Climate Change Impacts on Coastal Areas -Tools and Models for Coastal Resilience Planning

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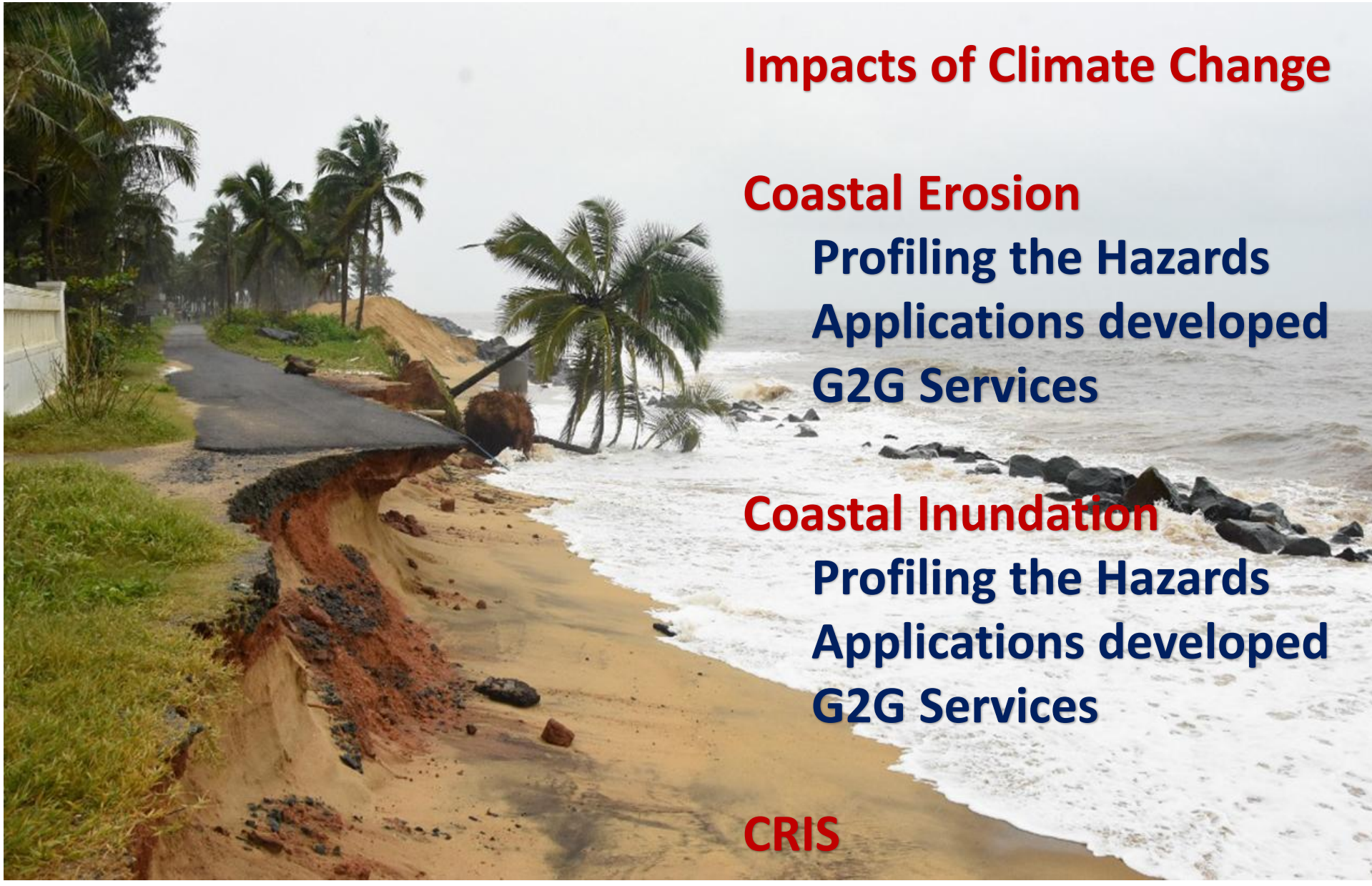
Outline of the talk



Impacts of Climate Change

Coastal Erosion

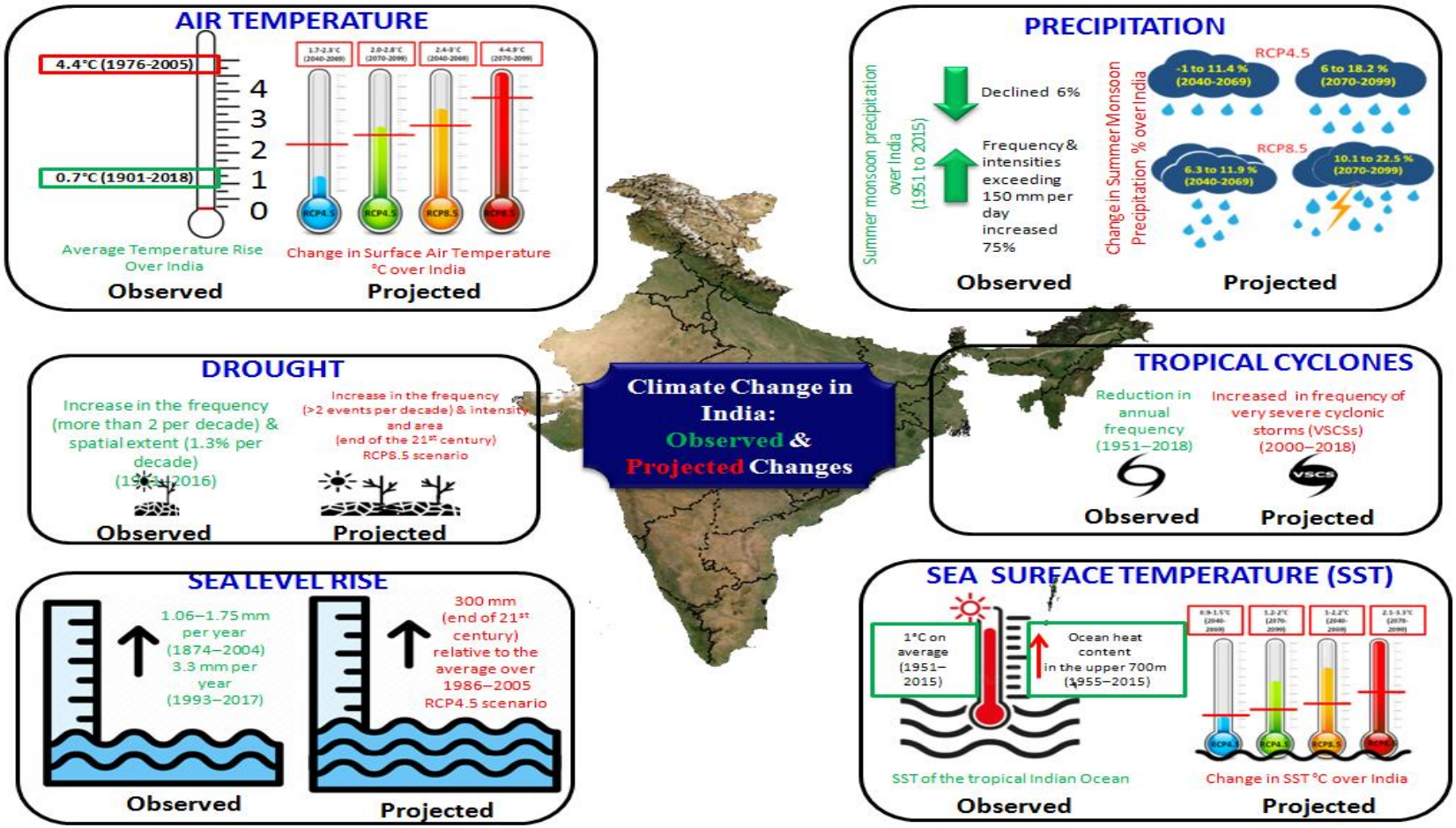
- Profiling the Hazards
- Applications developed
- G2G Services

Coastal Inundation

- Profiling the Hazards
- Applications developed
- G2G Services

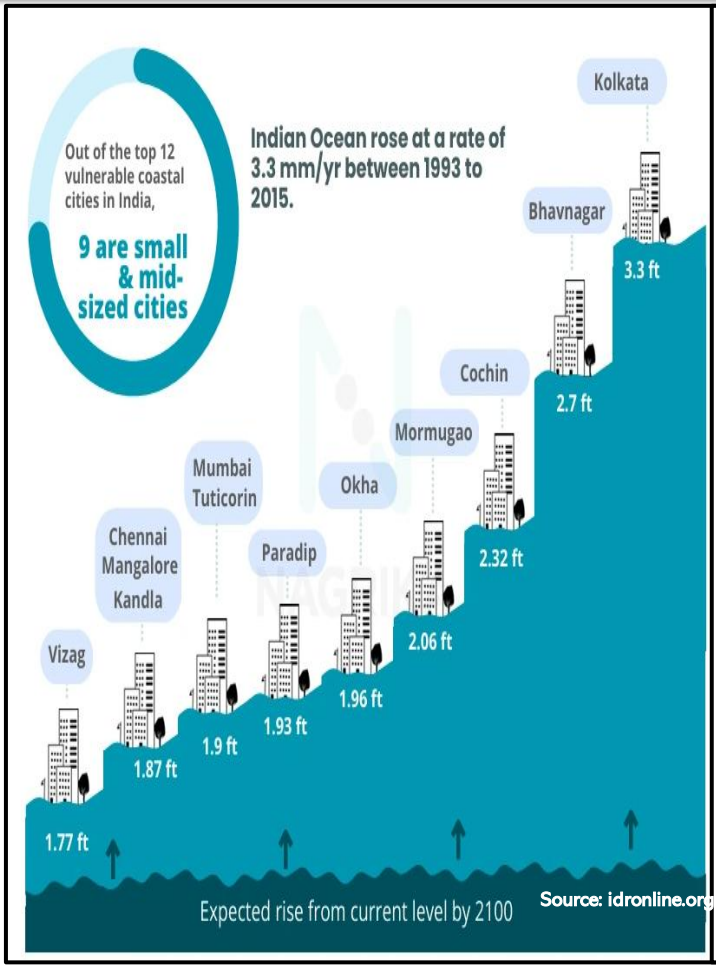
CRIS

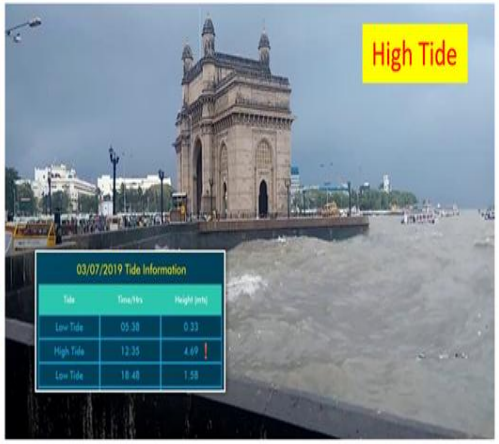
CLIMATE CHANGE – THE HAPPENING REALITY



Warming since the 1950s has already contributed to a significant increase in weather and climate extremes globally (e.g., heat waves, droughts, heavy precipitation, and severe cyclones), changes in precipitation and wind patterns, warming and acidification of the global oceans, melting of sea ice and glaciers, rising sea levels, and changes in marine and terrestrial ecosystems.

