



Snapshot of TERIs work on understanding risk and responses in coastal cities

**Coastlines, Coastal Cities, and Climate Change:
A Perspective on Risk & Vulnerabilities**

**Suruchi Bhadwal, Director and Senior Fellow, Earth
Science and Climate Change Division**



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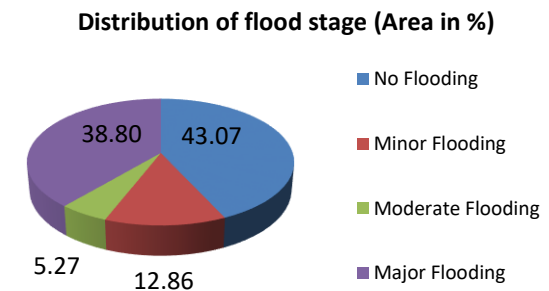
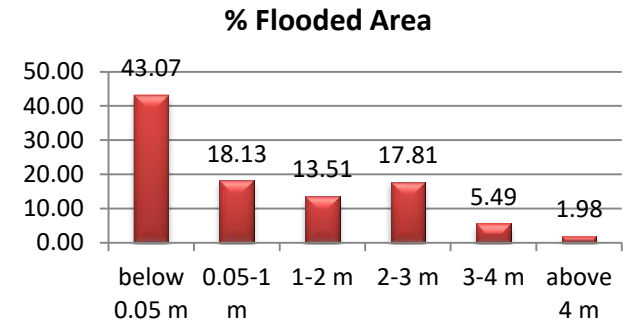
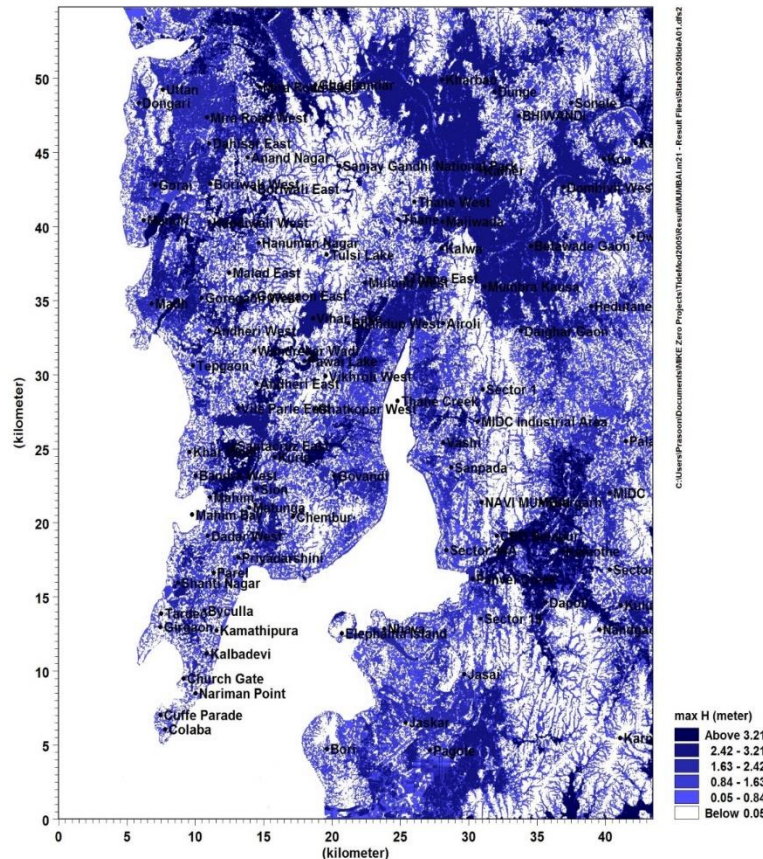
Context:

- India has a huge coastline and 2 island UTs that are highly exposed to the vagaries of weather and an enhanced climatic situation
- Coastal regions uniquely placed with exposure to additional element of risk largely with regard to SLR and storm surges apart from the impact on other sectors
- Geographical, biophysical factors further enhance the impacts with a low lying terrain and huge erosivity and subsidence
- Apart from other sectors – tourism and Infrastructure turn out to be sectors of importance in many coastal cities/ regions
- Specific impacts
 - From SLR, storm surges, cyclone incidences
 - Coastal and inland flooding, heavy precipitation incidences, human discomfort created by the wet bulb temperatures, increasing demands – energy, water, food, other services



