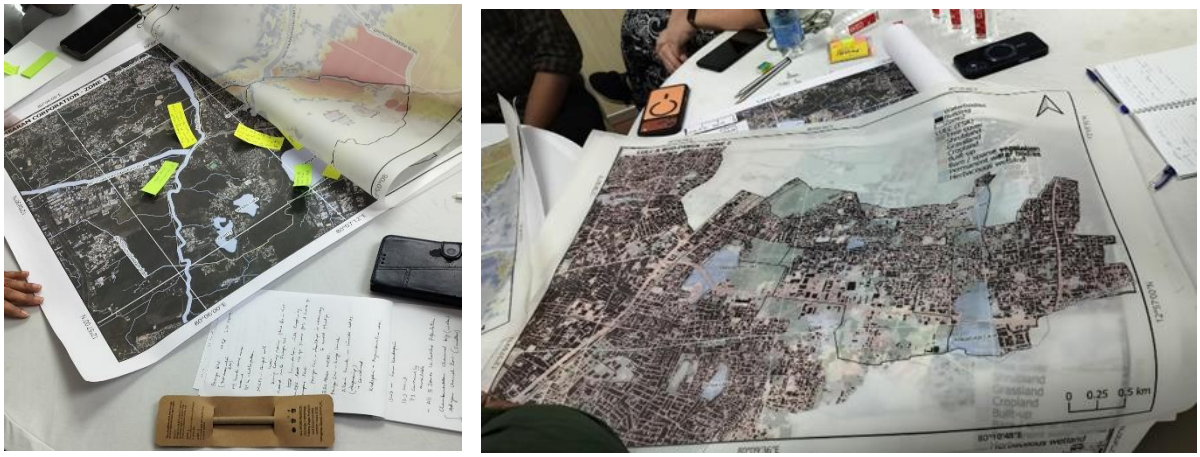
Dr. Parama Roy presenting on TCMC's monsoon preparedness and the scope of BGIs

The Visioning Exercise

A participatory mapping exercise was carried out to chalk out measures to build flood resilience in TCMC. The participants were divided into three groups, ensuring representation from each department or stakeholder organisation in every group. Flood depth maps for the worst-case scenario, considering a 75% release from the design discharge of Chembarambakkam Lake with a 100-year return period, were presented for Zones 1, 2, and 4 of TCMC, which are highly flood prone areas.

Google Earth base maps with layers showing rivers, lakes, drainage paths, zones, and wards were printed on standard sheets, while the flood maps were printed on tracing sheets showing zones and wards. These transparent flood maps were overlaid onto the base maps to facilitate group discussions on adaptive measures and potential interventions.

In parallel, a separate group comprising representatives from academia, government, and NGOs worked on developing a dynamic threshold definition for road transport resilience.



Participatory action: Glimpses from the visioning exercise

Group 1 – Key Discussion Points and Proposed Measures

1. Real-Time Flood Forecasting (RTFF) for lake inflows- Implementation of RTFF systems to predict lake inflows and anticipate flood conditions in advance.
2. Lake operation and monitoring system- Establishment of a monitoring system for major lakes using sensor-based technologies to track water levels and flow conditions in real time.
3. Sensor-based regulation of reservoir releases (Adyar river)- Installation of sensors to regulate optimal reservoir releases into the Adyar river to minimise downstream flood risk.
4. Target flood levels at sensitive locations- Identification and maintenance of threshold flood levels at critical and flood-sensitive areas (e.g., SIPCOT Thirumudivakkam), ensuring that flood depth does not exceed 30 cm during a 100-year flood event. This includes installing sensors to monitor water flow from the Thirumudivakkam SIPCOT/SIDCO area to nearby lakes or channels.
5. Strategic placement of sensors- Identification of ideal sensor locations, particularly near major transportation corridors, hospitals, primary health centres (PHCs), and other critical infrastructure.
6. Pre-emptying of tanks- Controlled pre-emptying of tanks prior to heavy rainfall events to create buffer storage capacity.
7. Interconnection of drainage networks- Improving connectivity between drains to enhance water flow and reduce localised flooding.