Future Scenario (Projected)





Over the coming decades, the populations of India's coastal regions and major cities are projected to grow significantly. This demographic shift, combined with the looming threats of climate change, rising sea levels, and an increasing frequency of extreme weather events, will expose coastal communities, homes, infrastructure, and ecosystems to heightened risks of disasters. In light of these challenges,

PREPAREDNESS IS NOT JUST AN OPTION—IT IS AN URGENT NECESSITY.

NCCR's Expertise

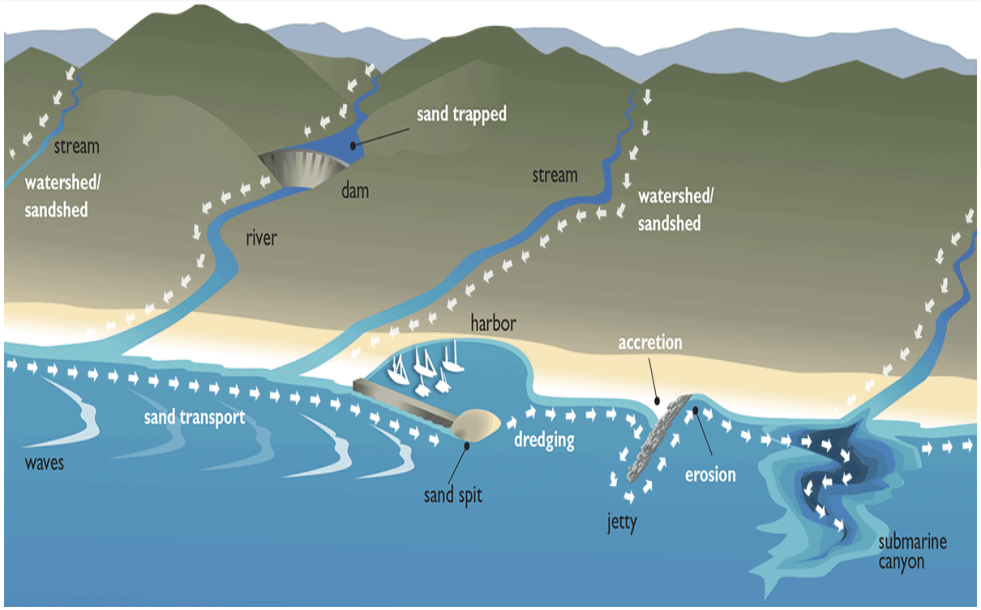
Coastal Hazard / Vulnerability

- Field observations
- Geomatics RS&GIS
- Numerical Modelling
- AI/ML Models

Profiling the Hazard

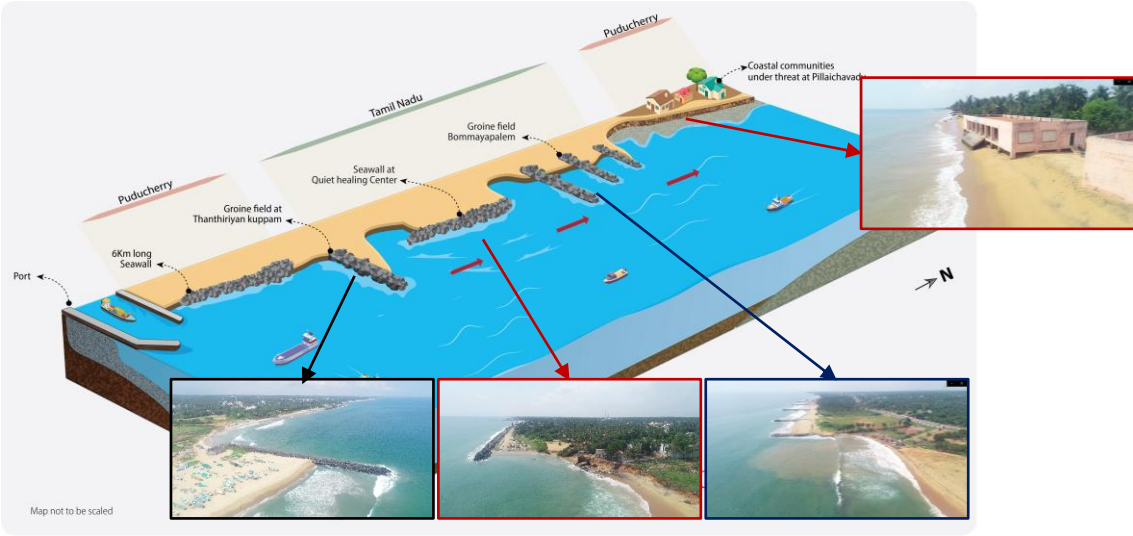
Coastal Erosion - Severity of the Situation

Understanding the causes

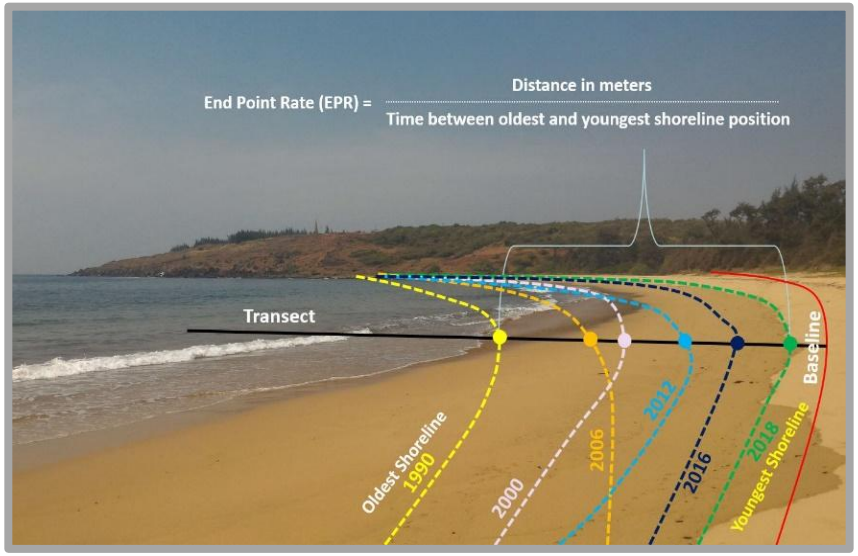


Understanding of Coastal Processes through Monitoring, Modelling

Anthropogenic reasons



Shoreline Analysis for Indian Coast



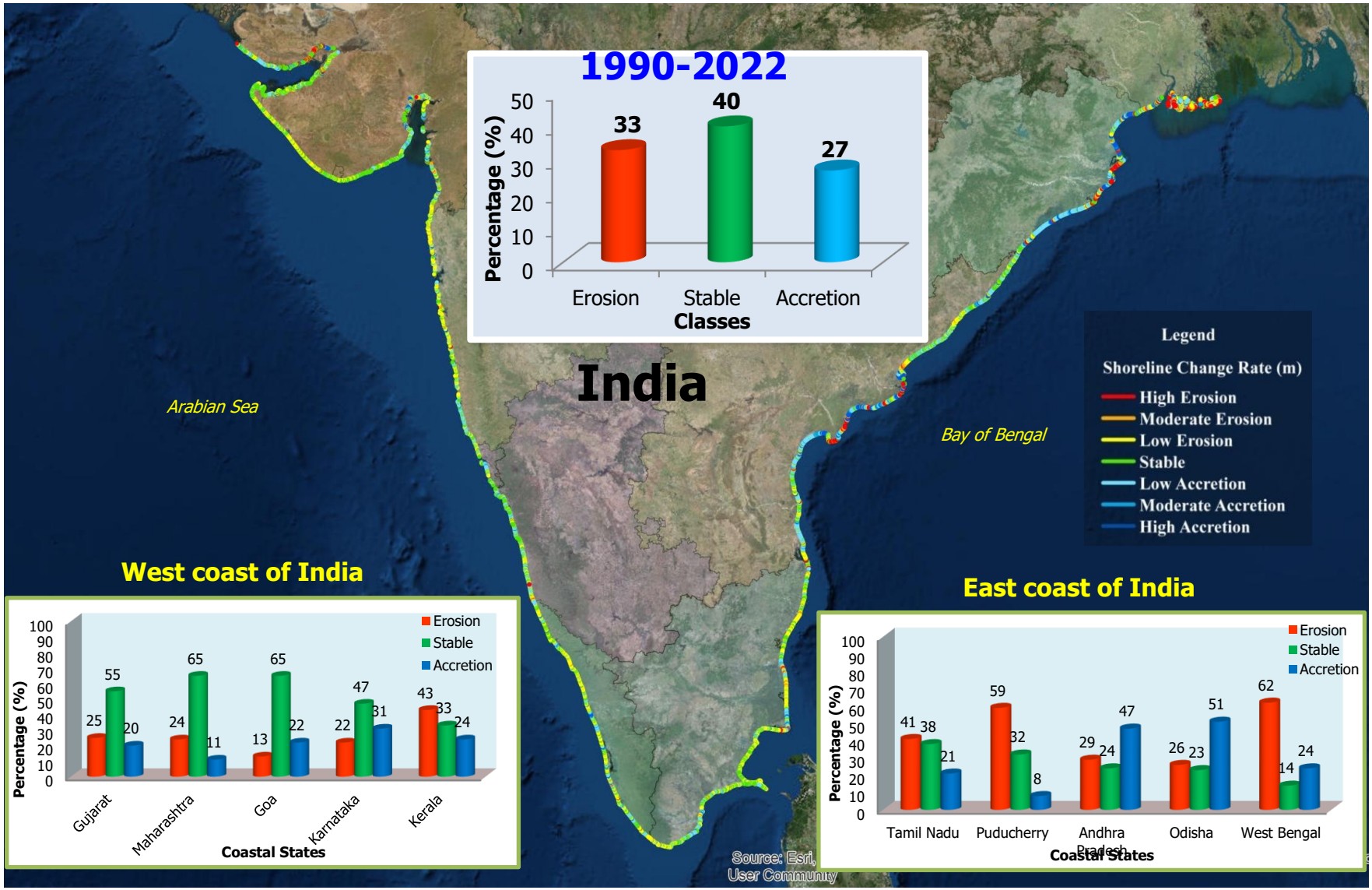
List of Image	Pixel Size(m)	Date	Source
Landsat 5 TM	30.0	1989-1992	USGS
Landsat 7 ETM+	30.0	1999-2001	USGS
IRS P5 (Cartosat-1) PAN	2.5	2005-2006	NRSC
IRS P6 (Resourcesat-1) - (LISS-III)	23.5	2008	NRSC
Resourcesat 2 - (LISS-IV)	5.8	2012	NRSC
Resourcesat 2 - (LISS-IV)	5.8	2013	NRSC
Resourcesat 2 - (LISS-IV)	5.8	2014	NRSC
Resourcesat 2 - (LISS-IV)	5.8	2015	NRSC
Resourcesat 2 - (LISS-IV)	5.8	2016	NRSC
Resourcesat 2 & 2A - (LISS-IV)	5.8	2017	NRSC
Resourcesat 2 & 2A- (LISS-IV)	5.8	2018	NRSC
Resourcesat 2 & 2A- (LISS-IV)	5.8	2019	NRSC
Resourcesat 2 & 2A- (LISS-IV)	5.8	2020	NRSC
Resourcesat 2 & 2A- (LISS-IV)	5.8	2021	NRSC
Resourcesat 2 & 2A- (LISS-IV)	5.8	2022	NRSC