Source: If mandatory, small sou

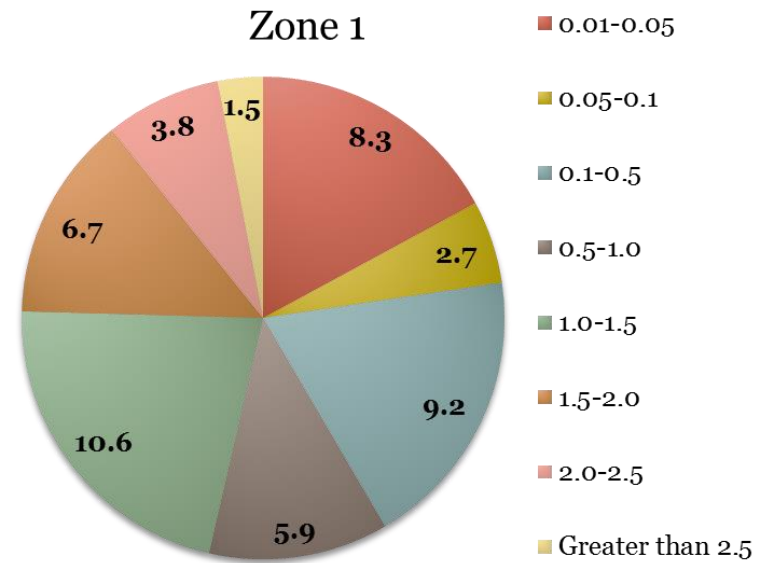
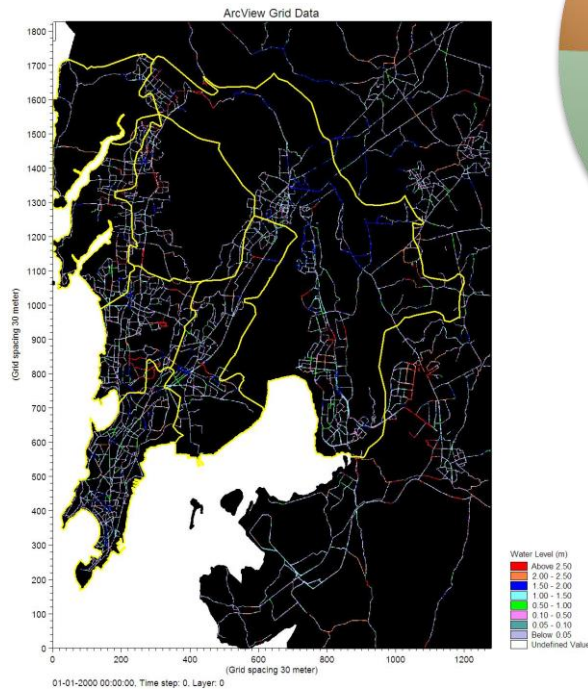
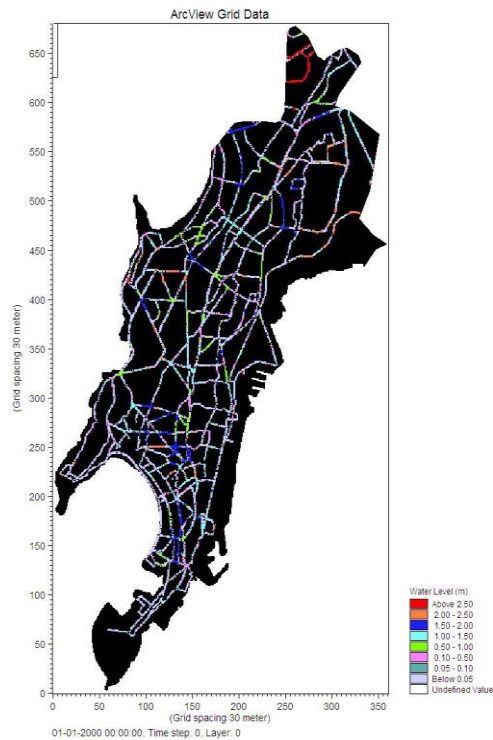
Spatial Modelling of Flooding in the city: Area flooded and Water Depth, during a heavy precipitation incidence, Mumbai 2005



What are the Infrastructure services in cities likely to be affected and therefore have a huge socioeconomic impact, where are the hotspots, vulnerable points that need to be targeted to ensure a response that effectively addresses the risk as in many cases all of this links upto investments that are needed either for new measures for grading up of existing systems

- Water services
- Sewerage and drainage – quality of water
- Transport – road network, the horizontal and vertical spreads
- Social infrastructure
- Tourism and telecommunications

