

# Mainstreaming Climate Responsive Water and Sanitation Systems for Planning Resilient Cities

Xerxes Rao  
Archana Goswami  
Urban Management Centre

Global South Academic Conclave on WASH and Climate 2026  
6th – 7th February 2026, Ahmedabad

**CWAS** CENTER  
FOR WATER  
AND SANITATION  
**CRDF** CEPT  
UNIVERSITY

**CEPT**  
UNIVERSITY  
FACULTY  
OF PLANNING

Gates Foundation

**viega** foundation

# Table of Contents

---

- 1. Build climate responsiveness of the sanitation systems**
- 2. Learnings from Chennai: Climate Mainstreaming for Climate Responsive Sanitation systems in a city:**
  - Baseline and Hazard Assessment
  - Climate Change Risk Assessment
  - Implementation Modalities
- 3. Way Forward**

# Need of Future-Proofing Sanitation in Climate-Vulnerable Cities

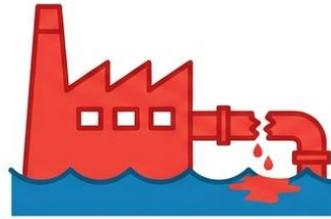
## Climate Hazard



Floods submerge non-sewered systems and cause backflows



## System Impact



Physical damage to STPs, burst pipes, inaccessible pumping stations, etc.



## Public Health Impact



Release of faecal pathogens into the environment and water supplies

## When Climate Shifts, Sanitation Fails

# Defining a Climate-responsive Water and Sanitation systems

Systems Deliberately planned to withstand risks and reduce emissions



## RESILIENT SOURCES

Diversified water sources  
Protection of catchments, Salinity-resistant systems in coastal areas



## ROBUST INFRASTRUCTURE

Elevated or flood-protected pumping stations  
treatment plants  
Smart storage,  
Flood-proof man-holes



## LOW-CARBON OPERATIONS

Solar-powered pumps  
Energy-efficient treatment  
Gravity-based distribution

### HOW...

### WHAT IS NEEDED...

**adaptation, mitigation, and resilience** into every stage of the service chain

1. a policy framework
2. a master plan checklist
3. indicators for monitoring climate-responsiveness



# **Build climate responsiveness of sanitation systems**

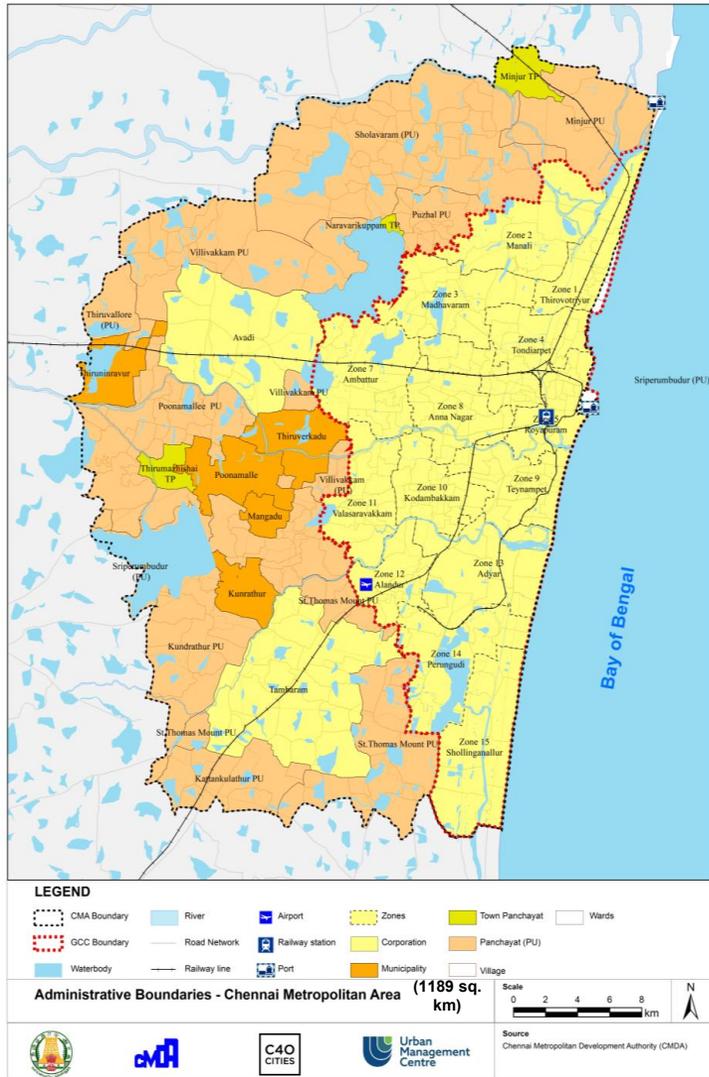


# How to Mainstream climate-responsiveness into Master Plans

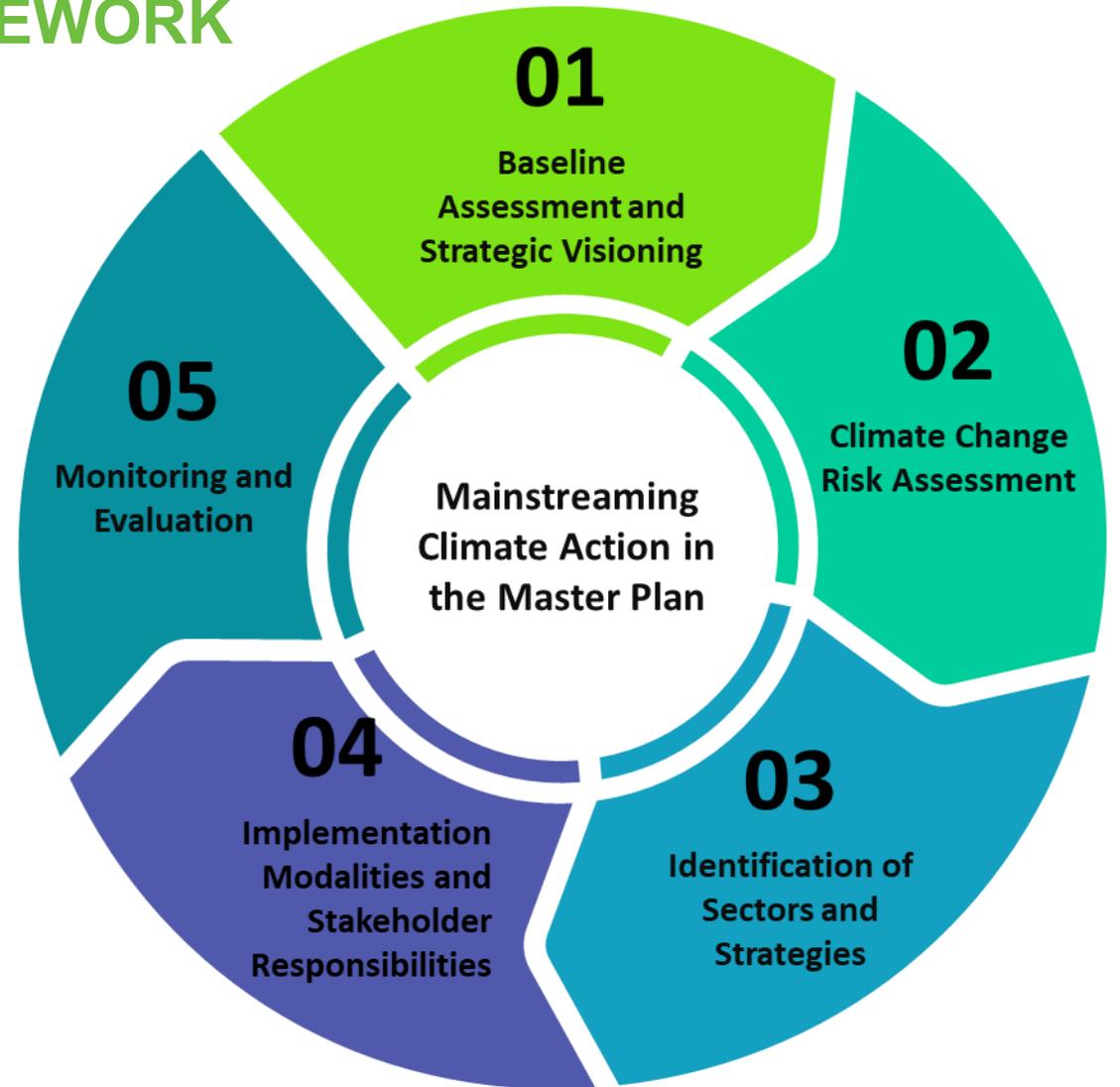
1. Framework for mainstreaming the climate responsive WASH
2. Creating Baseline and Climate Change Risk Assessment (CCRA)
3. Climate Strategies to enhance climate resilience
  - Floods, droughts, and sea-level rise, etc. jeopardize aging infrastructure, leading to system failures and contamination
  - To counter these risks - a multifaceted framework involving policy alignment, institutional flexibility, and the implementation of flood-proof technologies.
  - Goal is to mainstream adaptation and mitigation into city master plans to ensure the continuous delivery of safe, equitable services.
  - So that cities can better protect vulnerable communities and critical assets from the intensifying impacts of a changing climate.



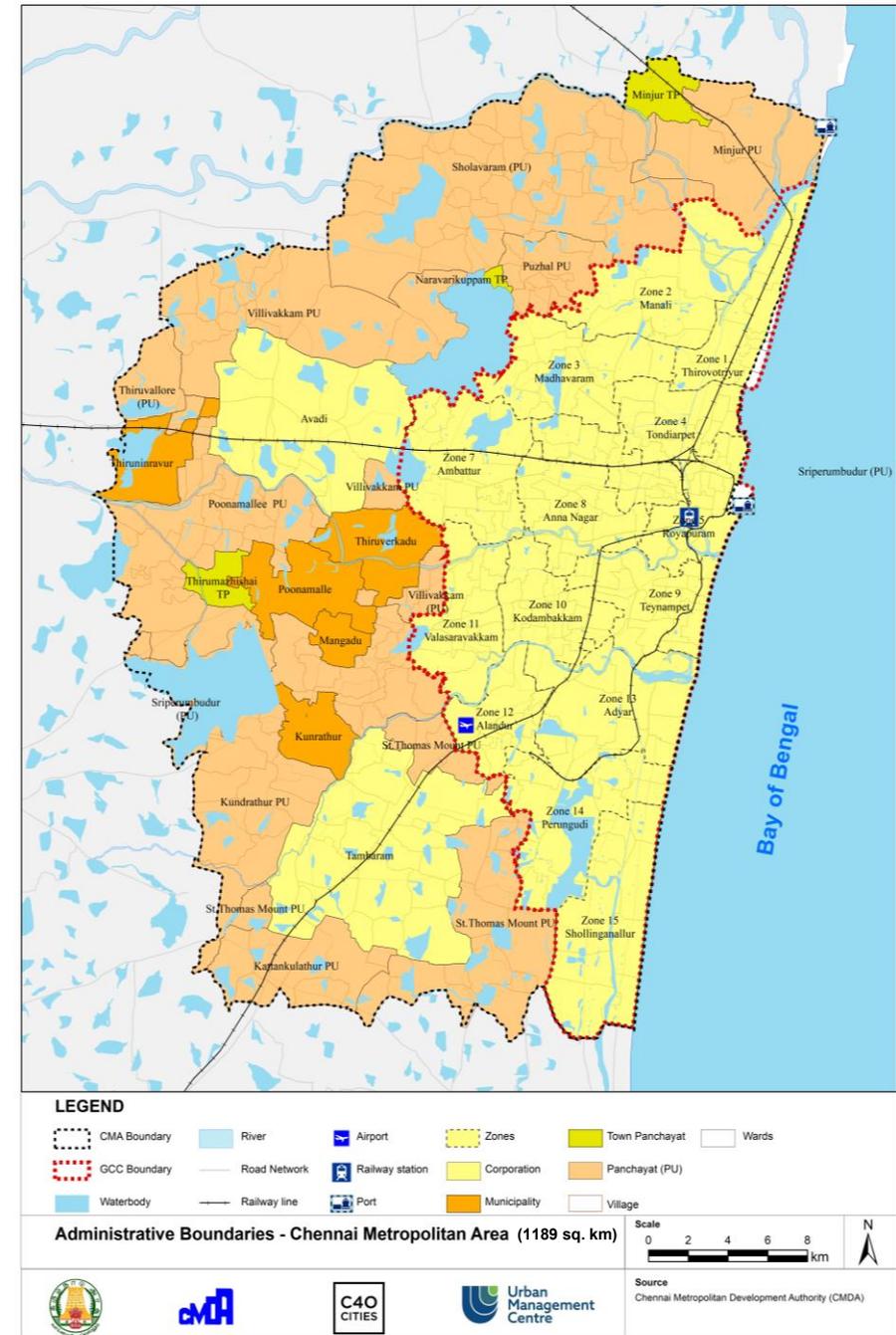
# Learnings from the 'Mainstreaming Climate actions in the Master Plan of Chennai'