Figure 5.a) shows the GCPs point collected rail/road intersection, Andhra Pradesh. and b) shows the shoreline tracking near paradip sea beach, Odisha.

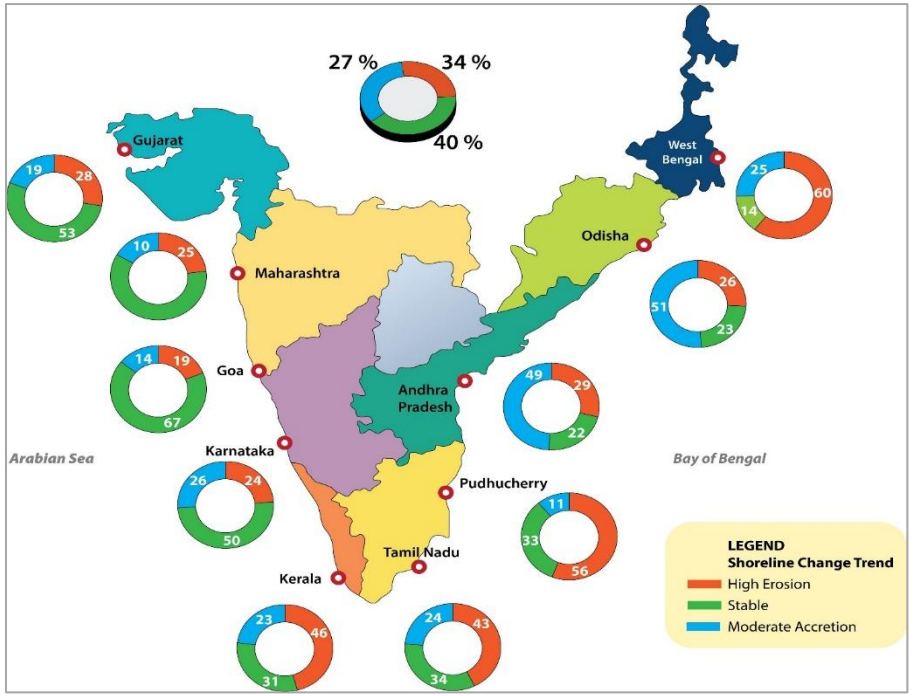
Weighted Linear Regression Rate (WLR)

- Shoreline change by the weighted linear regression rate method (determined by plotting the shoreline positions with respect to time and calculating the linear regression equation of y. The slope of the regression line is the rate).
- Used for long-term shoreline change studies

Shoreline Change mapping for entire Indian coast including islands

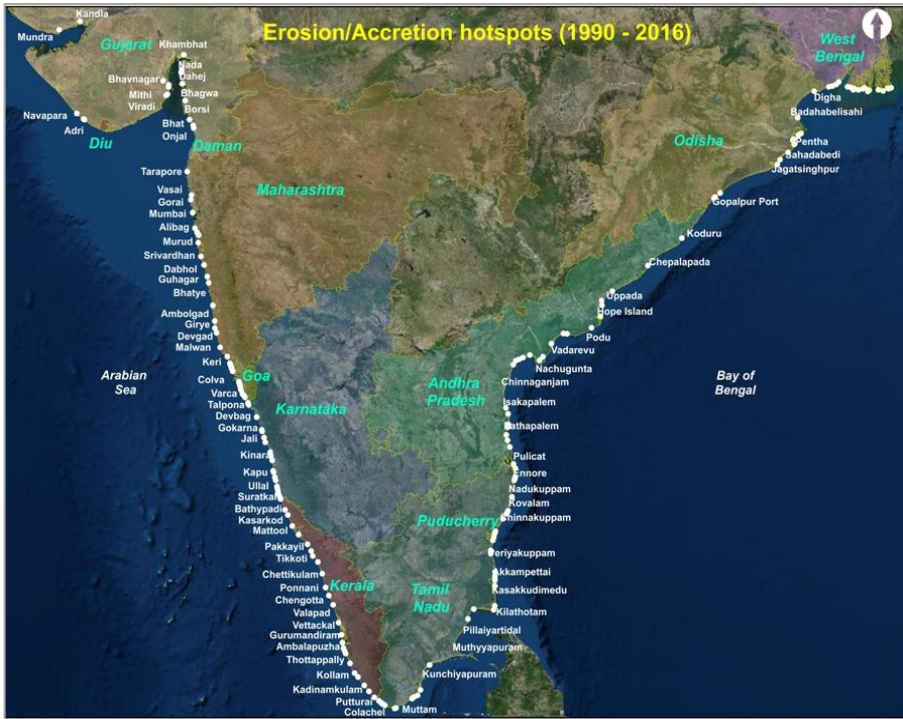


Erosion along Indian Coast



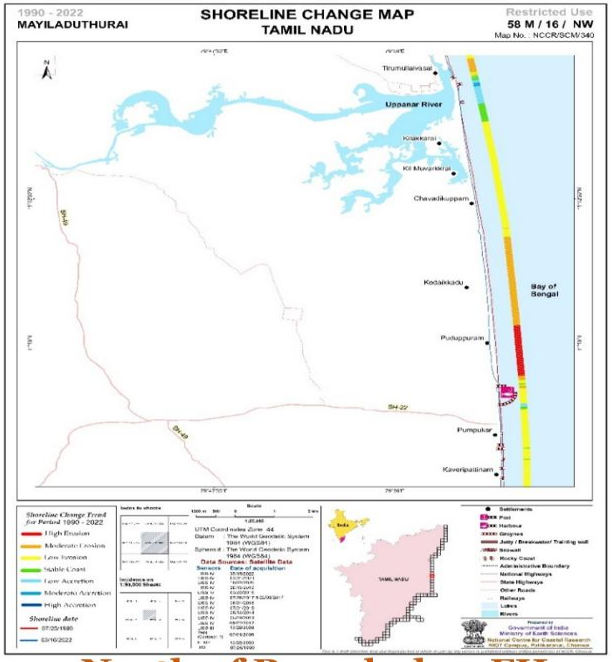
State wise analysis suggest that 40% of erosion is noticed in West Bengal , Tamil Nadu, Kerala and Pondicherry.

Accreting Coasts - Odisha and Andhra Pradesh.