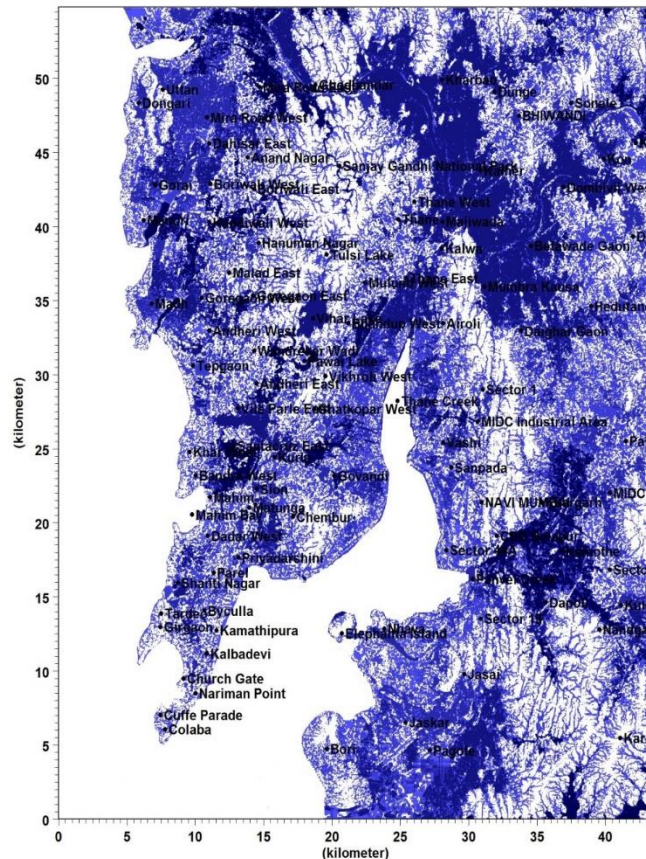
Flooding on Roads



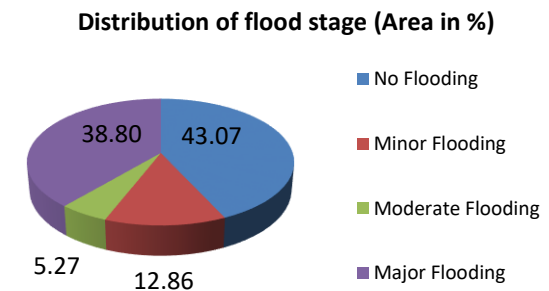
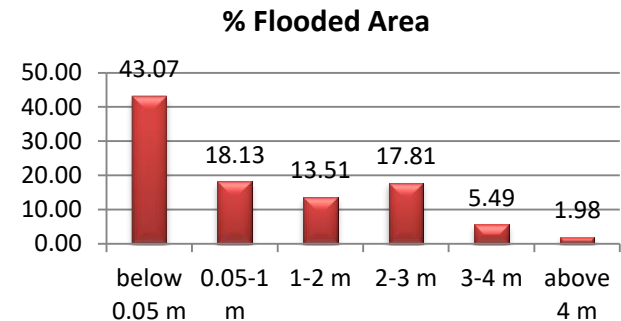
Preparing the Response – study done by TERI for the cities of Goa and Vizag, supported by the USAID

- A profiling of the city – identifying the high and low points of the city...understanding the contours
- What are the concerned impacts that concern the city for instance heavy precipitation incidences in the Konkan and it could be some other incidence elsewhere
- A thorough understanding and preparation of an Inventory – includes development of a database management system that provides a profiling of man made infrastructure in the city
 - A detailed elevation model
 - Data intensive process – collection of data of the infrastructure in the city
 - Spatial mapping of all relevant infrastructure

Spatial Modelling of Flooding in the city: Area flooded and Water Depth, during a heavy precipitation incidence, Mumbai 2005



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City profiling: Development of a DBMS