## FRAMEWORK

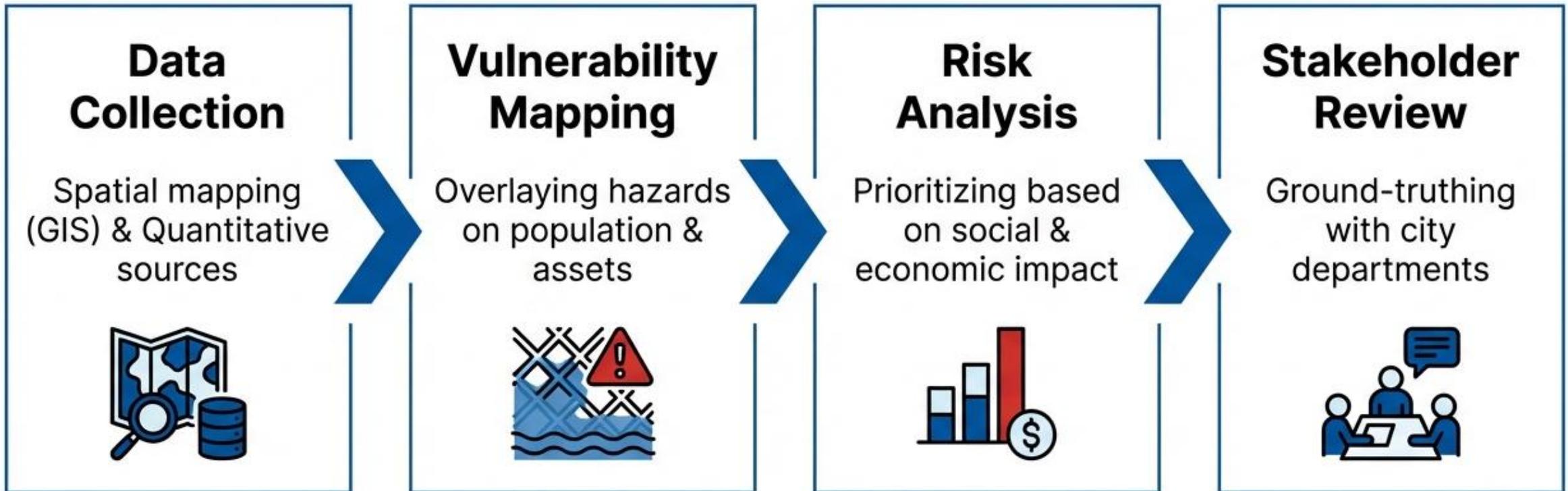


# Learnings from the 'Mainstreaming Climate actions in the Master Plan of Chennai'

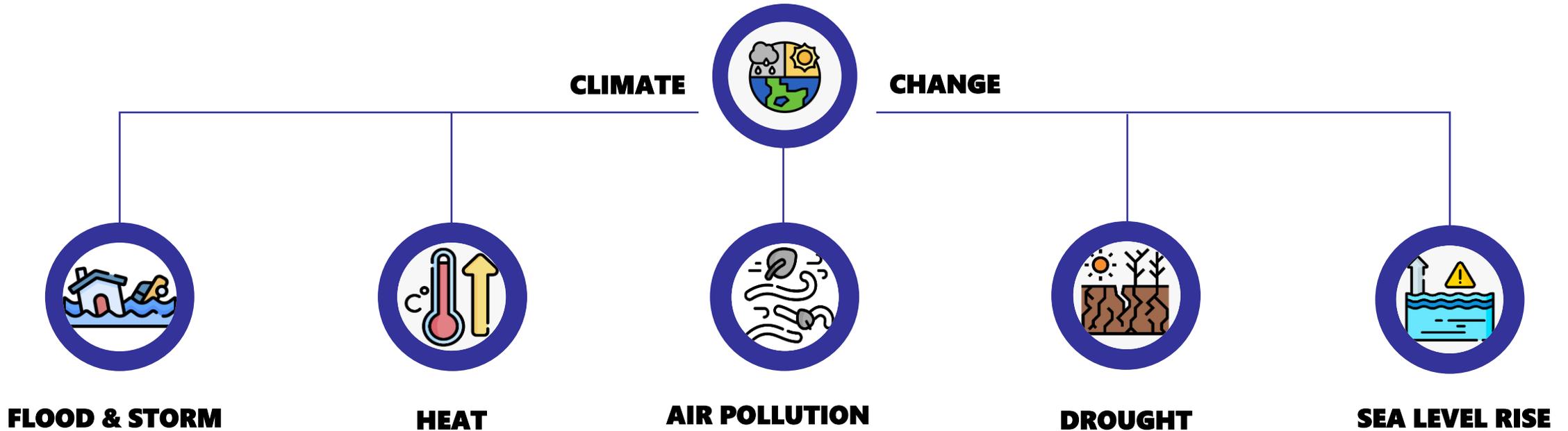


# Learnings from the 'Mainstreaming Climate actions in the Master Plan of Chennai'

## A Data-Driven Methodology (CCRA)



# Baseline and Climate Hazard Assessment



## FLOODS

- Floods can submerge non-sewered sanitation systems and cause backflows in sewer systems,
- Direct physical damage to non-sewered and sewered sanitation infrastructure
- Water ingress into sewers and are more likely to cause burst pipes and sewage overflow



# CLIMATE CHANGE RISK ASSESSMENT Step 1 - Data Collection

## Spatial Data - Hazard projection & impact visualization maps

### 1 Flood

**Source:** JICA's Comprehensive Flood Control Masterplan for CMA (assistive study)

### 2 Sea Level Rise

**Source:** NCCR's Assessment of Shoreline retreat study & Anna University's SLR projection due to CC for Tamil Nady coastal areas

### 3 Heat

**Source:** Generated in ArcGIS by applying atmospheric correction, emissivity estimation, and Planck's law to thermal infrared bands of Landsat 8

### 4 Drought

**Source:** Multi-index (NDVI, LST, SPI and soil moisture) geo-spatial analysis using Google Earth Engine

### 5 Air Pollution

**Source:** Multi-index (SO<sub>2</sub>, NO<sub>2</sub>, CO & O<sub>3</sub>) geo-spatial analysis using Google Earth Engine

### 6 Infra Assets, Services and Sensitive areas

**Source:** One-to one consultation and visits to Urban Local Bodies, Sectoral departments (Disaster, Water, Power, Transport and slums), Research organizations, academia and consultants working on TMP assistive studies

## Quantitative Data

### 1 Hazard impacts

**Source:** Govt. websites, research papers, journals, news paper articles, study/ assessment reports etc.

### 2 Sector impacts

**Source:** Govt. websites, research papers, journals, news paper articles, study/ assessment reports etc.

### 3 Infra assets, services and sensitive areas

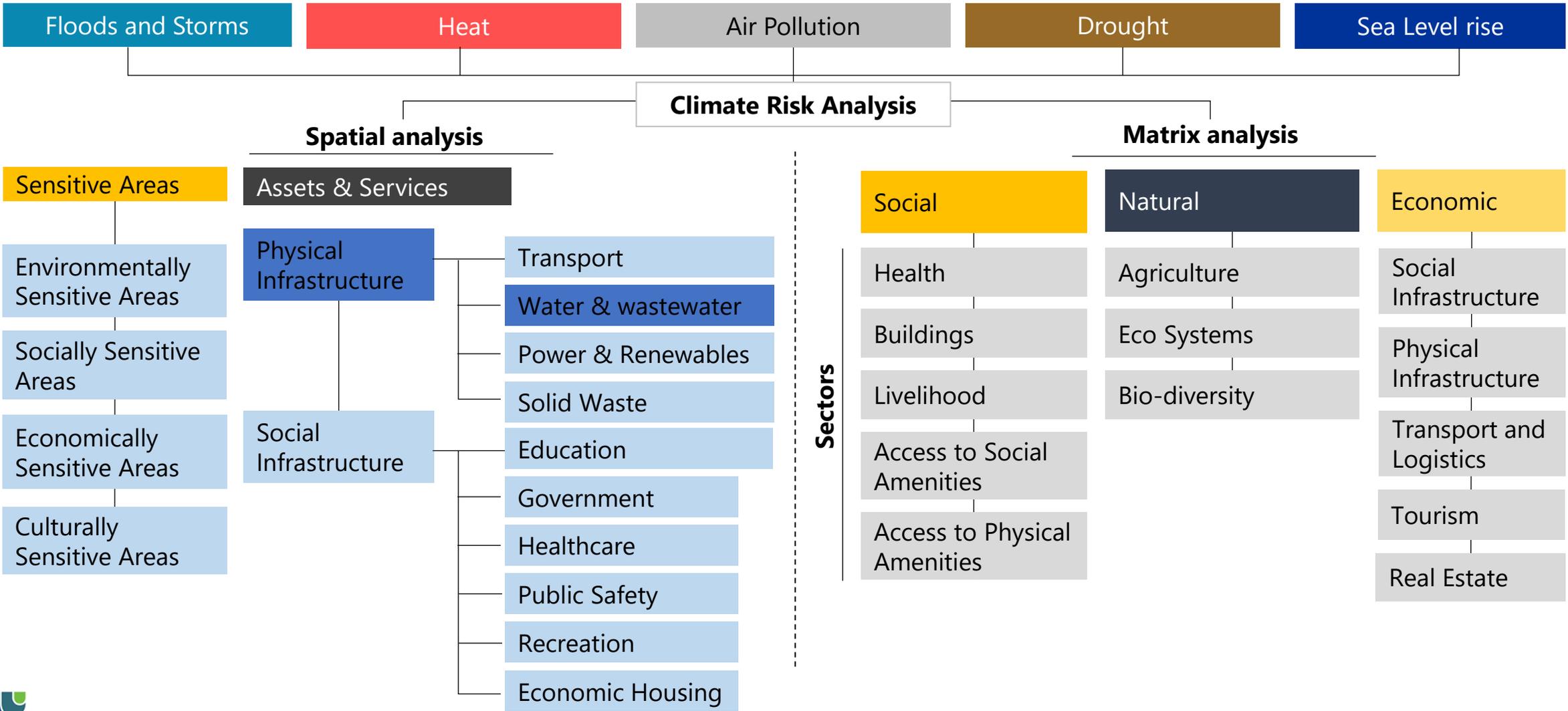
**Source:** Govt. websites, research papers, journals, news paper articles, study/ assessment reports etc.