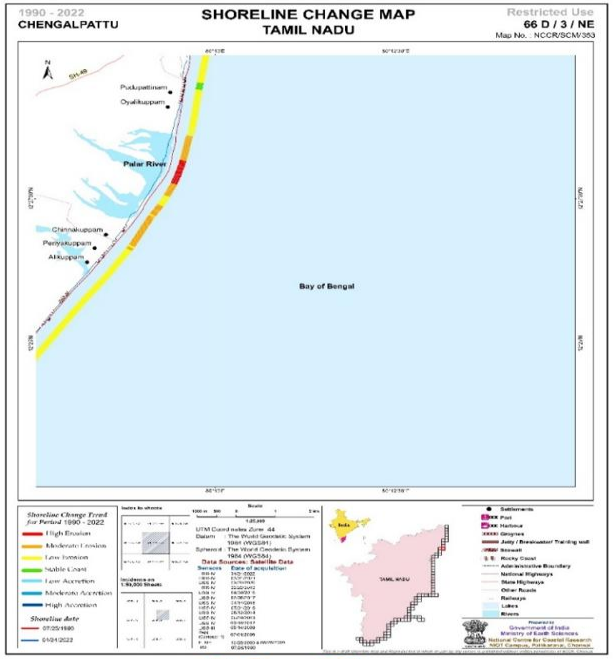


Applications Developed – updated regularly 1:25,000 Scale Maps

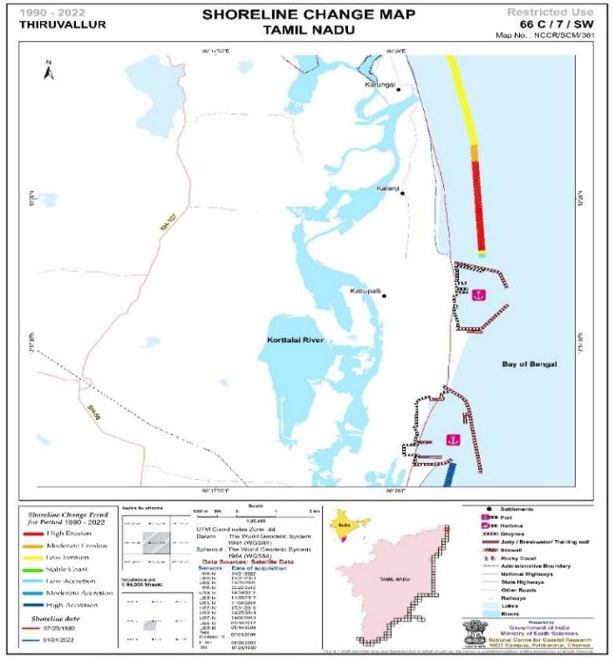
1:25,000 Scale Maps



North of Poombuhar FH



Palar River



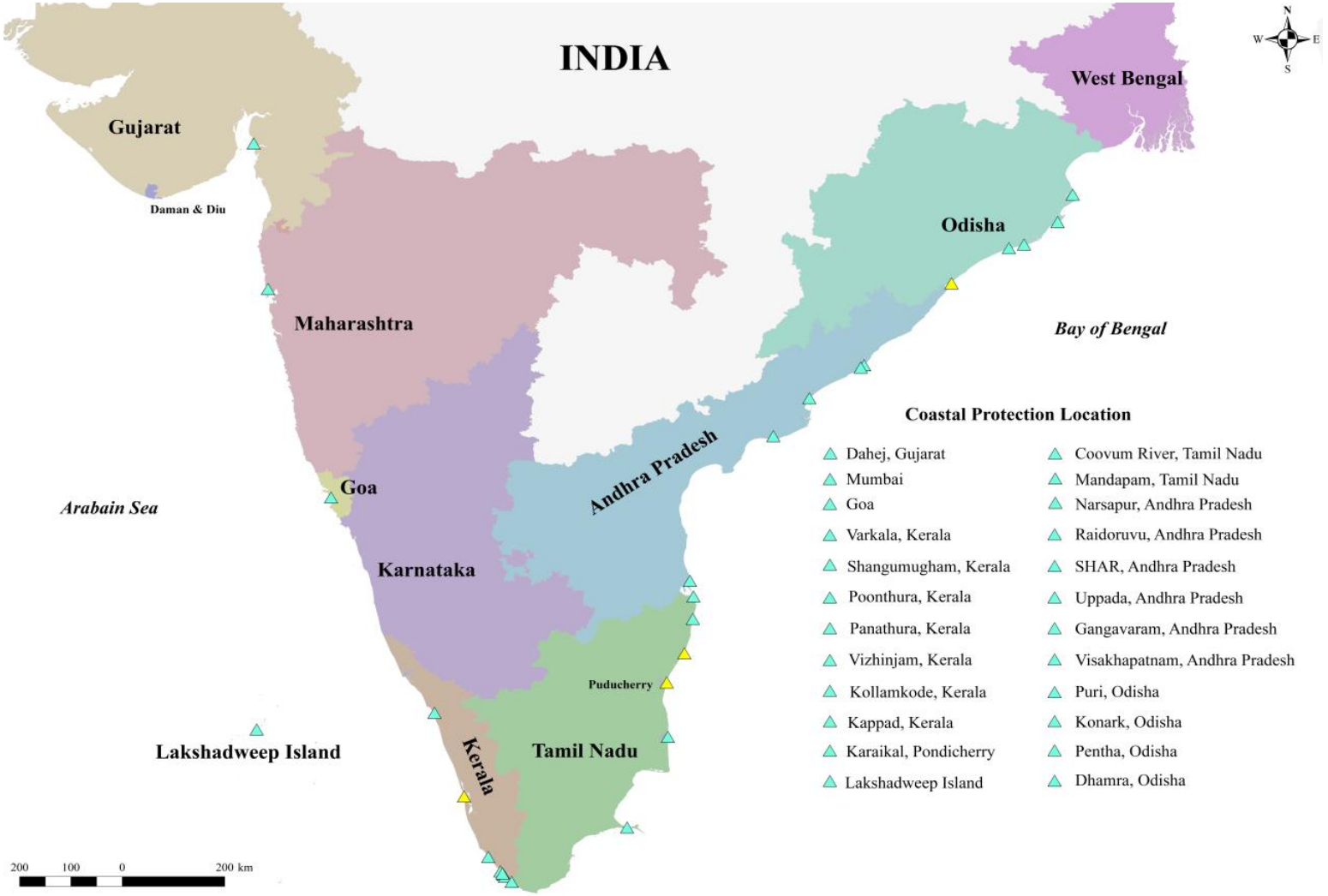
North of Kattupalli Port

National Shoreline Assessment System – N-SAS - 526 maps are prepared for the entire Indian Coast at 1:25000 scale; updated regularly.

National shoreline Assessment System is a webGIS based system that is developed to capture the shoreline changes including the erosion/accretion details all along the Indian coast.

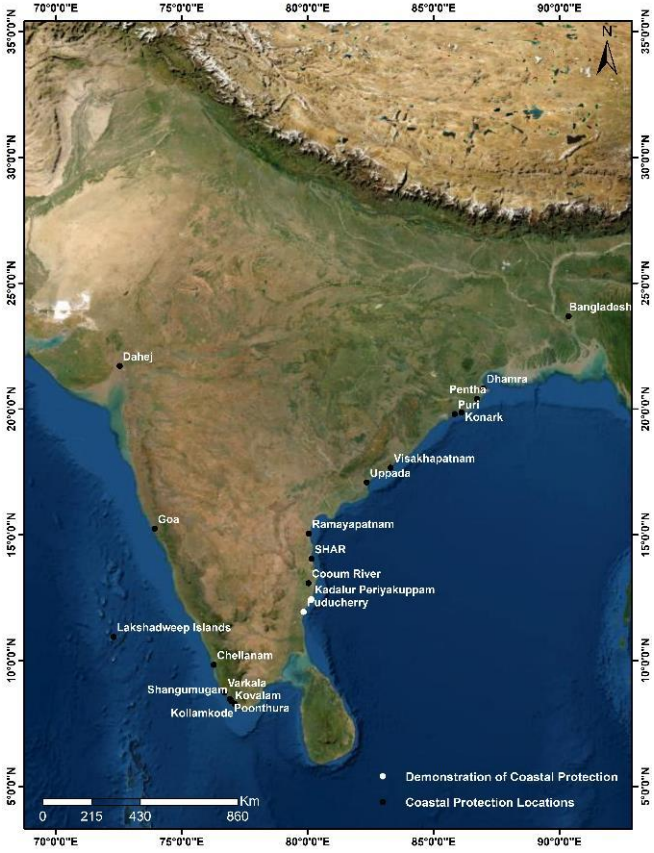
G2G Services

Coastal Projects along Indian Coast : NCCR



Coastal Protection Projects- Indian Coast

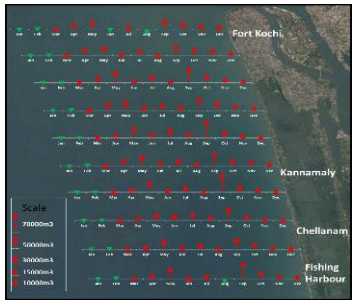
- Demonstration of Coastal Protection
  - ✓ Puducherry
  - ✓ Kadalur villages
- Inlet stabilization
  - ✓ Pulicat
  - ✓ Ennore
  - ✓ Cooum
- Shoreline Management Plans
  - ✓ Kerala
  - ✓ Odisha
  - ✓ Vishakhapatnam
  - ✓ Lakshadweep
- MoU with Kerala Government for Developing Coastal protection strategies.
- Developing new and innovative approaches for improving coastal resilience along the Bay of Bengal coast.



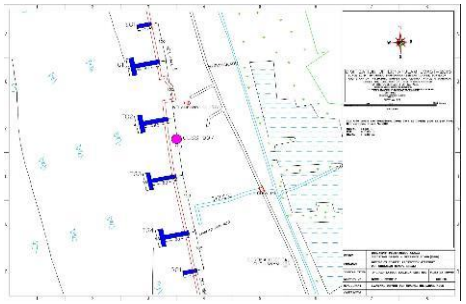
Shoreline Management Plan for Chellanam, Kerala

- Chellanam is on a narrow landform about 10 km in length sand witched between the Arabian sea and backwaters with 13,000 people.
- Chellanam coast has been suffering with sea erosion and coastal Inundation.
- A hybrid system is proposed
  - ✓T groynes
  - ✓Beach nourishment
- MoU Signed with Kerala State Government for providing technical support in developing Coastal Management Statagies.
- Developed for
  - ✓Kollemcode
  - ✓shankumugham

Coastal Flooding at Chellanam



Modal Studies

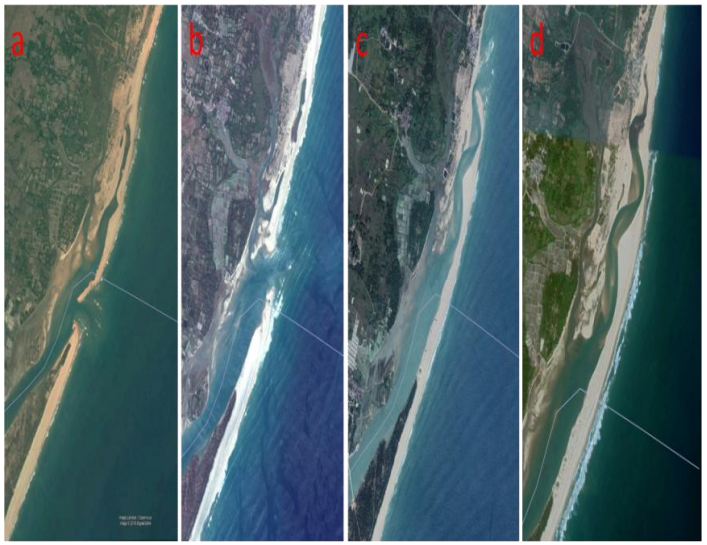


Proposed Solution

Implementation under progress

Coastal Protection Strategies – Ramayapatnam, Andhra Pradesh

- The dynamics of river Bahuda is causing severe erosion at Ramayapatnam village
- Short term - Nature based solution
  - Opening of mouth
- A wide beach of 100 width formed.
- Long term – hybrid solution
  - Training walls and Submerged seawall
  - Beach Nourishment.