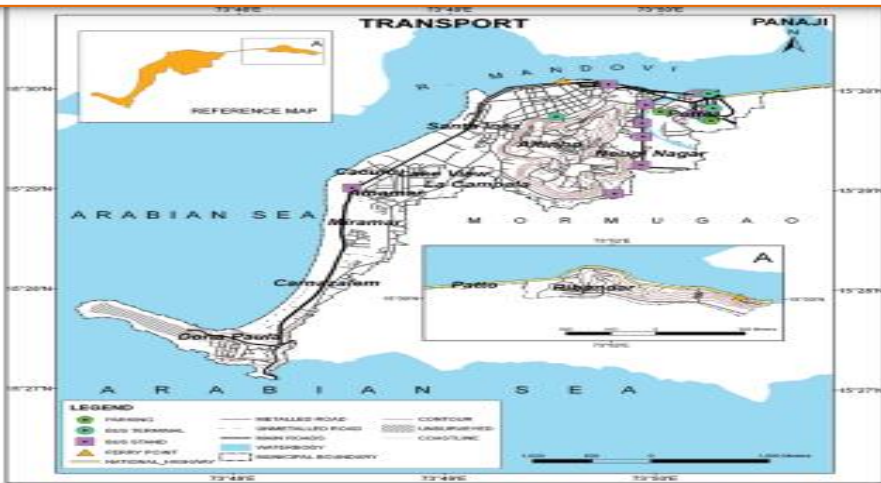


Figure 15: Map depicting the major transport infrastructure (parking areas, bus terminals and stands, and ferry points)

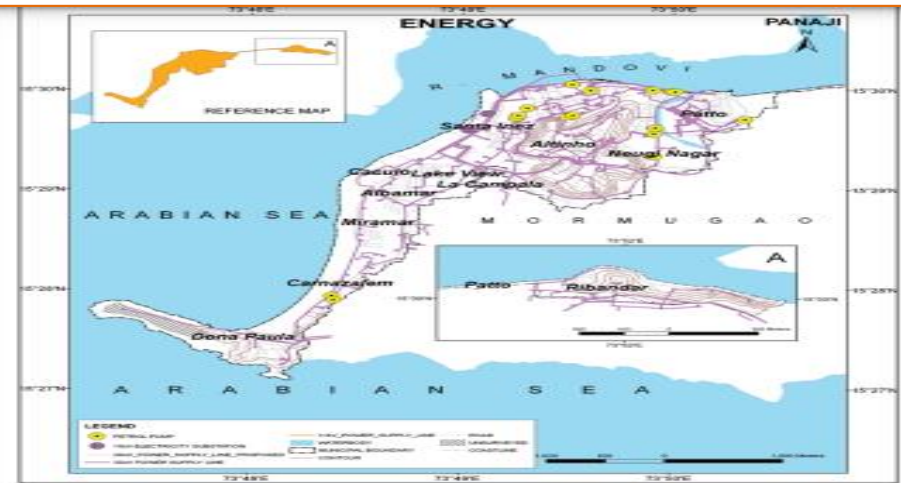
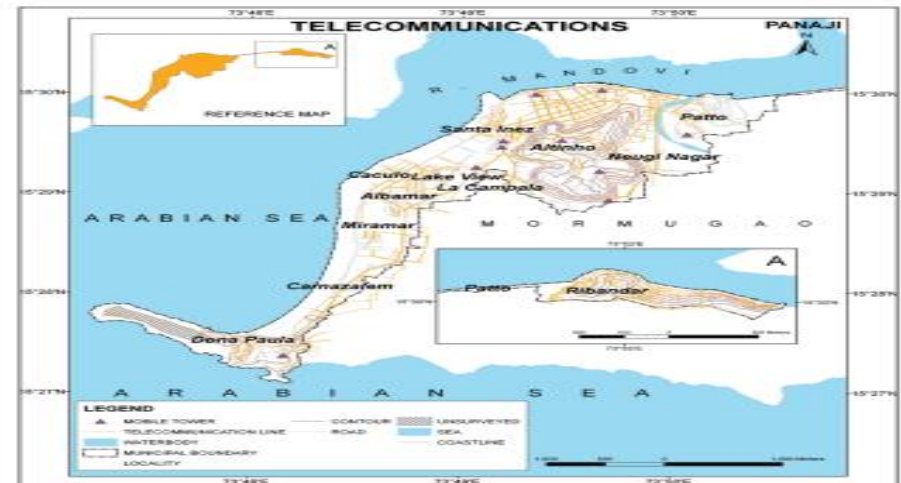
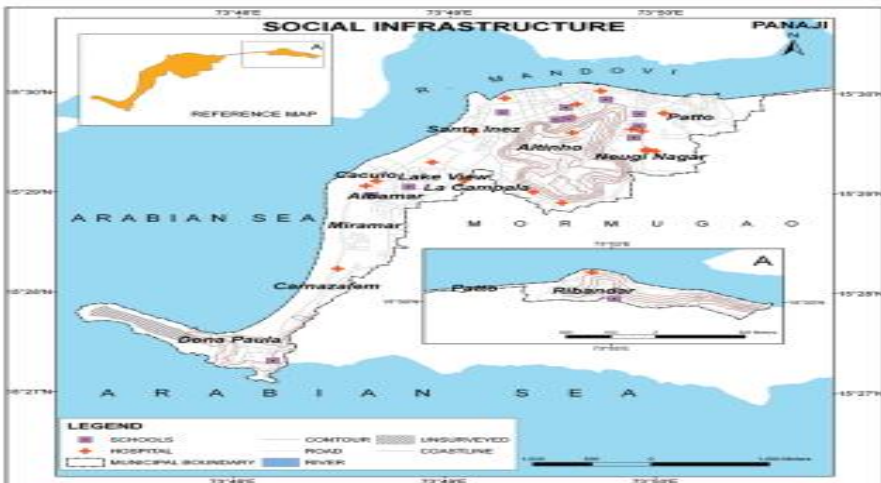