# CLIMATE CHANGE RISK ASSESSMENT

## Step 2 & 3 Vulnerability Mapping, Risk and Sectoral Impact Assessments

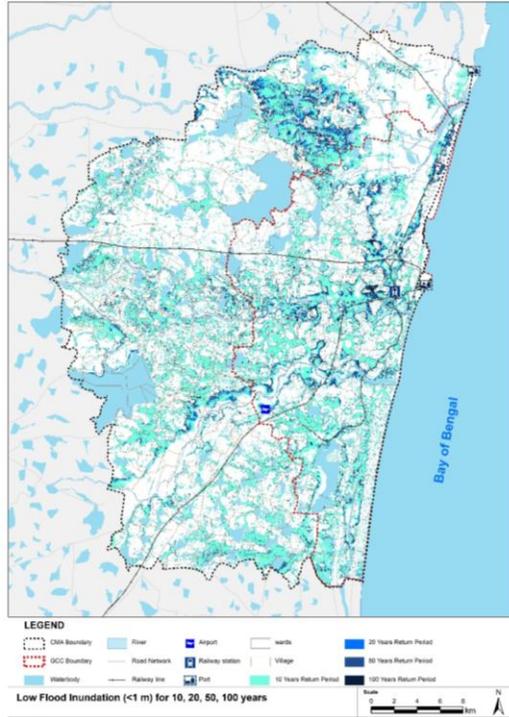
### Hazards impacting Chennai Metropolitan Area



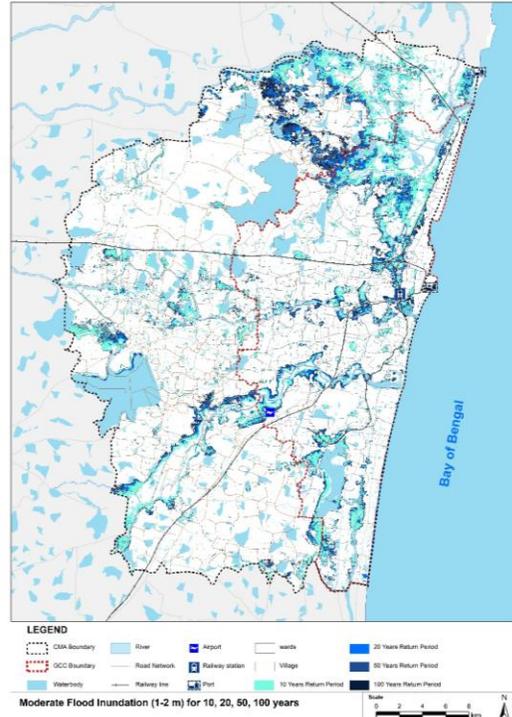
# CLIMATE VULNERABILITY MAPPING: HAZARD – FLOOD AND STORMS

## Flood Hazard Map – Areas covered due to inundation during floods and storms (Basemap)

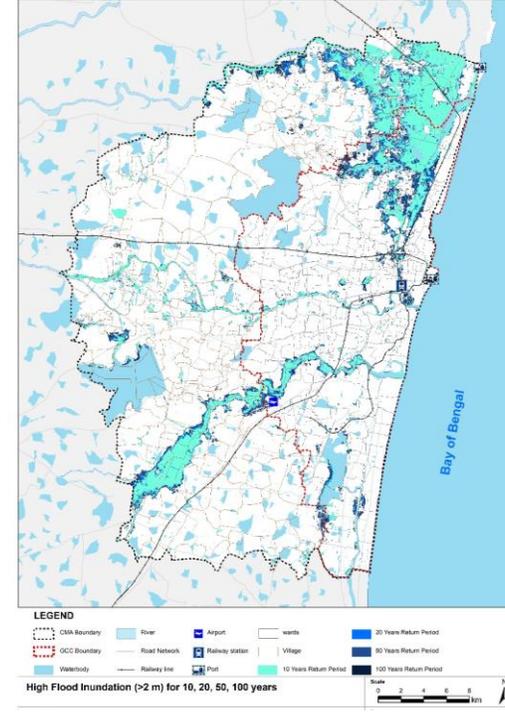
Low flood (<1m) projections



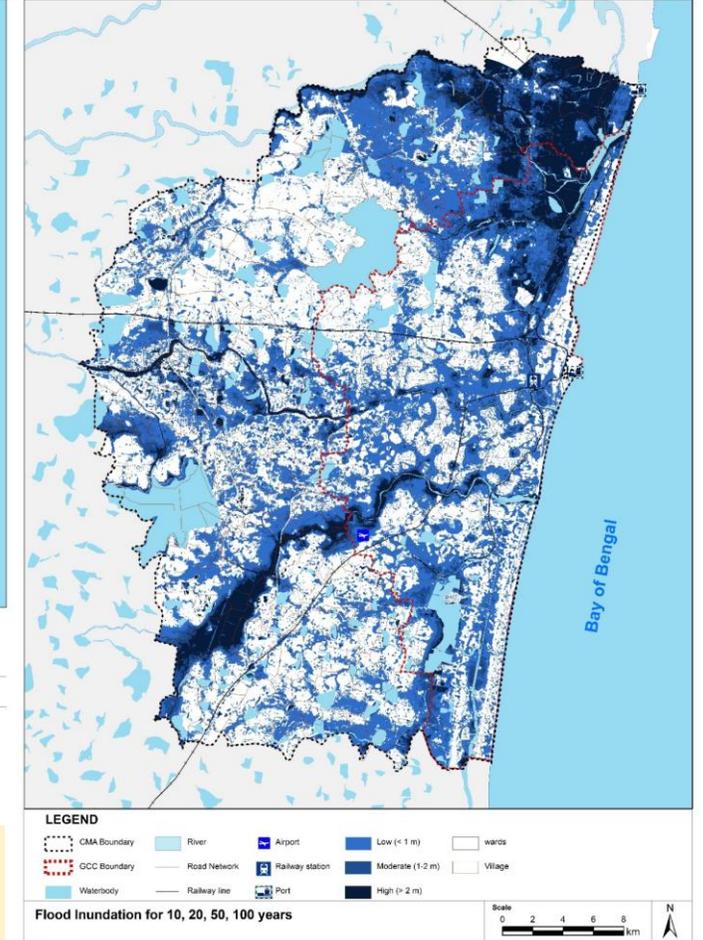
Moderate flood (1 – 2m) projections



High flood (>2m) projections



Combined flood hazard map for all intensities

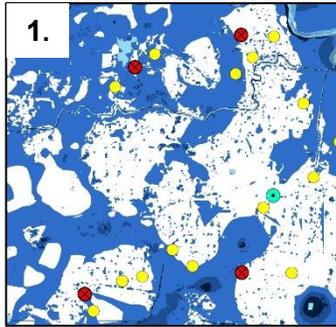


Low, Moderate and High Flood inundation areas projected for 10, 20, 50 and 100 year return period rainfall have been clubbed to formulate the base map and assess the impact of flooding in CMA.



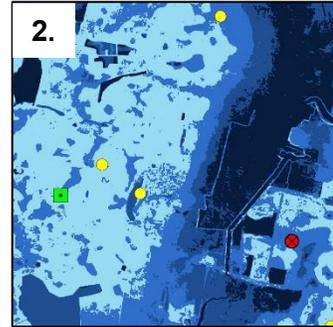
# CLIMATE VULNERABILITY MAPPING: HAZARD – FLOOD AND STORMS

## Impact of Flooding on Physical (water and wastewater) infrastructure



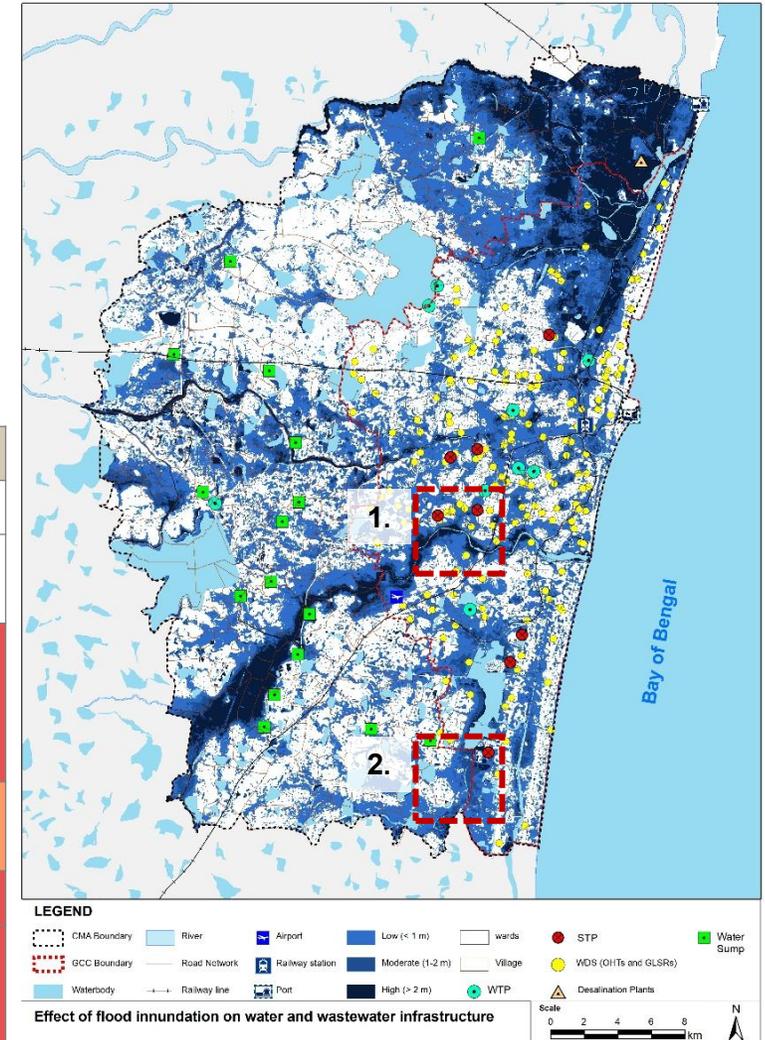
**1. Sample Grid 1- Kodambakkam**

**Impact:**  
 Water Distribution stations (WDS- OHT/GSLR)- 15  
 Water Treatment Plant (WTP)- 1  
 Sewage treatment Plants (STP)- 4



**2. Sample Grid 2- Perungudi**

**Impact:**  
 Water Distribution stations (WDS- OHT/GSLR)- 3  
 Water Sumps- 1  
 Sewage treatment Plants (STP)- 1



Impact of flooding on water and wastewater infrastructure							
Water and Wastewater Infrastructure	Approximate total number	Affected by floods					
		High flood	% Affected	Moderate flood	% Affected	Low flood	% Affected
Water Distribution stations (WDS-OHT/GSLR)	215	7	3%	16	7%	78	36%
Water Treatment Plant (WTP)	9	1	11%	1	11%	2	22%
Water Sumps	16	1	6%	2	12%	4	25%
Sewage treatment Plants (STP)	8	1	12%	1	12%	3	37%
Desalination Plant	2	1	50%	Nil	Nil	Nil	Nil

**Note-** The color intensity in the table is for comparative analysis of values within the table only. This analysis focuses on impact of high, moderate and low inundation areas for return periods of 10, 20, 50, 100 on CMA. The low, moderate and high inundation areas of all return periods have been clubbed to assess the impact of flooding in CMA.

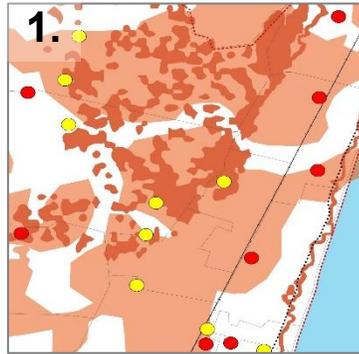


Source for data in maps –

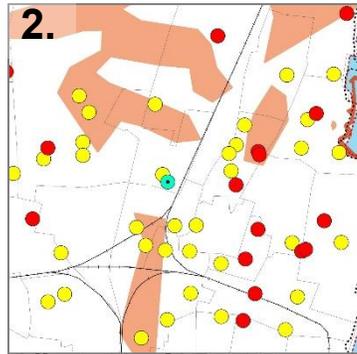
1. CMWSSB Master Plan and Secondary information from Govt. Dept. websites validated using Google Earth
2. JICA. (draft) Based on Comprehensive Flood Control Masterplan for Chennai Metropolitan Area.