8. Addressing pluvial flooding- Improving the local stormwater drainage network to effectively manage pluvial (rainfall-induced) flooding.
9. Increasing water storage capacity- Deepening lakes and channels to enhance their storage capacity and improve flood buffering potential

Group 1 mapping out mitigation measures for TCMC

Group 2 – Key Discussion Points and Zone-Wise Proposed Measures

Zone 1

1. Thiruneermalai Tank (Ward 31)

- Provision of an adequate stormwater drain (SWD) network.
- Completion of bund formation works.
- Desilting of the tank to restore storage capacity.

2. River Bed Deepening

Deepening of the riverbed from Guduvanchery Tank to the Adyar River to improve flow conveyance.

3. Widening of Thiruneermalai Bridge

Widening of the existing Thiruneermalai Bridge using a prestressed concrete long-span structure, as it is located at a confluence point and acts as a hydraulic bottleneck.

Zone 2

1. Stormwater Drain Provision (Left Side of GST Road) - Construction of a stormwater drain for the area located on the left side of GST Road, with proper outfall into the Kilkattalai Drain.

Zone 4

1. Sunken Pump Arrangement (Ward 55) -Installation of a sunken pump system within the stormwater drain to prevent river water backflow during high-flow conditions.
2. River Buffer Zone- Establishment and maintenance of a buffer zone along the river to enhance floodplain management.
3. Deepening of Alleri Tank (Ward 32) - Deepening of the tank to increase storage capacity and improve flood mitigation.
4. Stormwater Drain near Perungalthur Lake (Ward 61) - Provision of a stormwater drain in the vicinity of Perungalthur Lake to improve local drainage efficiency.

Group 2 discussing on zone-wise mitigation measures

Group 3 – Zone-wise Proposed BGI and Drainage Measures

Zone 1

1. Sponge Park and Forest Park Development (Ward 31) - Development of sponge parks and forest parks to enhance water retention and groundwater recharge.
2. Conversion of unlined canals into lined canals to improve flow efficiency (Ward 31) - Creation of retention ponds and widening of the Pammal drain to increase conveyance and storage capacity.
3. Strengthening of Local Stormwater Drain Network (Ward 12)- Upgrading and expanding the existing stormwater drainage (SWD) system to reduce localised flooding.

Zone 2

1. Stormwater Drain Under Execution (Ward 21) - Ongoing construction of a stormwater drain to improve drainage capacity.

2. Enhancing Pond Storage Capacity (Ward 15)- Reducing the gradient of wasteland areas near existing ponds to expand pond area and increase storage capacity.
3. Land Grading and SWD Provision (Ward 24)- Reducing the gradient of wastelands adjacent to ponds to enhance water retention. Provision of an additional stormwater drain to support improved runoff management.

Zone 4

1. Sponge Park Development (Ward 52 and Ward 60)- Establishment of sponge parks to enhance infiltration and temporary water storage.
2. No-Development Zone (Ward 55)- Declaration of no-development zones in flood-prone areas to reduce exposure and future risk.
3. River Buffer Zone (Ward 32)- Creation and maintenance of a buffer zone along the river to protect the floodplain and manage encroachments.

Group 3 discussing on zone-wise BGI mitigation measures

Parallel Session on Road Transport Resilience during Flood Hazards

Prof Maria Nogal and Dr. Erica Arango from TU Delft briefed the group on the research methodology they have developed to determine road transport resilience and how it would feed into Behavioral DT. They detailed on the system functionalities, after which the participants were asked to imagine themselves as managers of the transportation network and asked to comment on the transportation matrix that was developed based on safety, connectivity, and reliability.