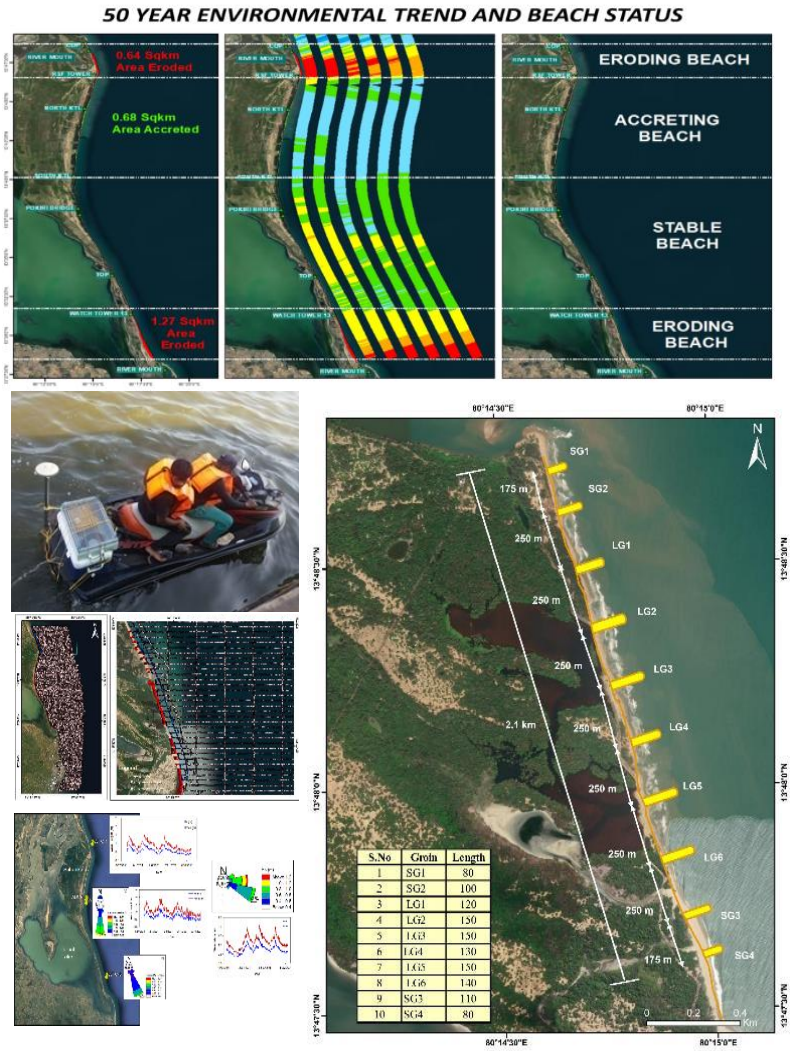
Coastal Protection Studies For SDSC-SHAR

- The North part of SHAR Island has been facing severe erosion and Department of Space has requested to take up long-term shoreline prediction studies.

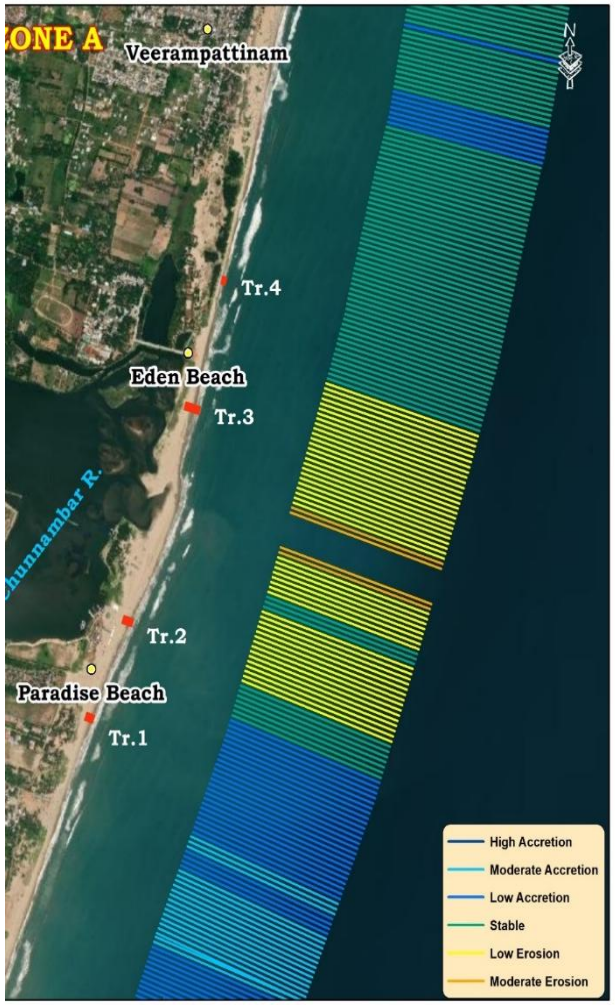
- The satellite images from 1965 to 2020 were analyzed
  - ✓Retreat of beach width of 250m
  - ✓Land loss of 0.64 sq. km

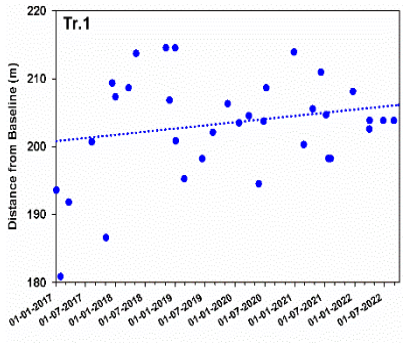
- Field measurements and Numerical Model studies was carried out.

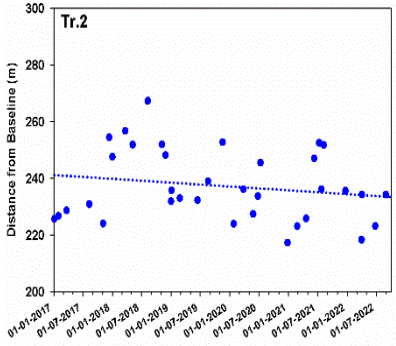
- Tapered Groyne field is proposed for restoration of beach.

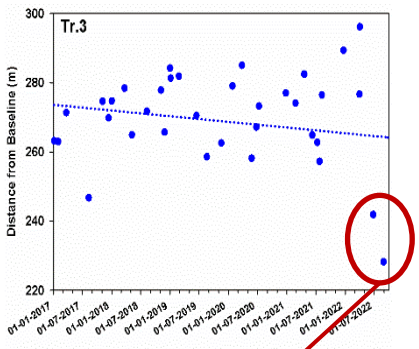


Tourism Development – Eden Beach, Puducherry

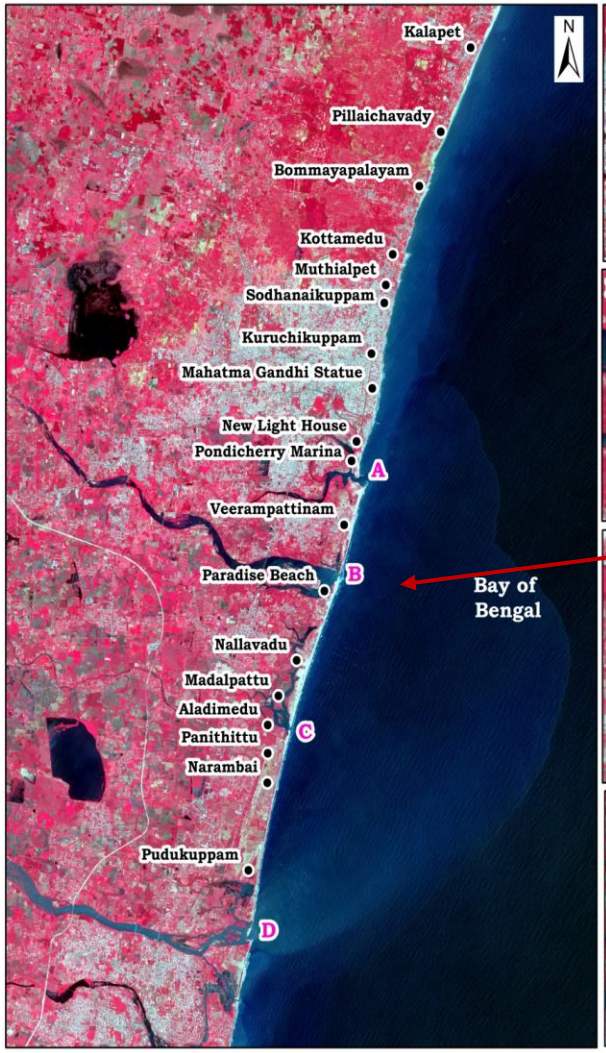




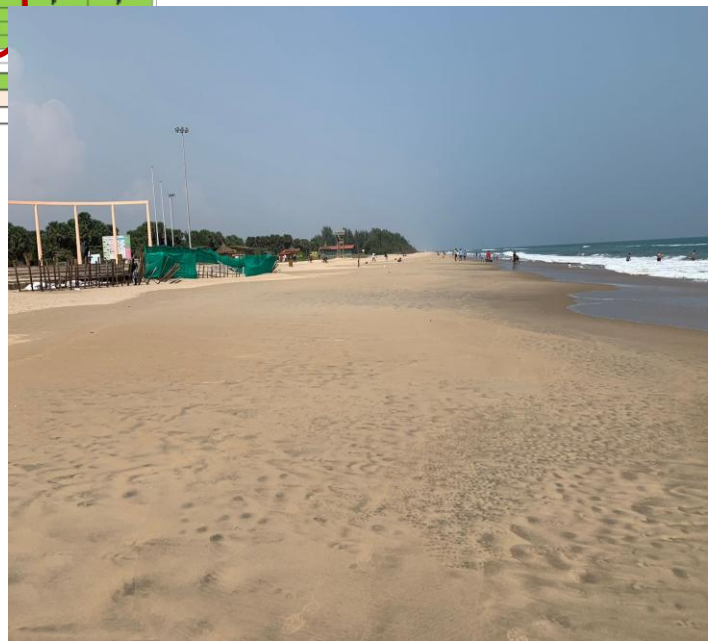




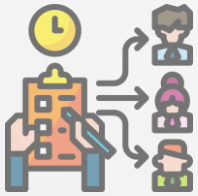
Do Nothing --- Eden Beach, Puducherry



YEAR	MONTH	Varaha Nadi	Malattar River	Pennai River
2017	JAN			
	MAR		A	
	APR			
	MAY			
	OCT			
	DEC	F	F	F
2018	JAN	F		P
	MAR			
	MAY			
	JUL			
	SEP			
	NOV	F		
2019	JAN	F	F	
	FEB			
	APR			
	JUN			
	AUG			
	NOV	F	F	
2020	JAN	F	F	P
	MAR	F	F	
	MAY			
	JUN			
	OCT		F	P
	DEC	F	F	P
2021	FEB	F	F	F
	APR	F	F	F
	JUN			
	JUL			
	AUG			
	OCT			P
2022	DEC	F	F	F
	FEB	F	F	F
	MAR	F	F	F
	JUN	F		
	AUG	F		
	SEP	F		
	OCT			