# CLIMATE VULNERABILITY MAPPING - HAZARD – SEA LEVEL RISE

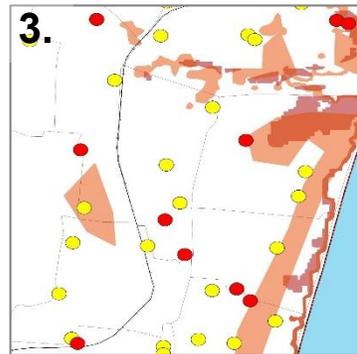
## Impact on Physical (Water and wastewater) Infrastructure



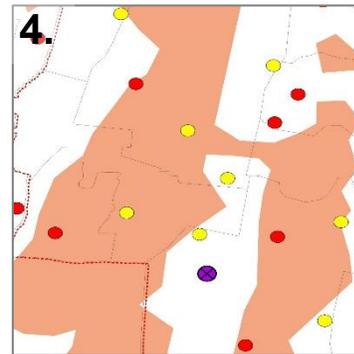
**1.**  
Affected by SLR 2050, 2100  
**Grid 1- Manali**  
WDS- 4  
Pumping stations- 8



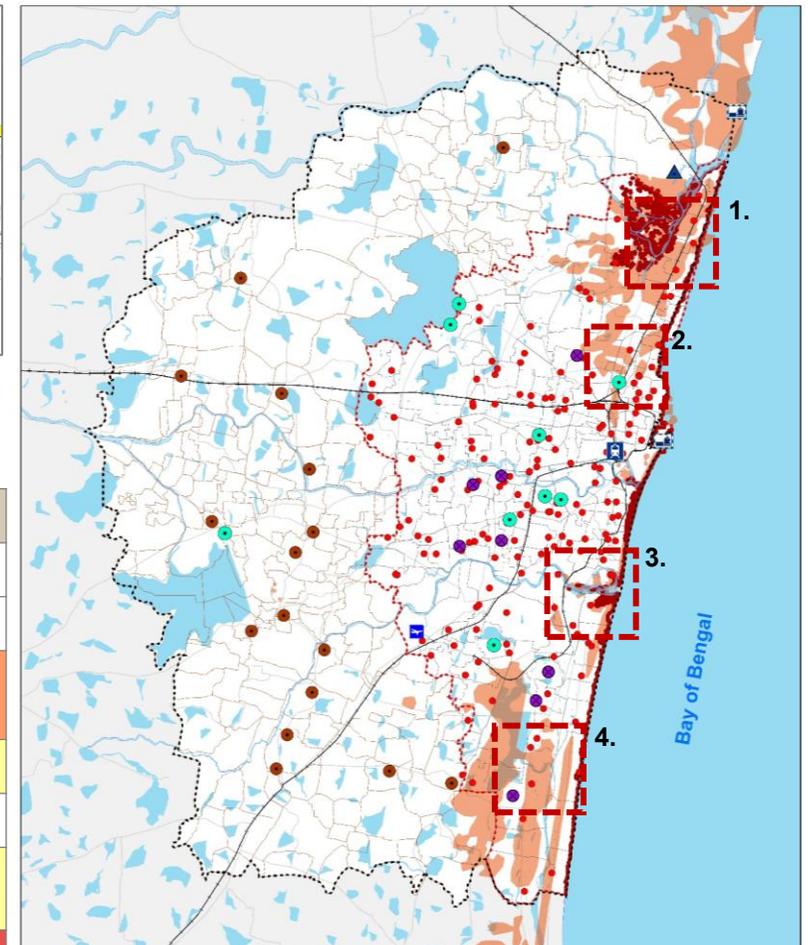
**2.**  
Affected by SLR 2100  
**Grid 2- Royapuram**  
WDS- 4  
Pumping stations- 11



**3.**  
Affected by SLR 2050, 2100  
**Grid 3- Adyar**  
WDS- 5  
Pumping stations- 9



**4.**  
Affected by SLR 2100  
**Grid 4- Perungudi**  
WDS- 6  
Pumping stations- 4



### Water and wastewater infrastructure affected due to sea level rise

Water and Wastewater Infrastructure	Approximate numbers in CMA	Affected by sea level rise			
		2050	% Affected	2100	% Affected
Water Distribution stations (WDS- OHT/GSLR)	215	16	7%	58	27%
Water Treatment Plant (WTP)	9	Nil	Nil	1	11%
Water Sumps	16	Nil	Nil	Nil	Nil
Sewage treatment Plants (STP)	8	Nil	Nil	1	12%
Desalination Plant	2	Nil	Nil	1	50%

Note- The color intensity in the table is for comparative analysis of values within the table only. The analysis considers a 500m buffer around the subjects to account for potential accessibility issues due to sea level rise.

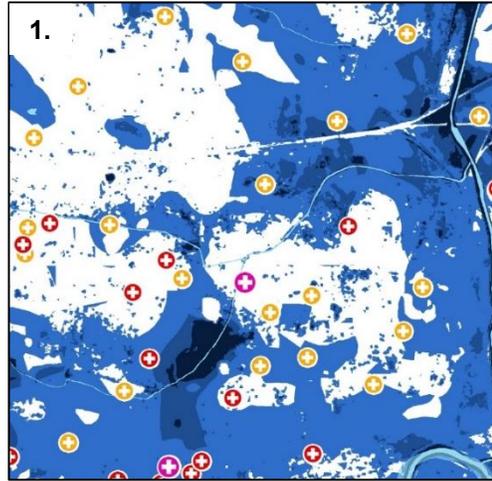
Source for data in maps-

- CMWSSB Master Plan and Secondary information from Govt. Dept. websites validated using Google Earth
- Silamban, Dhanalakshmi & Kankara, R. S.. (2020). Assessment on Shoreline Retreat in Response to Sea Level Rise – Chennai Coast. *Journal of Coastal Research*. 89. 145. 10.2112/SI89-024.1.
- Sea level rise map and coastal flood tool — US and global. (n.d.). <https://coastal.climatecentral.org/>



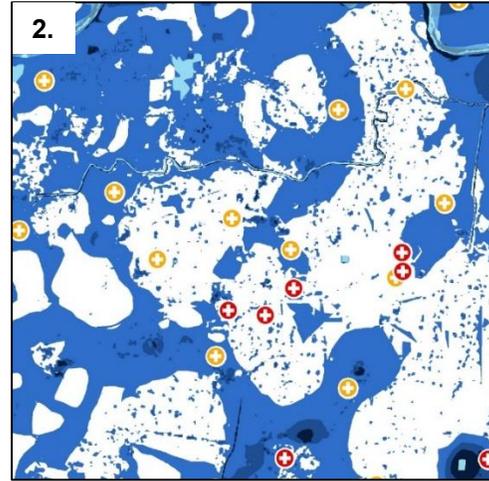
# CLIMATE VULNERABILITY MAPPING: HAZARD – FLOOD AND STORMS

## Impact of Flooding on Healthcare Infrastructure



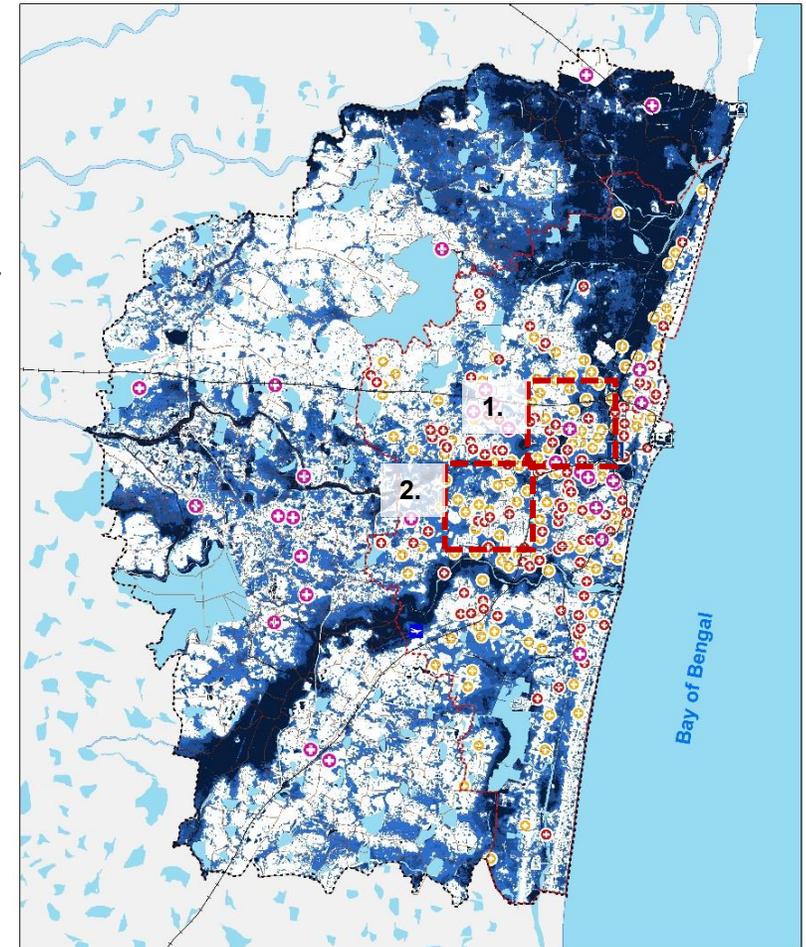
**Sample Grid 1- Anna Nagar**

**Impact:**  
 Urban Health Centers- 1  
 Primary Health Centers- 20  
 Community Health Centers- 9



**Sample Grid 2- Kodambakkam**

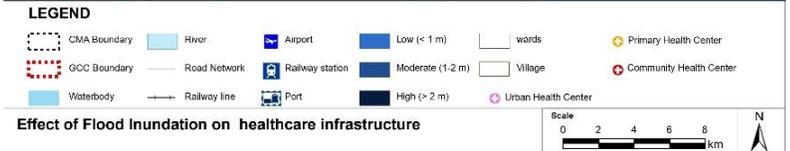
**Impact:**  
 Primary Health Centers- 10  
 Community Health Centers- 7



### Impact of flooding on Healthcare Infrastructure

Healthcare Infrastructure	Approximate number	Affected by floods					
		High flood	% Affected	Moderate flood	% Affected	Low flood	% Affected
Urban Health Centers	31	Nil	Nil	3	10%	7	22%
Primary Health Centers	140	7	5%	23	16%	58	41%
Community Health Centers	113	5	4%	14	12%	36	32%

**Note-** The color intensity in the table is for comparative analysis of values within the table only. This analysis focuses on impact of high, moderate and low inundation areas for return periods of 10, 20, 50, 100 on CMA. The low, moderate and high inundation areas of all return periods have been clubbed to assess the impact of flooding in CMA.



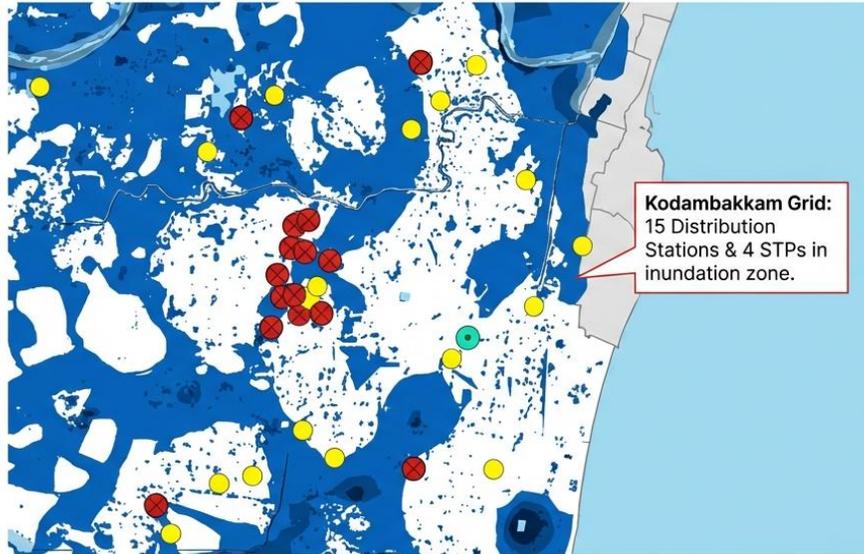
Source for data in maps –

- Greater Chennai Corporation [GCC], C40 cities, & Urban management Center. (2023). *Chennai Climate Action Plan*. Government of Tamil Nadu.
- Secondary information from Govt. Dept. websites validated using GE
- JICA. (draft) Based on *Comprehensive Flood Control Masterplan for Chennai Metropolitan Area*.