Figure 16: Map depicting the electricity substations, power supply lines, and petrol pumps in the city



Hotspot identification and Mapping sensitivities for each location

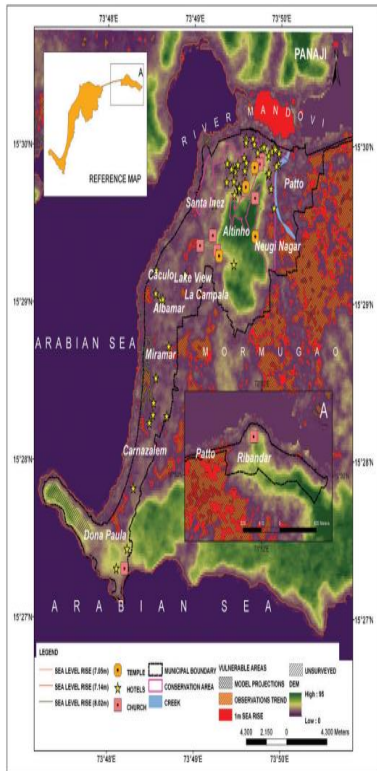


Figure 28: DEM overlay on heritage and tourism sector

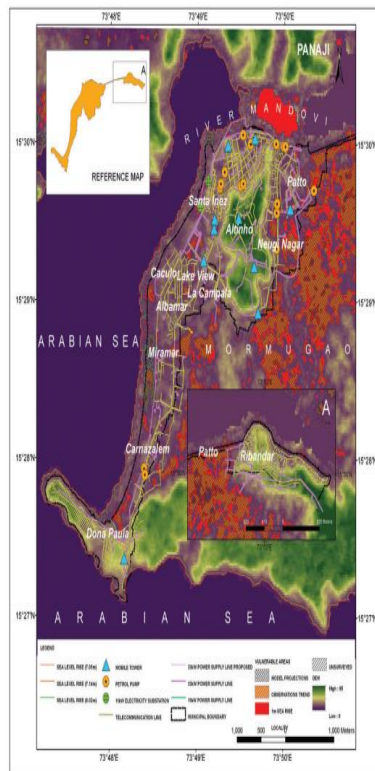


Figure 30: DEM overlay on energy and telecommunications sector

Table 1: Sector-specific sensitivity of range

Area	Sensitive sectors	Factors causing sensitivity
St. Inez	Solid Waste Management Social Infrastructure Tourism and Heritage Water Supply Transport Sewerage and Drainage Ecologically Sensitive Areas Energy and Telecommunication	SLR Low elevation Flood prone
Patto	Solid Waste Management Transport Sewerage and Drainage Ecologically Sensitive Areas Social Infrastructure Water Supply Energy and Telecommunication Tourism and Heritage	SLR Low elevation Flood prone High-density
Neugi Nagar	Social Infrastructure Tourism and Heritage Sewerage and Drainage	SLR Flood prone Low elevation

What do you want to target for response measures?

Addressing the safety and resilience of the critical man- made infrastructure

- Social Infrastructure
- Solid waste management
- Heritage and Tourism
- Water supply
- Transport
- Sewerage and drainage
- Energy and telecommunication

Addressing the safety and resilience of natural infrastructure

- Khazan Lands
- Mangroves
- Sand dunes
- Creeks

Supporting and enabling measures

- Planning measures
- Regulations and institutions
- Capacity building and awareness generation