Dr. Erica Arango briefing the group on the transport resilience session

The discussion highlighted the difficulty of defining "acceptable" flood thresholds for road use. While some participants suggested that pedestrians can tolerate water up to knee level and vehicles up to just below the exhaust pipe, these numbers quickly became contentious. In practice, ankle-level water (around 20 cm) may be manageable for pedestrians, but the presence of sewage, open potholes, and floating debris significantly reduces willingness to walk. For vehicles, distinctions between two-wheelers, private cars, and public transport, particularly normal versus low-floor buses become critical, given their varying ground clearance and vulnerability. Participants also emphasized that low water levels are typically allowed to recede naturally, without pump deployment, making "acceptable" thresholds closely tied to expected drainage time and recovery.

Participants sharing feedback on system functionalities for transport resilience

Feedback from the participants:

1. Discomfort in assigning fixed numerical limits, as such thresholds may not reflect the complex Indian urban context where multiple transport modes coexist.
2. Acceptability is not only about water depth but also about trip purpose, distance, and road hierarchy.
3. Users may tolerate higher water levels for short, essential trips within neighbourhoods but hesitate for longer travel, especially on arterial roads.
4. Reliability expectations differ depending on whether the journey is urgent or not.
5. Pedestrians often avoid travel during heavy rainfall altogether, making it challenging to define meaningful benchmarks for them.
6. The discussion underscored that behavioural risk-taking and infrastructure variability, together shape operational threshold framework.

Closing Remarks and Way Forward

Prof Ashwin Mahalingam sharing closing remarks

The workshop concluded with remarks by Dr. Ashwin Mahalingam, Professor at IIT Madras and Co-Principal Investigator of the Resilient Hydro Twin project. He reflected on how planning has traditionally relied on maps developed as independent layers, such as land use, drainage, transport, and infrastructure, often functioning in silos. He emphasized that cities can no longer be planned through disconnected datasets. Instead, each layer must dynamically interact with others to reflect the complex and interdependent nature of urban systems. He highlighted that a fully integrated Digital Twin can serve as a powerful decision-support platform, bringing together a range of data into an unified, interactive system. He concluded by highlighting that the participatory Digital Twin approach should be explored for preparing future Master Plans, ensuring that urban development is resilient, adaptive, and data-driven.

The workshop provided a platform to deliberate both grey infrastructure and Blue-Green Infrastructure (BGI) measures to enhance flood resilience in TCMC. Importantly, these measures will now be translated into modelled intervention scenarios. The next phase of the project will involve conducting scenario analysis using hydrological and hydraulic models to test different combinations of BGI, structural, and operational measures under varying climate and land-use change conditions.

The five key stakeholder-identified priorities/takeaways are summarized below:

1. **Strengthening and expansion of the stormwater drainage system**, including completion of ongoing works, provision of new drains, installation of submersible pumps to prevent river backflow, and interconnection of drains to improve stormwater conveyance.
2. **Incorporation of Blue-Green Infrastructure (BGI) measures**, such as sponge parks, forest parks, retention and detention ponds, river buffer restoration, and conversion of wastelands near ponds into flood storage areas in flood-prone regions.

3. **Deepening and desilting of water bodies**, including tanks (e.g., Alleri Tank) and rivers (e.g., Adyar River).

4. **Widening of the existing Thiruneermalai Bridge** using a prestressed concrete long-span structure, given its critical location at a confluence point.

5. **Operational and monitoring measures for lakes**, including sensor deployment, pre-emptying strategies, Real-Time Flood Forecasting (RTFF)-based flow predictions, and implementation of a Lake Operation System.

In parallel, a BGI assessment matrix will be developed to evaluate environmental, social, economic, and institutional dimensions, capturing both co-benefits and trade-offs. The outputs from the modelling and matrix-based assessment will then be integrated into the Digital Twin platform. Future workshops will build upon these model results, allowing stakeholders to interact with simulation outputs and collectively refine strategies. Thus, the workshop served as a foundational step that directly shapes the modelling process and subsequent decision-support mechanisms within the broader project framework.