# CLIMATE VULNERABILITY MAPPING: HAZARD – FLOOD AND STORMS

## Critical Overlay of Infrastructure



**36%**  
of Water Distribution Stations affected by low floods

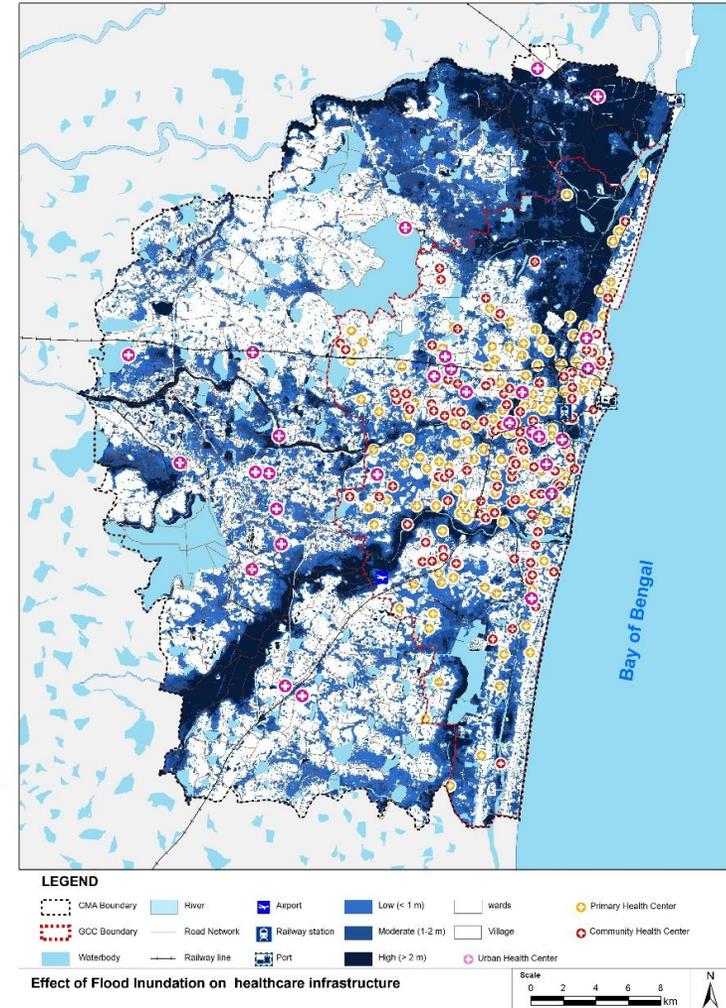
**12%**  
of Sewage Treatment Plants (STP) affected by high floods.

**50%**  
of Desalination Plants affected

**41%**  
of Primary Health Centers affected (58 centers)

**32%**  
of Community Health Centers affected

## Critical Overlay of Health Infrastructure



# Climate Change Risk Assessment

## List of Infrastructure at Highest Risk

Sensitives areas, Assets and Services			
Hazard		Type of Infrastructure	
<b>Flood</b>	Socially Sensitive Areas	Slum settlements	
	Cultural Sensitive Areas	Heritage sites	
	Physical Infrastructure	Transport - Air, Sea, Road, Rail	
		CMRL Stations	
		MTC Bus Stops	
		Suburban Railway Stations	
		Water and Wastewater systems	
		Sewage treatment Plants (STP)	
		Water Distribution stations (WDS- OHT/GSLR)	
		Power Infrastructure	
		EV Charging stations	
		Social Infrastructure	Educational Infrastructure
	Schools		
	Universities		
	Healthcare Infrastructure		
	Primary Health Centers		
	Urban Health Centers		
	Community Health Centers		
	Public Safety Infrastructure		
	Disaster Relief Centers		
	Police stations		
	Courts		
	Fire Stations		
	Recreational Infrastructure		
	Parks		
	Playgrounds		
	Community Centers		
	Auditorium		
Affordable Housing			

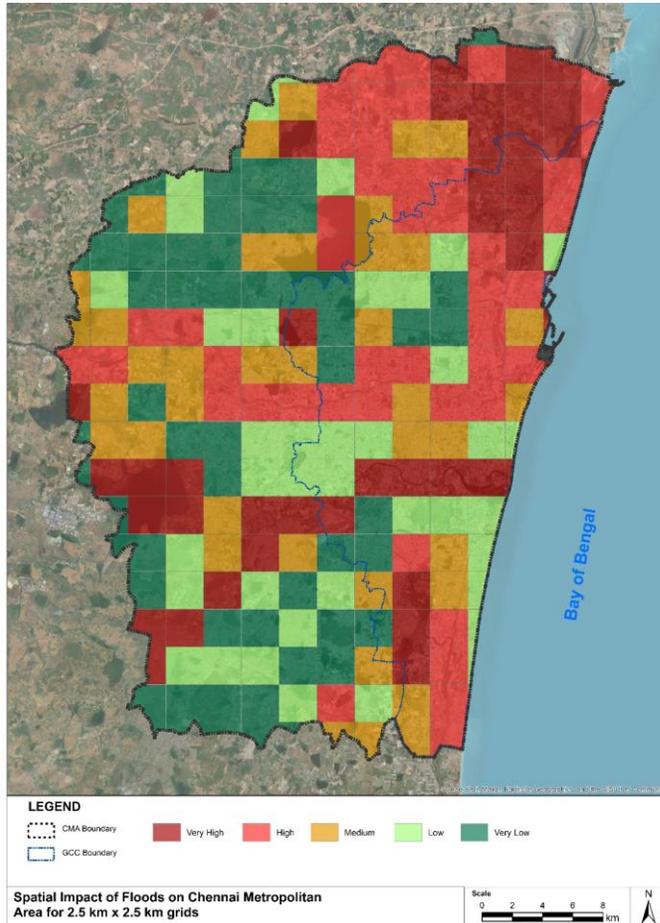
Sensitives areas, Assets and Services			
Hazard		Type of Infrastructure	
<b>Drought</b>	Socially Sensitive Areas	Slum settlements	
<b>LST (Heat)</b>	Socially Sensitive Areas	Slum settlements	
<b>Air Pollution</b>	Socially Sensitive Areas	Slum settlements	
<b>Sea Level Rise</b>	Socially Sensitive Areas	Slum settlements	
	Cultural Sensitive Areas	Heritage sites	
	Physical Infrastructure	Transport - Air, Sea, Road, Rail	
		CMRL Stations	
		MTC Bus Stops	
		Suburban Railway Stations	
		Water and Wastewater systems	
		Sewage treatment Plants (STP)	
		Water Distribution stations (WDS- OHT/GSLR)	
		Power Infrastructure	
		EV Charging stations	
		Social Infrastructure	Educational Infrastructure
	Schools		
	Universities		
	Healthcare Infrastructure		
	Primary Health Centers		
	Urban Health Centers		
	Community Health Centers		
	Public Safety Infrastructure		
	Disaster Relief Centers		
	Police stations		
	Courts		
	Fire Stations		
	Recreational Infrastructure		
	Parks		
	Playgrounds		
	Community Centers		
	Auditorium		
Affordable Housing			



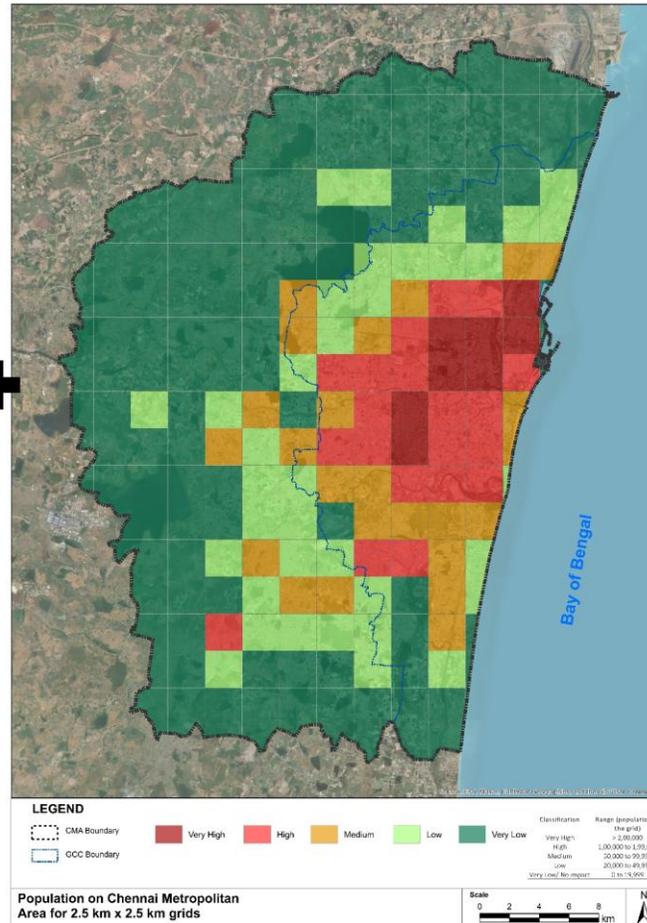
# CLIMATE VULNERABILITY MAPPING: HAZARD – FLOOD AND STORMS

## Hazard impact on Chennai Metropolitan Area and Population (Grid Map)

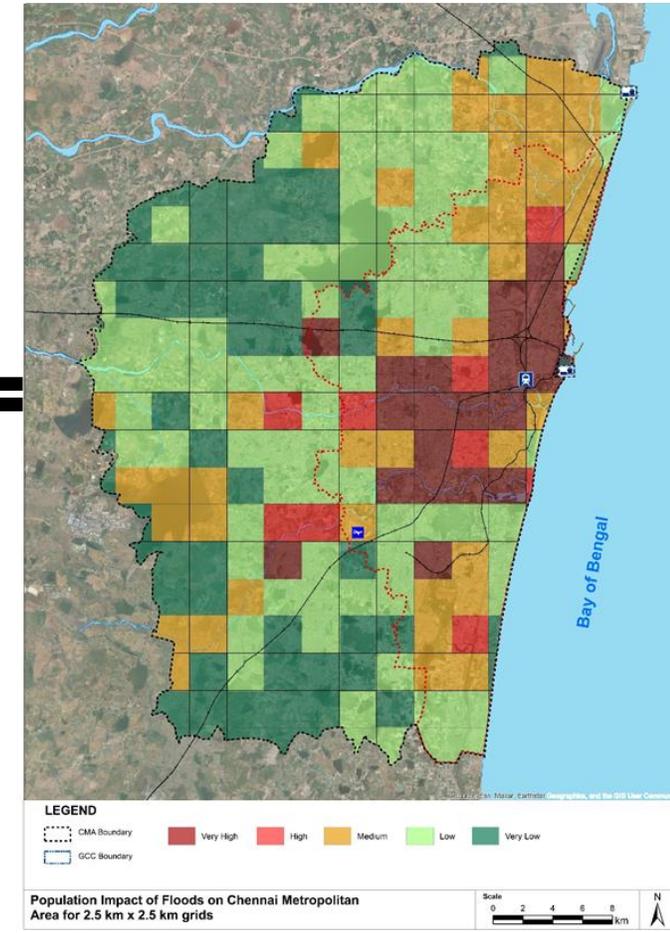
Spatial Impact of Flood on CMA



Population density in CMA



Impact of Flood on Population in CMA



The CMA region has been divided into 2.5x2.5 km grids to identify the most vulnerable areas. The flood impact was analyzed using the flood base map and overlaid with population density data to determine the areas where the highest population in CMA is affected by floods.