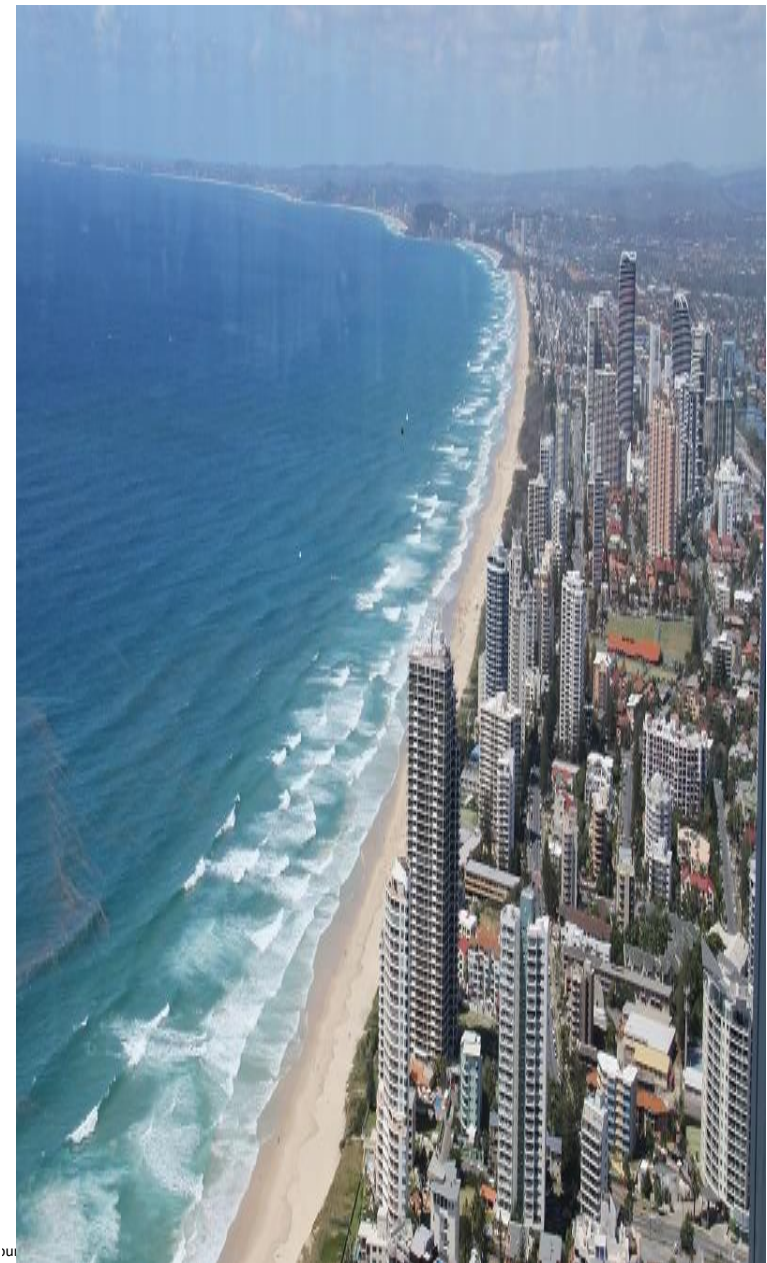


Figure 31: Overview of recommendations

Table 2: Sector-wise recommendations for addressing vulnerabilities associated with SLR in the city

Sector	Structural measures	Non-structural measures	Suggested data fields
Ecologically Sensitive Areas (khazan lands; mangroves; creeks)	<ul style="list-style-type: none"> • Rehabilitation and preservation measures around sand dunes and mangroves. For instance, plantation of vegetation along the dunes can help restore and stabilize the dunes • Immediate need of identifying and curbing the point and non-point sources of pollution along its course, de-silting, and cleaning of the creek 	<ul style="list-style-type: none"> • Spatial maps of natural assets like khazan lands, salt pans, mangroves, creeks, etc., should be maintained. The entire shore line ecosystem should be demarcated in a GIS framework • The natural assets of the city should be demarcated and preserved and no construction /man-made interventions should be allowed in the ecologically sensitive areas 	<ul style="list-style-type: none"> • Sea-level rise will change the coastal morphology and soil characteristics. Cities must, therefore, maintain beach erosion information.
Solid Waste Management	<ul style="list-style-type: none"> • Introducing waterproofing measures, like barriers to reduce contact from flood water, waterproof covers and rain shelters • Creating elevated storage spaces 	<ul style="list-style-type: none"> • Framing up of siting regulations (for landfill sites, sorting centres and compost stations) after assessing the vulnerable areas with respect to the impact of sea-level rise • Identifying a number of alternate disposal sites in case of restricted access due to flooding 	<ul style="list-style-type: none"> • Elevation of important disposal and treatment sites • Location of curb side refuse collection bins, primary collection, and segregation centres • The bins and centres located in flood prone areas