Shoreline Management Plan (SMP) - Overview



Shoreline Management Plan (SMP)

Vulnerability
Shoreline Changes
Inundation

Geomorphology
Headlands/Cliffs
River mouths/inlets
Sand Dunes

Status of Coast
Coastal Protection
Coastal Infra

Sediment Budgeting
Characteristics
Met-Ocean

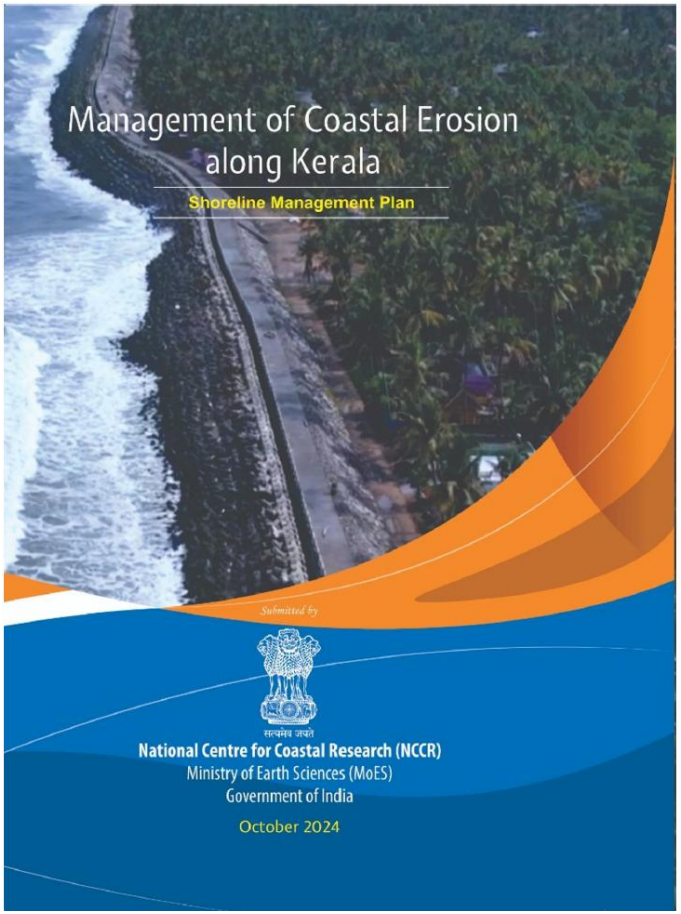
Stakeholders
Fisheries
Tourism
WRD
DoE

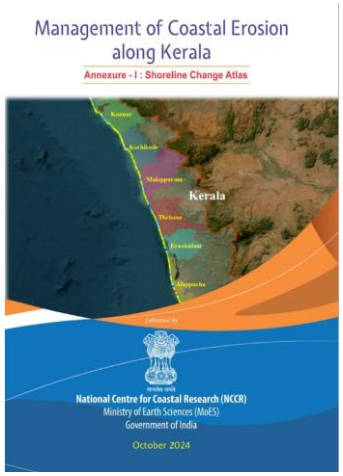
Management Plan
Sediment cells
Strategies
Policy units

Framework

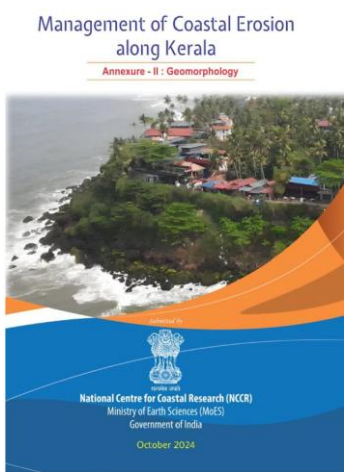

Geomorphology
Coastal River/Inlet
Eco-sensitive Area
Socio-economic Condition
Shoreline Status
Coastal Structures
Met-ocean Parameters
Sediment budgeting
Stakeholder Interaction
Action Plan
Shoreline Management Plan

SMP and Enclosures

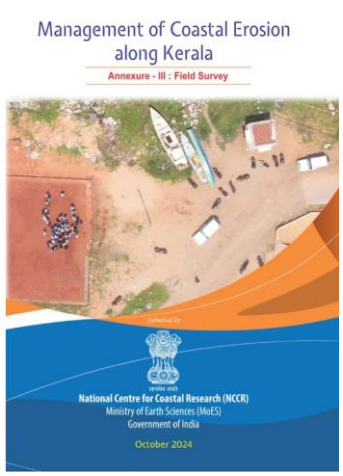




Shoreline Change Atlas



Geomorphology

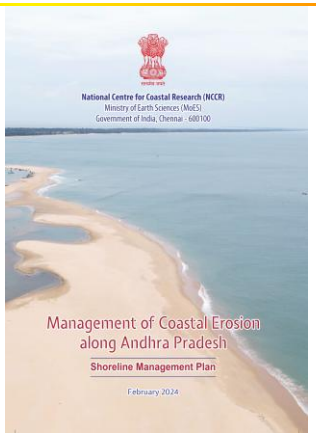


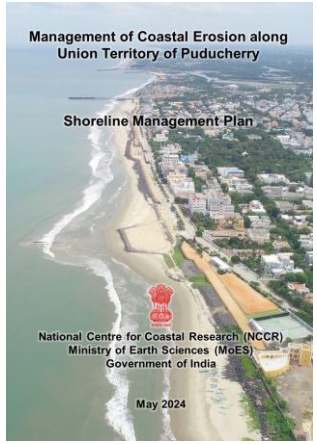
Coastal Structures

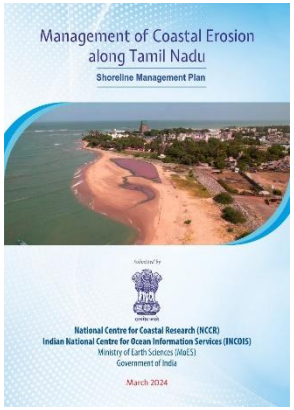
SMP Release

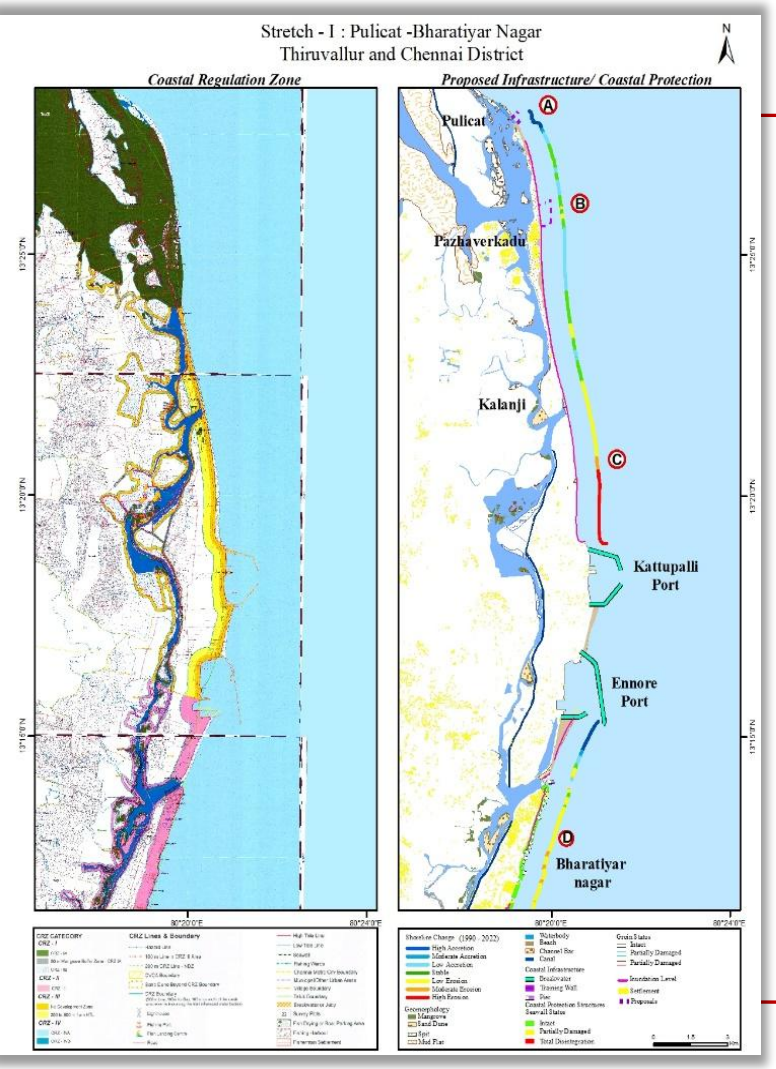
Release of Draft Kerala Shoreline Management Plan (SMP) to Minister of Water Resources, Government of Kerala – 16th October 2024

Shoreline Management Plans – NCCR Expertise









Policy Unit - I

Proposed Infrastructure/Coastal Protection	Observations/ Recommendations	Environmental Safeguard
Training wall at Pulicat for inlet stabilization and facilitating navigation of fishing vessels	**A** Training wall at Pulicat facilitates the navigation of fishing vessels to and from the sea. It allows the free exchange of water through the inlet aiding inlet stabilization and improves ecosystem of Pulicat lake.	Dredged sediments has to be placed along the Northern side of training wall.
Fishing harbour along open coast of Pazhaverkadu with shore facilities	**B** Training wall is already proposed at Pulicat. It is preferable to use this facility for safe maneuvering of boats instead of constructing new open coast fishing harbour, causing environmental issues. Fish landing centers and other amenities can be constructed inside the lake for supporting fishing activities.	Fish landing center has to be constructed inside the lake to aid the fishing activities.
Protection of Kalanji from sea erosion	**C** Beach nourishment can be done from the dredgeding activities at Kattupalli port. Strengthening of sand dunes and encouraging coastal vegetation.	-
Protection of Ennore to Bharathiyar Nagar stretch from sea erosion	**D** Beach nourishment required between the groin cells at Thazankuppam and Chinnakuppam and North of Ennore training wall. The sediments can be sourced from Kosasthalaiyar river.	-

Early Flood Warning System - An essential need

The socio-economic impact of a flood disaster events coupled with the high risk and vulnerability profiles of our coastal areas make it imperative to strengthen disaster preparedness, mitigation and enforcement of guidelines, building codes and restrictions on construction of buildings in flood-prone areas and storm surge prone coastal areas.