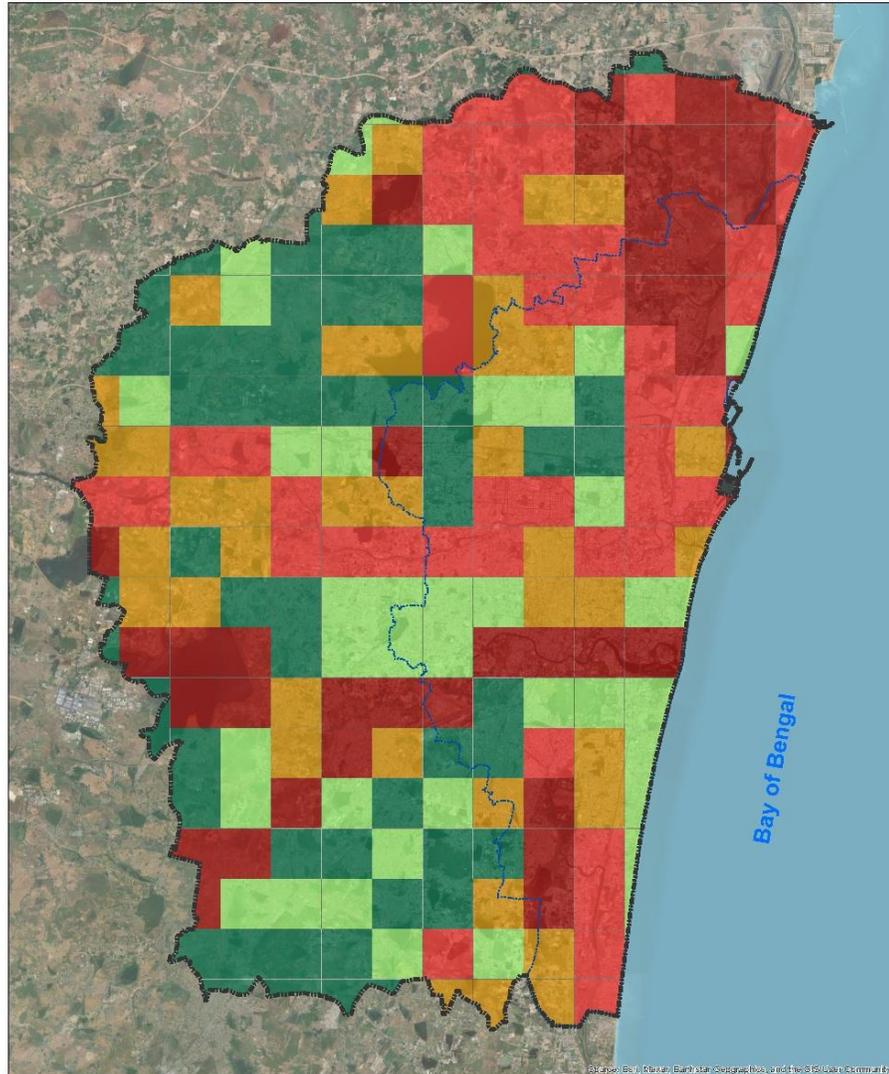


Source:

- Office of the Registrar General and Census Commissioner. (2011). *Census 2011*. Retrieved November 10, 2024
- JICA. (draft) Based on *Comprehensive Flood Control Masterplan for Chennai Metropolitan Area*.

# CLIMATE VULNERABILITY MAPPING: HAZARD – FLOOD AND STORMS

## Probable High Risk Impact Areas



### LEGEND

- CMA Boundary
- GCC Boundary
- Very High
- High
- Medium
- Low
- Very Low

### Probable "very high and High" impact areas due to Flood – 219 Grids

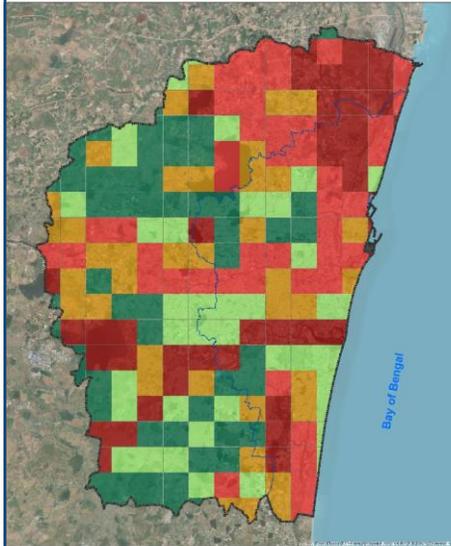
#### Very High

<b>GCC Zone</b>	Thirovotriyur, Manali, Tondiarpet, Royapuram, Ambattur, Teynampet, Kodambakkam, Valasaravakkam, Alandur, Adyar, Perungudi, Shollinganallur
<b>Corporation</b>	Avadi, Tambaram
<b>Municipality</b>	Thiruninravur
<b>Town Panchayat</b>	Minjur
<b>Panchayat (PU)</b>	Sholavaram (PU), Villivakkam (PU), Kattankulathur (PU), Minjur (PU), Poonamallee (PU), Sriperumbudur (PU), St.Thomas Mount (PU)

#### High

<b>GCC Zone</b>	Thirovotriyur, Manali, Madhavaram, Tondiarpet, Royapuram, Thiru-Vi-Ka-Nagar, Ambattur, Anna Nagar, Teynampet, Kodambakkam, Valasaravakkam, Alandur, Adyar, Perungudi, Shollinganallur
<b>Corporation</b>	Avadi, Tambaram
<b>Municipality</b>	Thiruninravur, Thiruverkadu
<b>Town Panchayat</b>	Naravarikuppam
<b>Panchayat (PU)</b>	Minjur (PU), Poonamallee (PU), Puzhal (PU), Sholavaram (PU), Villivakkam (PU), St.Thomas Mount (PU)

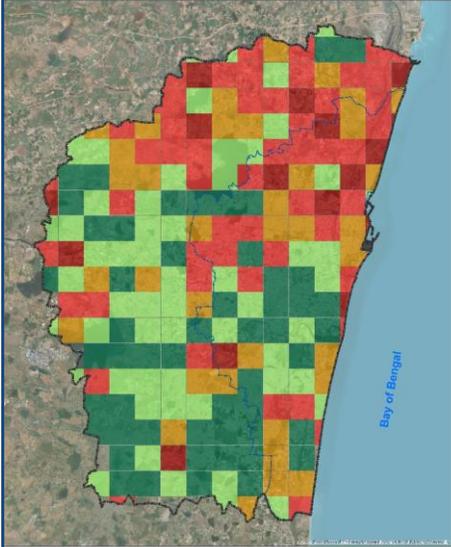
# COMBINED CLIMATE VULNERABILITY MAPPING



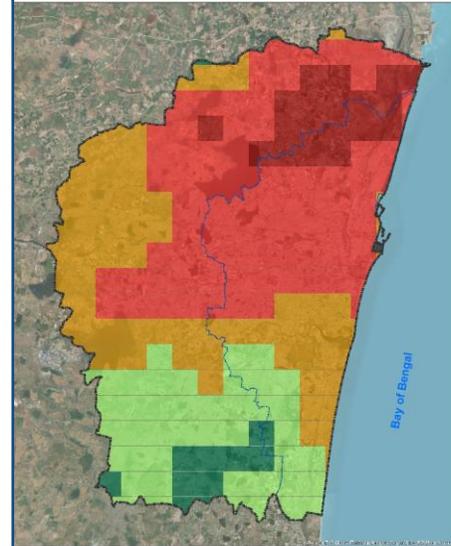
**Spatial Impact of Floods on Chennai Metropolitan Area for 2.5 km x 2.5 km grids**

**Spatial Impact of Flood on CMA**

**Spatial Impact of Heat on CMA**



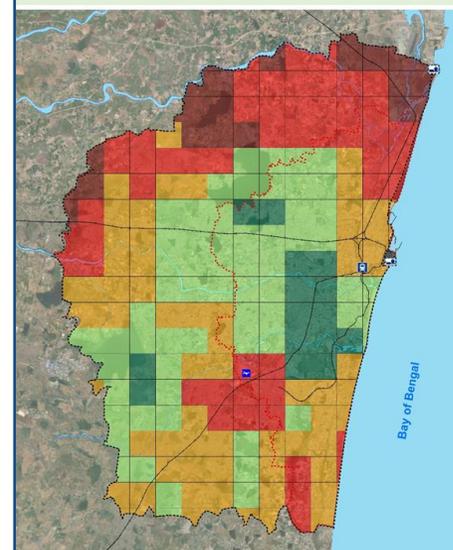
**Spatial Impact of Land Surface Heat on Chennai Metropolitan Area for 2.5 km x 2.5 km grids**



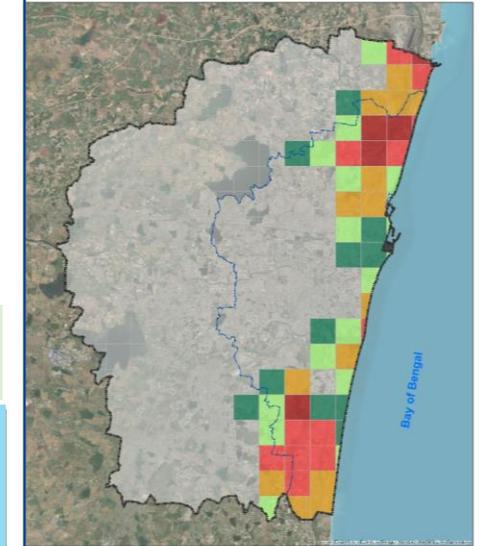
**Spatial Impact of Air Pollution on Chennai Metropolitan Area for 2.5 km x 2.5 km grids**

**Spatial Impact of Air Pollution on CMA**

**Spatial Impact of Drought on CMA**



**Spatial Impact of Drought on Chennai Metropolitan Area for 2.5 km x 2.5 km grids**



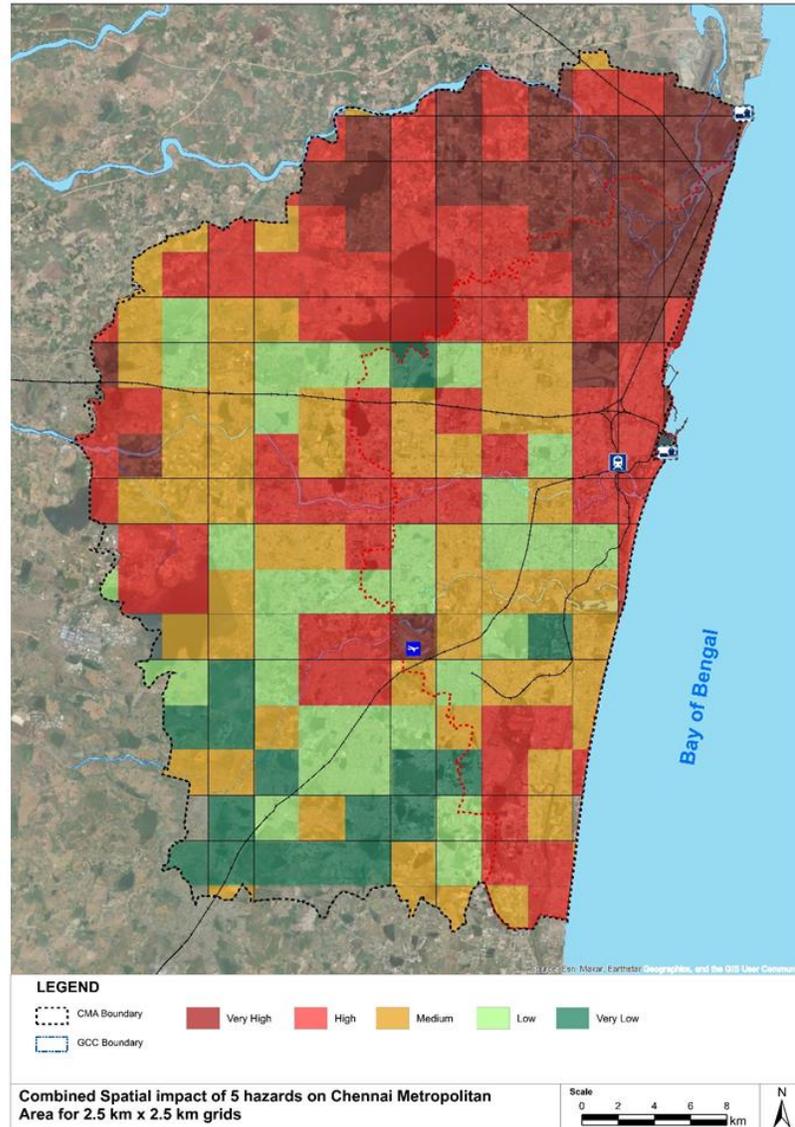
**Spatial Impact of Sea Level Rise on Chennai Metropolitan Area for 2.5 km x 2.5 km grids**

**Spatial Impact of Sea Level Rise on CMA**



# COMBINED CLIMATE VULNERABILITY MAPPING

**Spatial Impact Overlay of 5 critical climate hazards**



## Potential "very high and High" impact areas

### Very High

**GCC Zone** Thirovotriyur, Manali, Tondiarpet, Royapuram, Valasaravakkam, Alandur

**Municipality** Thiruninravur

**Panchayat (PU)** Kundrathur (PU), Minjur (PU), Poonamallee (PU), Puzhal (PU), Sholavaram (PU), St.Thomas Mount (PU), Thiruvallore (PU), Villivakkam (PU)

### High

**GCC Zone** Thirovotriyur, Manali, Madhavaram, Tondiarpet, Royapuram, Ambattur, Anna Nagar, Teynampet, Kodambakkam, Valasaravakkam, Alandur, Adyar, Perungudi, Shollinganallur

**Corporation** Avadi, Tambaram

**Municipality** Mangadu, Thiruninravur, Thiruverkadu

**Town Panchayat** Naravarikuppam, Thirumazhishai

**Panchayat (PU)** Kattankulathur (PU), Kundrathur (PU), Minjur (PU), Poonamallee (PU), Puzhal (PU), Sholavaram (PU), Sriperumbudur (PU), St.Thomas Mount (PU), Thiruvallore (PU), Villivakkam (PU)



# STAKEHOLDER CONSULTATION Step 4

The Chennai Metropolitan Development Authority (CMDA), supported by C40 Cities and the Urban Management Centre (UMC), held a stakeholder consultation workshop on 13th December, 2024 at the Ramada Hotel in Chennai as a part of Climate change risk assessment to gather inputs from the stakeholders. **The workshop focused on validation of risk assessment from the stakeholders.**

## Presentation

Presentation of **Climate Change Risk Assessment** by UMC and C40 teams

## Breakout Session

Breakout session with stakeholders divided into 3 groups based on hazards.