Heritage and Tourism	<ul style="list-style-type: none"> • Reducing the impact of flooding • Addressing the requirements after the flood has receded • Checking for building stability and efficiency 	<ul style="list-style-type: none"> • Flood proofing and conservation programmes based on expert advice • Emergency plan for the safety of the tourists, for example emergency evacuation, safe transport facilities, and health facilities • Assessments regarding impact of sea-level rise on tourism activities for siting of upcoming infrastructure like hotels and beach tourism, etc. • All future tourism infrastructure projects must comply with the Coastal Regulation Zone rules. 	<ul style="list-style-type: none"> • Data on intensity of tourist inflows in the city at a particular time of the year • Age, condition, and last maintenance carried out in heritage sites • An inventory of informal sector that supports tourism should be maintained
Water Supply	<ul style="list-style-type: none"> • Prevent water leakage and infiltration of flood water into the pipelines—marking and monitoring the infiltration points to facilitate maintenance 	<ul style="list-style-type: none"> • An emergency supply plan with demarcated network routes as well as alternate modes of supply to restore water supply in the affected zones • Quality monitoring has to be frequently carried out during rainy season. 	<ul style="list-style-type: none"> • Data on the age and capacity of treatment plants • Data on incidences of shutting down of pumps • Influent and effluent data from the treatment plant • Emergency supply plan • Seasonal reports on water quality should be maintained • Regular maintenance details

Sewerage and Drainage	<ul style="list-style-type: none"> • The vertical elevation of the outfall channel should be above the high tide level to avoid back flows from sea • Planning the gradual augmentation of the sewerage system—New drains to take into account the vulnerable zones of the city and appropriately in-built resilience features 	<ul style="list-style-type: none"> • Identifying alternate energy sources in vulnerable zones housing pumping stations • Regular maintenance— The drains must be cleaned periodically to avoid blockages during peak time • Integrating vulnerability assessment and resilience planning in institutional framework and plans, acts, rules, bylaws, building codes, etc. 	<ul style="list-style-type: none"> • Data on flood-prone areas • Yearly data on water logged areas • Locational details of drainage • Height of outfall sewers from the mean sea level/ high tide level • Maximum capacity of pumps and treatment plants • Distance of waste water plant from sea
Transport	<ul style="list-style-type: none"> • Retrofit and adaptation of airport and sea port systems • Appropriate design of public transport systems— siting, entry and exits, drainage, manholes, considerations for safety of structures, equipment, and operations. 	<ul style="list-style-type: none"> • Emergency transport arrangements and alternative route planning— SOPs • Emergency operations and control measures— SOPs • Planning new infrastructure: avoiding low-lying vulnerable hotspots 	<ul style="list-style-type: none"> • Road infrastructure— Location and elevation of roads, bridges, subways, tunnels, etc, data on age, type of structures, building materials, etc., drainage information