Team members of Resilient Hydrotwin

Annexure 1: Workshop Agenda

Resilient HydroTwin: Participatory Integrated Digital Twin for Adaptive Urban Resilience to Water Extremities

Visioning Workshop

(Raman Hall, IIT Madras Research Park- 28th January 2026)

Address: MGR Film City Road, Kanagam, Tharamani, Chennai – 600 113

09:30 AM	**Welcome and introductory remarks** *Prof Balaji Narasimhan, Department of Civil Engineering* (IIT Madras)
09:45 AM	**Participant Introduction**
10:00 AM	**Resilient Hydrotwin- Project Briefing** • Overview of the Digital Hydrotwin *Prof Balaji Narasimhan* • Digital Twin Experience from TU Delft *Prof Ranjith Kuttantharappel Soman* • Resilient HydroTwin Development for Tambaram *IIT Madras project team and Okapi* (IIT Madras, TU Delft & Okapi)
10:45 AM	**Tea Break**
11:00 AM	**Break-out Session** Theme 1- Identifying measures to improve the stormwater drainage master plan (Grey and Blue-Green-Infrastructure) in TCMC Theme 2- Assessment of transportation system resilience in TCMC to flooding (IIT Madras, TU Delft & Okapi)
12:30 PM	**Debriefing from the Break-out Session** *IIT Madras project team* (IIT Madras)
12:50 PM	**Concluding Remarks** *Prof Ashwin Mahalingam, Department of Civil Engineering* (IIT Madras)
01:00 PM	**Lunch**

Annexure 2: Workshop Participants

Participants

1. Mr. Ajay A P, Sponge Collabrative
2. Mr. Albert Raja NP, CUMTA
3. Mr. Antony Anbarasu. S, SECON
4. Mr. Arun Karthik, TCMC
5. Mr. Arunmozhi, WRD
6. Mr. Elumalai N, IITMRP
7. Dr. Kirthiga SM, IFMC TNSDMA
8. Ms. Malarvizhi R, IFMC
9. Ms. Maria Thomas, Care Earth Trust
10. Ms. Priya Dharshini M, ITDP
11. Ms. Priyanka Karn, IITM Parvartak
12. Mr. Rajadurai, NIT Warangal
13. Mr. Rajesh R, TCMC
14. Dr. Ramesh. S, DMA
15. Ms. Sakila S, IFMC
16. Ms. Shilesh Hariharan, Madras Terrace
17. Ms. Shreya Krishnan, SKDO
18. Mr. Sivanesan. K, Care Earth Trust
19. Dr. Suman.A, Care Earth Trust
20. Ms. Surya Bharathi R, TNDRRA IFMC
21. Mr. Thangadurai, TCMC
22. Mr. Vignesh.A, IIT Madras

Dutch Partners

23. Dr. Erica Arango, TU Delft
24. Dr. Johan Ninan, TU Delft
25. Dr. Maria Nogal, TU Delft
26. Dr. Marian Bosch-Rekveldt, TU Delft
27. Dr. Pieter Pauwels, TU Eindhoven
28. Dr. Ranjith K Soman, TU Delft
29. Dr. Zhaowen Liu, TU Delft

Organizing Team

30. Ms. Akshaya A, Okapi Research & Advisory
31. Dr. Ashwin Mahalingam, IIT Madras
32. Dr. Balaji L, IIT Madras
33. Dr. Balaji Narasimhan, IIT Madras
34. Ms. Bavithra R, IIT Madras
35. Mr. Elanchezhiyan D, IIT Madras
36. Dr. Elango Lakshmanan, IIT Madras
37. Dr. Jayshree Vencatesan, Care Earth Trust
38. Ms. Nivedita Shridhar, Okapi Research & Advisory
39. Dr. Parama Roy, Okapi Research & Advisory
40. Mr. Ramachandran A, Okapi Research & Advisory
41. Mr. Santhosh Kumar S, IIT Madras
42. Ms. Soffiya E, IIT Madras