**Group 1- Flood and Storms**

**Group 2- Drought, Air pollution, Heat**

**Group 3- Sea level rise**

## Sector Impact Validation

**Each group** collectively **rated** the **sector impact and frequency** caused by the hazard on mutual agreement

## Findings

Once the sectoral impact and frequency ratings were done, a **group representative summarized** the **assessment** and **concluded their session**



Breakout session with the stakeholders



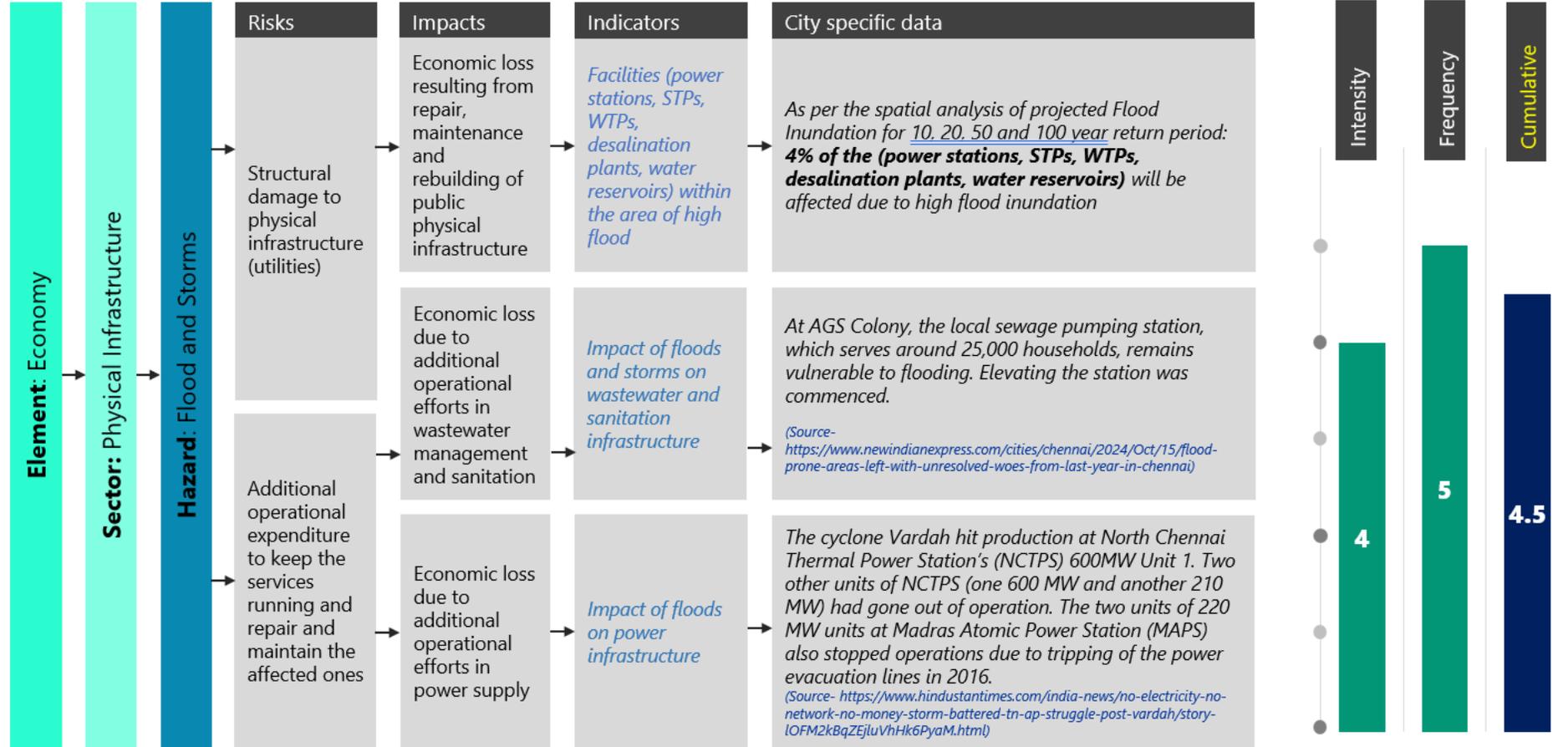
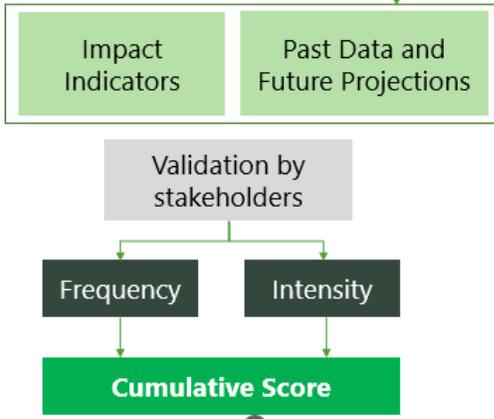
Group discussion during the breakout session



Concluding session by the stakeholder (group representative)

# CLIMATE CHANGE RISK ASSESSMENT (EVALUATION BASED ON SCORES)

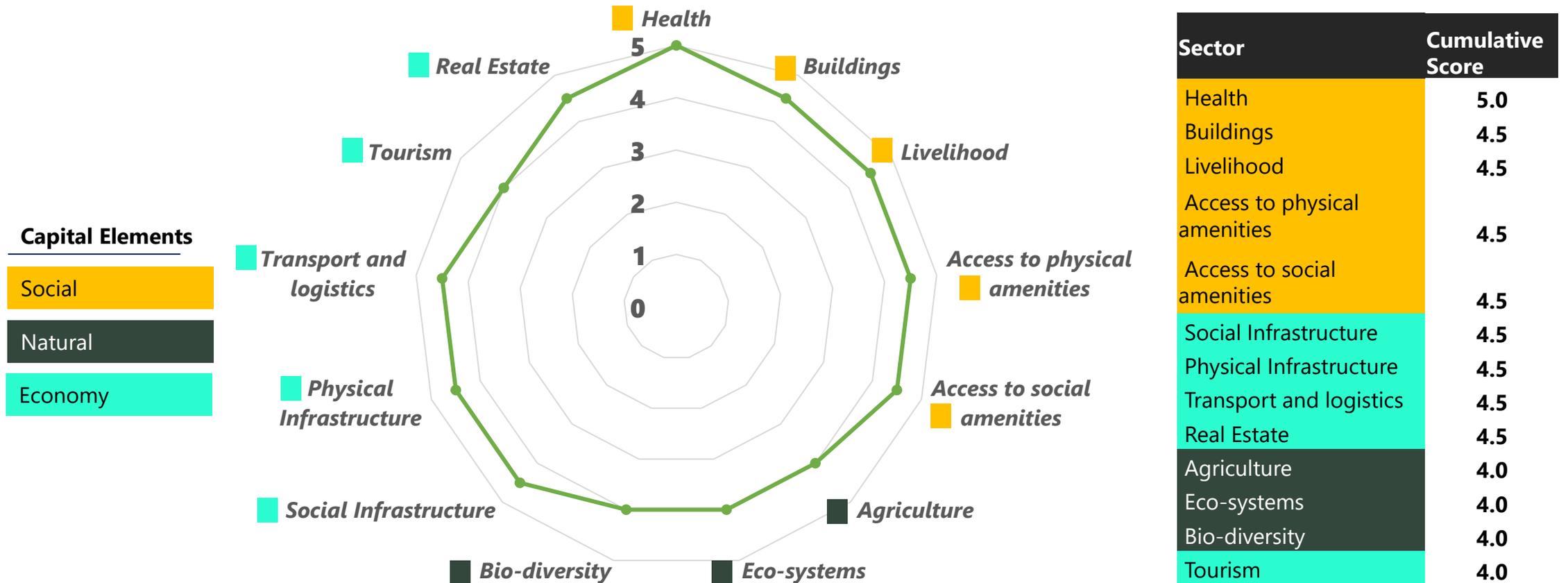
## Risk Assessment Matrix Analysis: Hazard – Floods And Storm



# RISK ASSESSMENT MATRIX ANALYSIS: HAZARD – FLOODS AND STORM

Floods and storms pose significant threats to urban resilience, disrupting social, economic, and natural systems. These extreme weather events lead to infrastructure damage, displacement, health risks, and economic losses, particularly in vulnerable regions. The risk assessment matrix analysis evaluates the impact of floods and storms on social, natural, and economic sectors under climate risk elements. Sector-specific hazard risks are prioritized based on impact intensity and frequency. Health is identified as the most affected sector, with a cumulative score of 5.0, followed by buildings, livelihood, access to physical and social amenities, and social infrastructure, each scoring 4.5. Other sectors, including agriculture, ecosystems, biodiversity, and tourism, score slightly lower at 4.0.

## Impact of “Flood and Storm” on “Social, Natural and Economy” under “Climate Risk Elements” Prioritized by sector-specific hazard risk

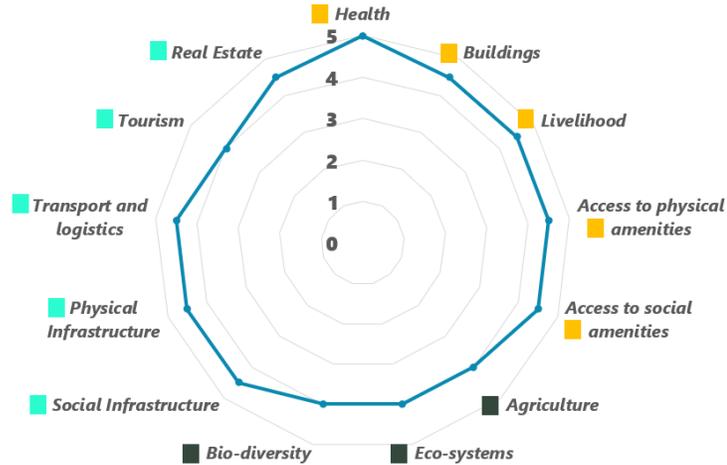


**Note-** The scores assigned to sector impact intensity and frequency are derived from primary and secondary research, further validated by the consultant-client technical team based on subject knowledge and expertise. Stakeholder inputs are taken to ascertain the findings.