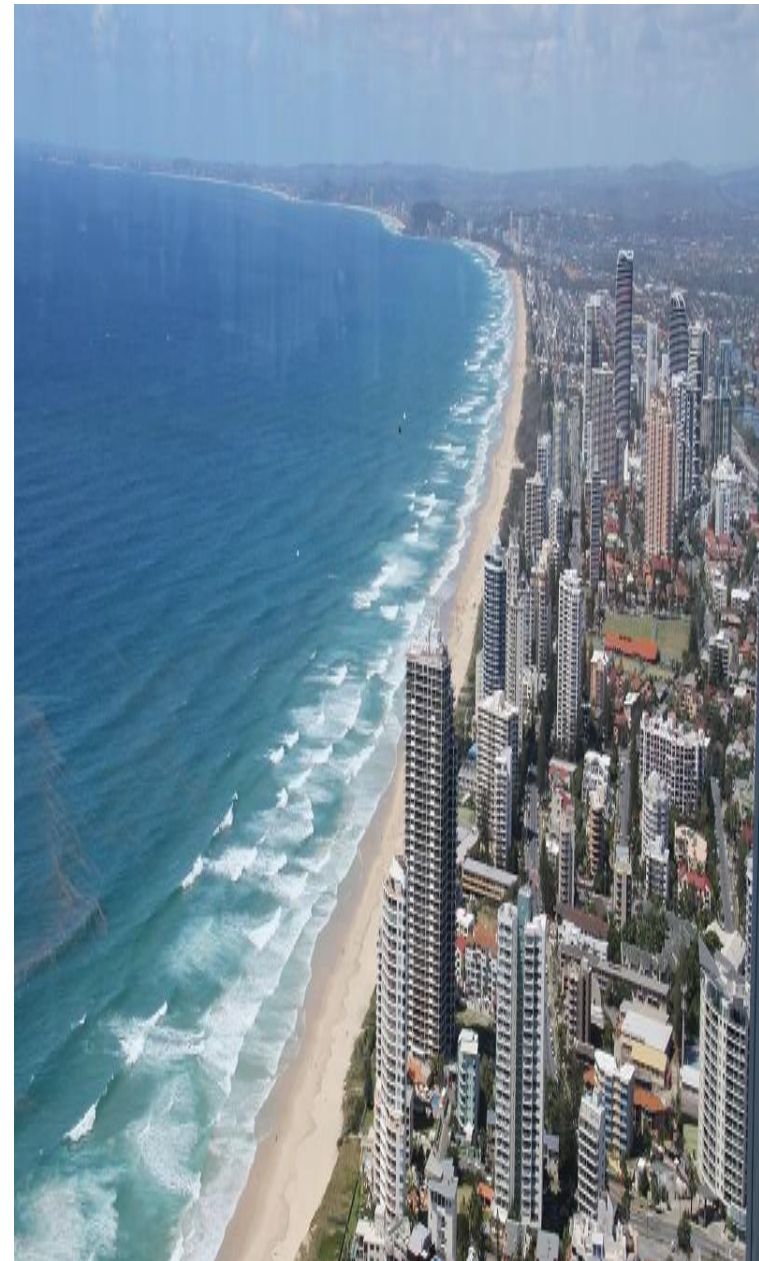
	<ul style="list-style-type: none"> • Building elevations and materials for structural safety • For transport networks, appropriate drainage provisions with optimum design capacity, length, depth, and the gradient are required • If the parking lot is not to be used for retaining water, provision of drains, impervious surface area and adequate slope at strategic locations to prevent flooding and water logging would be required 	<ul style="list-style-type: none"> • Integrating vulnerability assessment and resilience planning in institutional framework and plans, acts, rules, by-laws, building codes, etc. • Enforcement of CRZ Notification 2011 while development and siting of transport infrastructure and networks • Siting of processing and industrial units in and around port areas as per the CRZ Notification 2011 	<ul style="list-style-type: none"> • Railways— Information on location and networks, maintenance plan and frequency, elevation, flood prone areas, data on disruptions due to extreme weather phenomena, data on railway buildings • Airport— Capacity, footfalls, age, building material, elevation, plinth level, entry to runway/taxi ways, details of low-lying/ flood-prone areas
Social Infrastructure	<ul style="list-style-type: none"> • Reducing the impact of flooding through appropriate building design solutions • Addressing the requirements after the flood has receded • Checking for building stability and efficiency 	<ul style="list-style-type: none"> • Planning for evacuation, response and relief in case of extreme events—SOPs • Planning new infrastructure: Avoiding low-lying vulnerable hotspots • Integrating vulnerability assessment and resilience planning in institutional framework and plans, acts, rules, by-laws, building codes, etc. 	<ul style="list-style-type: none"> • Health— Information on location of hospitals and health centres, ambulances, medicine stocks, doctors, nursing and paramedical personnel, yearly data on diseases, etc. • Education — Information on location of schools, number of students, available rooms and infrastructure, transport facilities, etc.

Energy and Telecommunication

- Appropriate building design solutions for reducing flood damage in vulnerable areas
 - Appropriate on-site drainage on production and refuelling stations
 - Maintaining safe heights for infrastructure assets like Electric Substation and for leak- proof equipment storage
 - Appropriate reinforcement measures for the safety and stability of towers and cables/ lines
- Planning new infrastructure: Avoiding vulnerable hotspots for siting
 - Integrating vulnerability assessment and resilience planning in institutional framework and plans, acts, rules, by-laws, building codes, etc.
 - Enforcing state level Renewable Portfolio Obligation (RPO) in line with The Electricity Act of 2003 for promoting smaller, distributed power generation units to minimize and manage impact on grid and develop climate resilient power infrastructure
- Location and elevation of facilities— production sites, substations, etc
 - Details of transmission lines— location of towers, network, underground cabling details for flood prone and low-lying areas

In conclusion...

- However, it is only a first step in demonstrating and initiating climate action at a city level and for coastal cities
- City governance and management plays a crucial role in the implementation of the various actions
- Actions may be staggered over the short, medium, and long term period with clear target timelines and quantifiable goals,
 - To be based on expert advice, scientific studies, and financial considerations.
- Supporting and enabling mechanisms in terms of policy and regulatory frameworks, finance allocation, and sensitization and capacity-building of stakeholders will be an integral part of climate resilience planning efforts and need to be continuous.
- Besides, since infrastructure development and management for a number of sectors and services is beyond the powers and functions of the ULB, an integrated multi-sectoral approach with dedicated institutional framework needs to be formulated for coordinating infrastructure development and management at city level for building resilience





Thank You

suruchib@teri.res.in