•On the face of it, unstoppable rains is the primary cause for any floods. However, the underlying factors are :

- **Unchecked growth in the flood plain**
- **Choked drains, lack of open spaces**
- **High tide conditions**
- **Poor dam management**
- **Social, political, economic, ecological and technical perspectives on floods**
- **Existing policies and strategies concerning flood management**

Flood Prone Urban cities : Similar Scenes

Mumbai 2005 Flood

26 July 2005 : 944mm in 24 hours

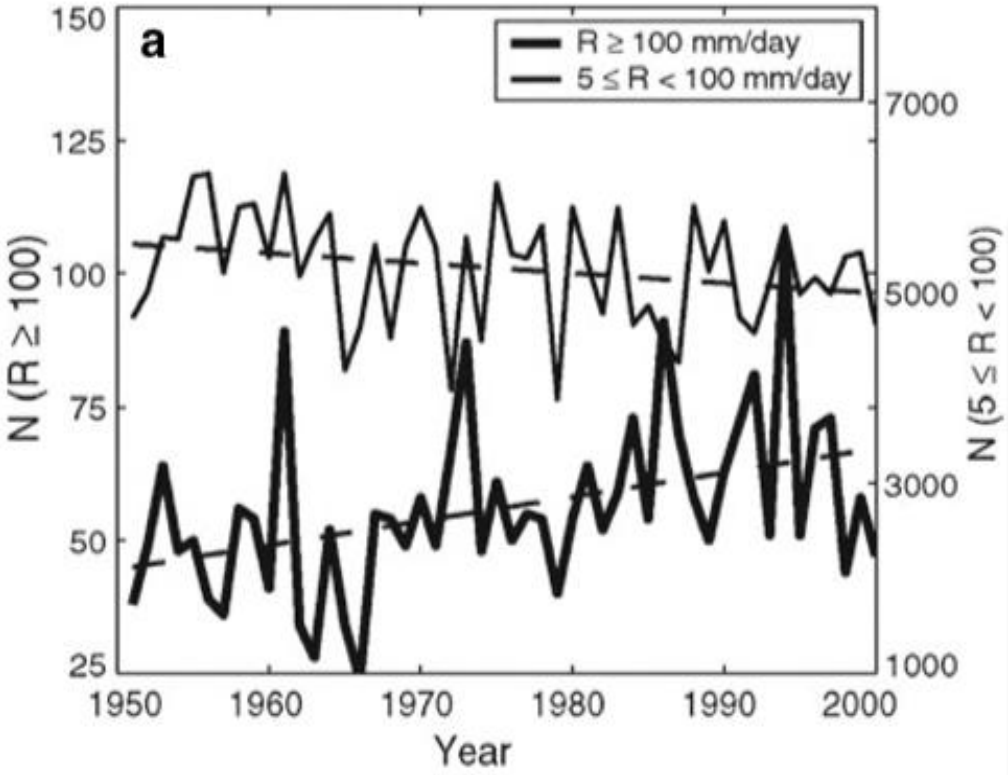
Chennai 2015 Floods

1 Dec 2015 : 494mm in 24 hours

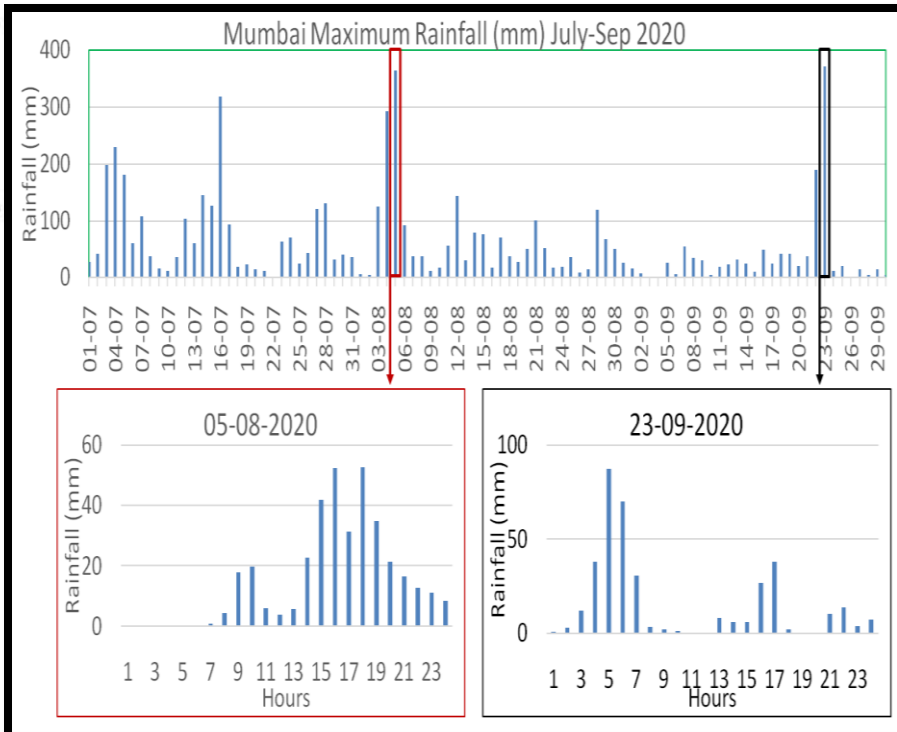
Monsoon Mayhem in India

It has been observed that from 1950 onwards there has been a significant rising trend in the frequency and intensity of extreme heavy rain events over central India, along with a decreasing trend in the moderate rain events

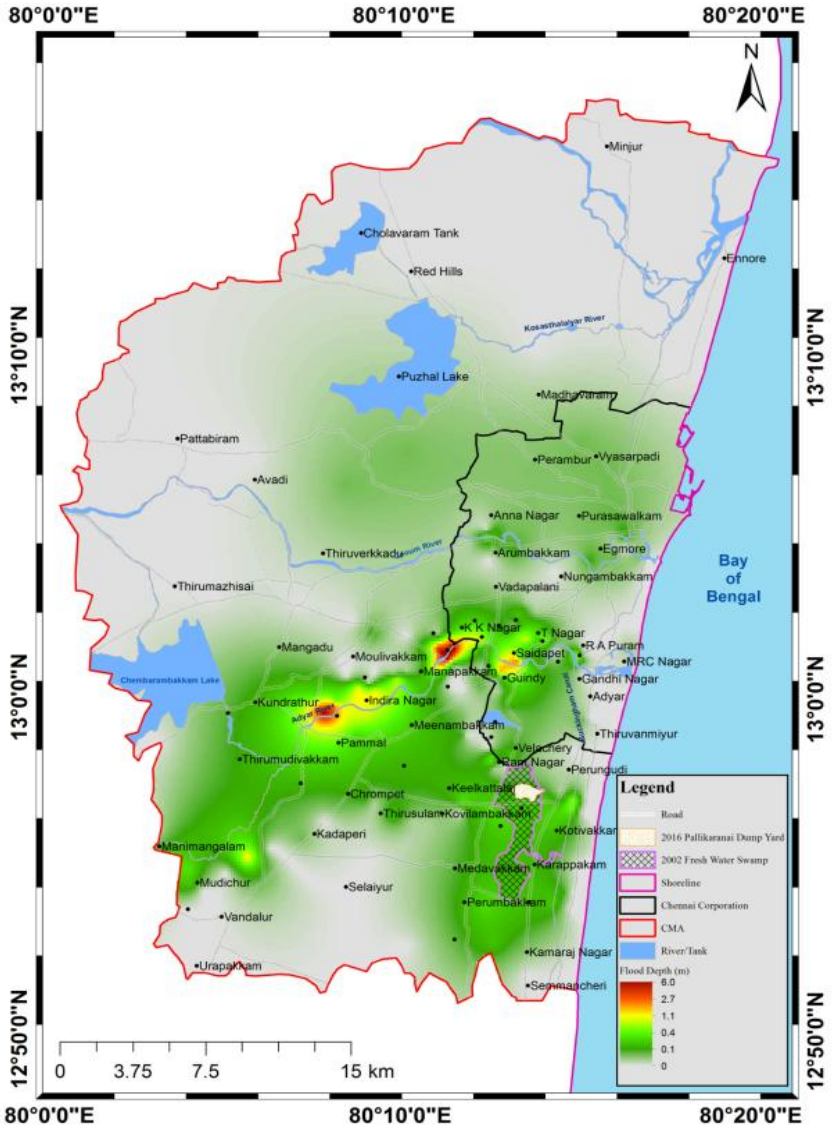
Trend in Extreme and moderate precipitation