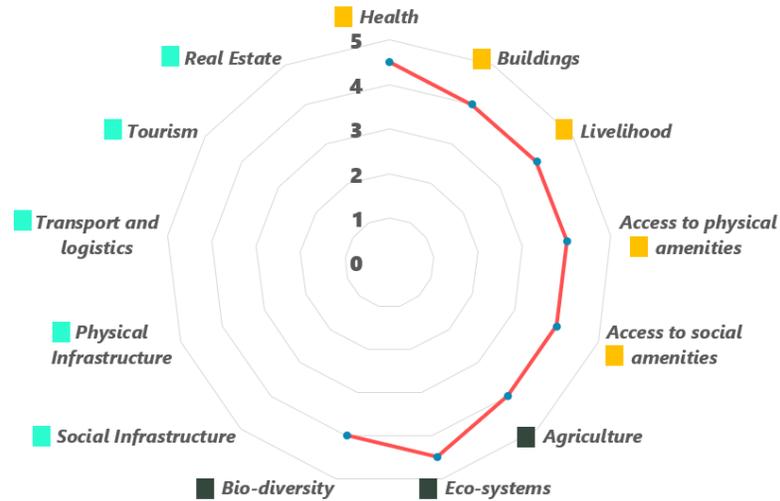


# COMPREHENSIVE RISK PRIORITY MATRIX

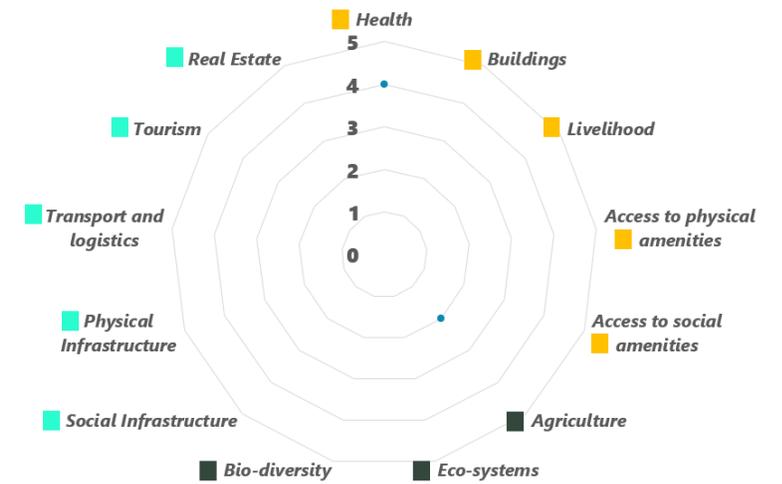
## Flood & storm



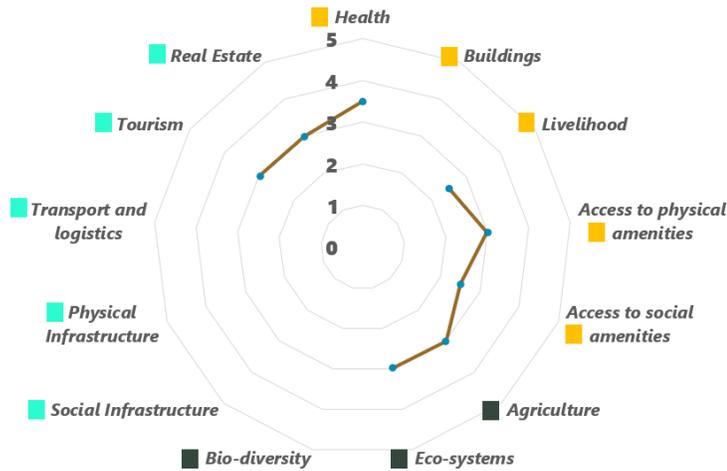
## Heat



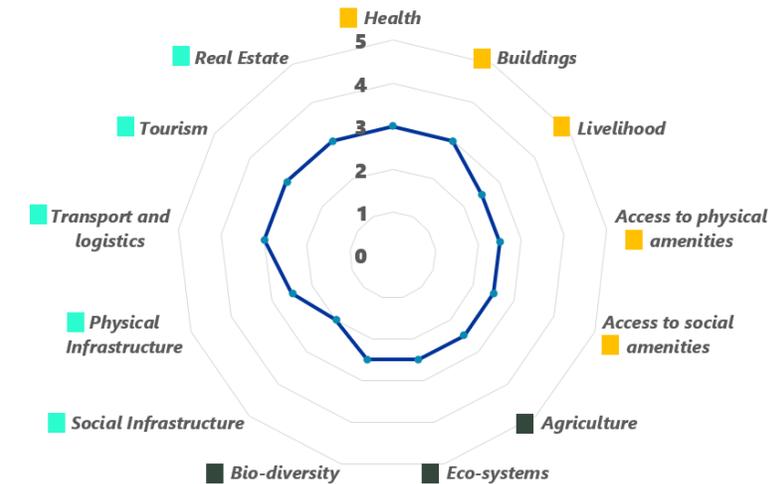
## Air Pollution



## Drought



## Sea Level Rise



The **Comprehensive Risk Priority Matrix** evaluates the cumulative impact of key climate hazards—**Flood & Storm, Heat, Air Pollution, Drought, and Sea Level Rise**—on social, natural, and economic systems. Among the most affected sectors are **health, buildings, transport & logistics, and livelihoods**, highlighting the urgent need for climate adaptation strategies. Floods and storms pose significant risks to infrastructure, while heat extremes impact public health and agriculture. Air pollution remains a critical concern for respiratory health, and drought threatens water security and livelihoods. Sea level rise endangers coastal infrastructure, tourism, and ecosystems, emphasizing the need for resilient planning.

**Note-** The scores assigned to sector impact intensity and frequency are derived from primary and secondary research, further validated by the consultant-client technical team based on subject knowledge and expertise. The findings were ascertained through stakeholder input.



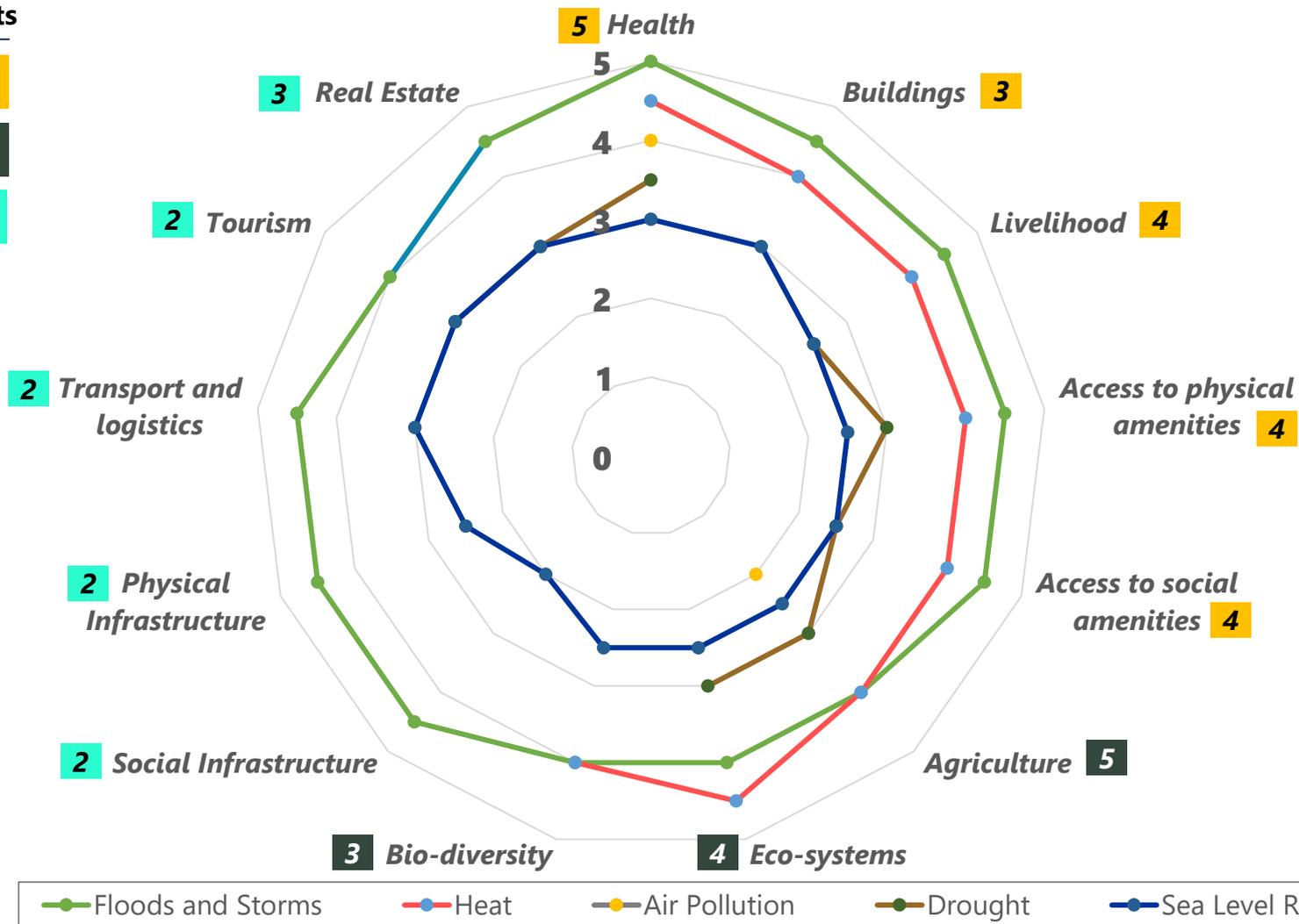
# COMPREHENSIVE RISK PRIORITY MATRIX

Cumulative Impact of all hazards on "Social, Natural and Economy" under "Climate Risk Elements"

Prioritized by sector-specific hazard risk

## Capital Elements

- Social
- Natural
- Economy



Sector	Cumulative Score
Health	4.00
Buildings	3.83
Transport and logistics	3.75
Access to physical amenities	3.50
Eco-systems	3.50
Bio-diversity	3.50
Physical Infrastructure	3.50
Real Estate	3.50
Livelihood	3.38
Access to social amenities	3.38
Tourism	3.33
Social Infrastructure	3.25
Agriculture	3.10



**Note-** The scores assigned to sector impact intensity and frequency are derived from primary and secondary research, further validated by the consultant-client technical team based on subject knowledge and expertise. The findings were ascertained through stakeholder input.



# Implementation Modalities For Climate-responsive Master Plan

## Macro Level tools

- **Guidelines and Policy Documents** - form the base of the planning regulations and are implemented through various acts and regulations, e.g., Tamil Nadu Town and Country Planning Act, 1971, Tamil Nadu Comprehensive Building and Development Control Regulations
- **Zoning** - Regulates land use and development within a city or metropolitan area. It divides the urban area into different zones, each with specific land use regulations
- **Development Control Regulations** - are specialized provisions designed to regulate development in alignment with the land use plan and policies outlined in the Master Plan

## Micro Level tools

- **Local Area Plans (LAPs) or Area Development Plans** - aim to address specific development needs, infrastructure improvements, and zoning regulations within smaller geographical areas



# STRATEGIES FOR CLIMATE-RESPONSIVE MASTER PLAN



## Policy & Regulation

Update Building codes  
Separate blackwater/greywater systems  
Protect recharge zones



## Infrastructure and Technologies

Decentralized systems (DEWATS)  
Raise pumps > 2m (or as per High flood line)  
Seal Machine holes



## Nature-Based Solution

Sponge city concepts  
Rainwater harvesting buffers

# Way forward



# The Way forward: A Template for Global Cities

## From Assessment to Implementation

1

### Map the Invisible

Use GIS Overlay to see where hazards meets assets (areas, communities, and infrastructure)

2

### Prioritize the Vulnerable

Focus on 'Very High' risk grids and prioritize sectors

3

### Integrate

Climate action belongs in the Master Plan, not a side document  
Support data-driven and Evidence-Based Decision-Making

A structured Climate Change Risk Assessment is essential for cities to **anticipate, prepare for, and respond to climate hazards effectively.**



# Thank You

**Global South Academic Conclave on WASH and Climate 2026**

**CWAS** CENTER  
FOR WATER  
AND SANITATION  
**CRDF** CEPT  
UNIVERSITY

**CEPT**  
UNIVERSITY  
FACULTY  
OF PLANNING

**Gates Foundation**

**viega** foundation