Extreme precipitation in short duration



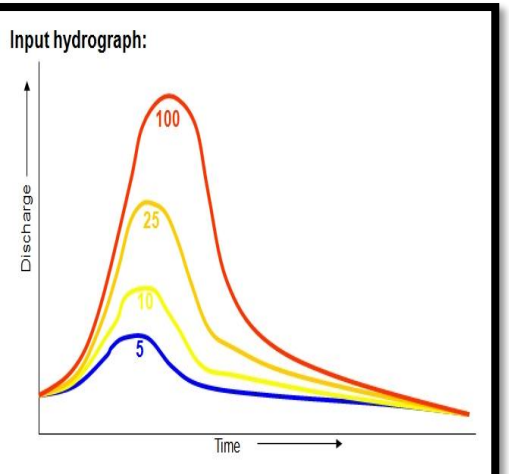
2015 Chennai Floods – that brought Chennai to a standstill

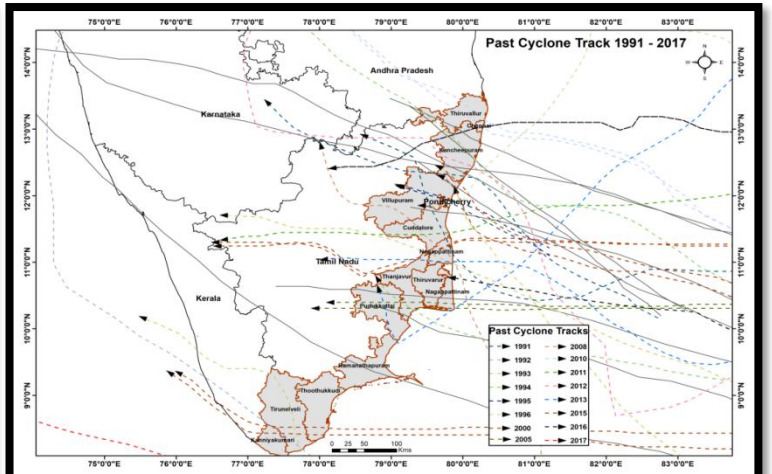


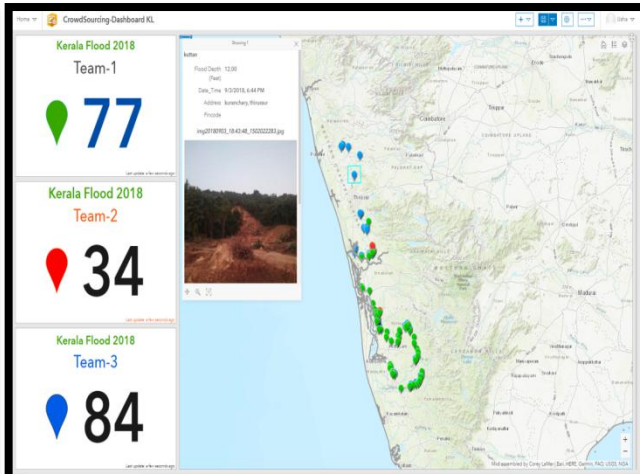
Water level mapped from field data

Building the hazard database

- Field Data / Crowd sourcing
- Histoical database (International/ national)
- Probability and likelihood of occurrence
- Direct mapping / Crowd sourcing
- Expert assessment
- Statistical analysis
- Numerical / spatial models







Coastal Vulnerability

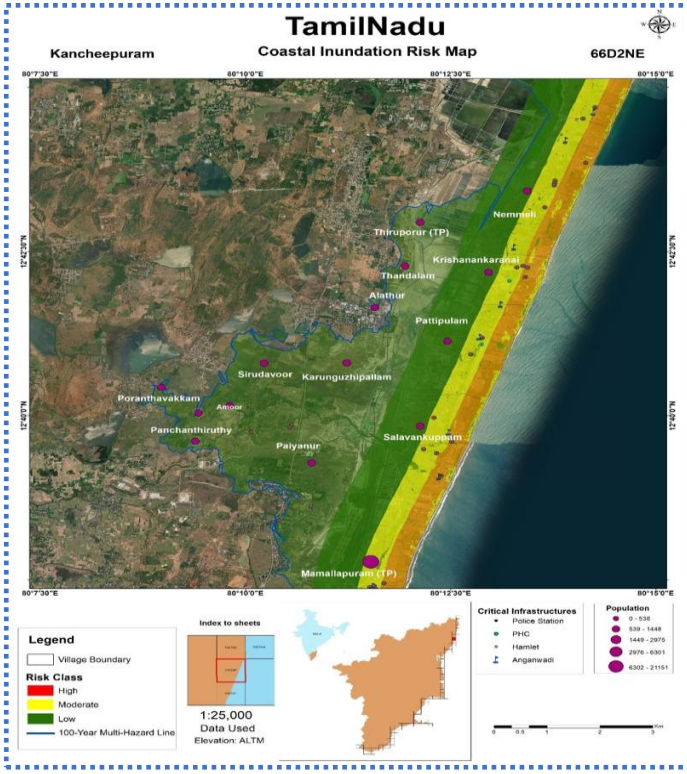
NCCR developed stakeholder focused Decision Support System (DSS) tools for the State Governments by providing localized risk information for adaptive management

Released the Coastal Inundation Risk Atlas (CIRA) for Tamil Nadu on July 2023

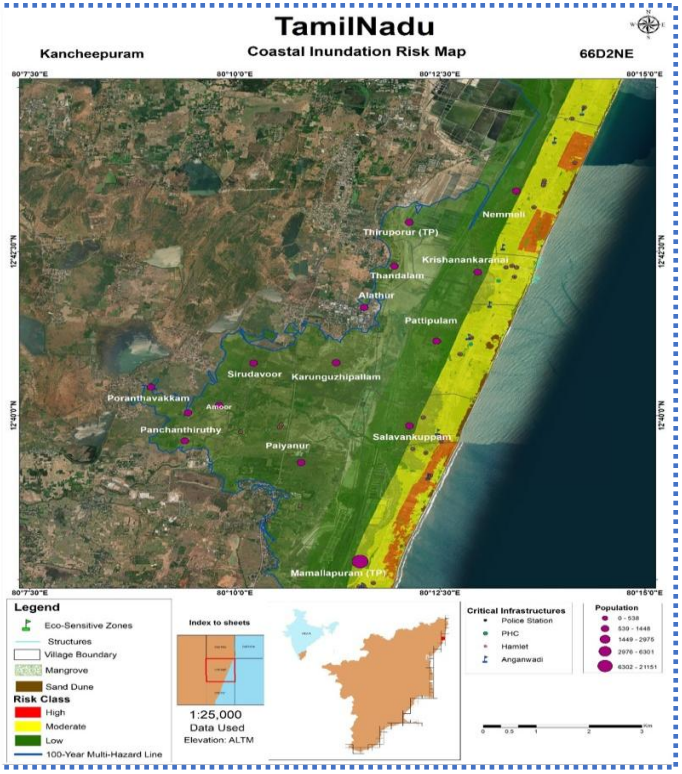
- The CIRA study has been initiated by the National Centre for Coastal Research (NCCR) in collaboration with the Indian National Centre for Ocean Information Services (INCOIS) to provide the Coastal Inundation Risk Maps on 1:25000 scales for the coastal regions of Tamil Nadu (~1076 Km coastline) using the multi-hazard inundation line already developed by INCOIS.

- The maps provided in this Atlas serves as a vital input for disaster management authorities to formulate and implement better hazard management plans in the future.

Village Level CIRA Maps with and without Protection



CIRA without Protection

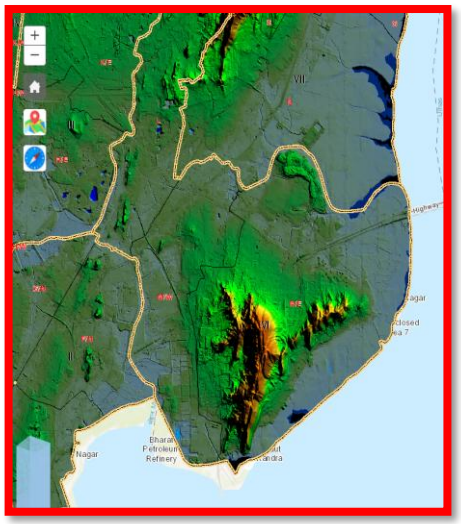


CIRA with Protection

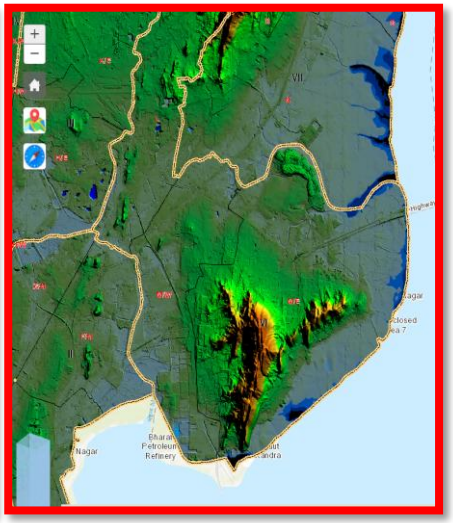
		Risk Area in sq.km			
District	Village	High	Low	Moderate	Total
Kancheepuram	Nemmeli	0.98	0.2	1.89	3.08
Kancheepuram	Krishanankaranai	-	0.05	0.09	0.14
Kancheepuram	Pattipulam	-	0.21	1.28	1.48
Kancheepuram	Salavankuppam	1.13	0.05	0.13	1.31
Kancheepuram	Paiyanur	-	0.11	-	0.11
Kancheepuram	Mamallapuram	0.01	0.36	0.33	0.7

Coastal Inundation in low lying areas due to storm surge scenarios

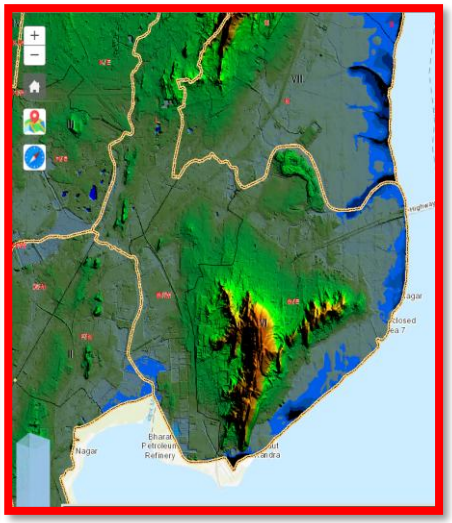
1.0 m Storm surge



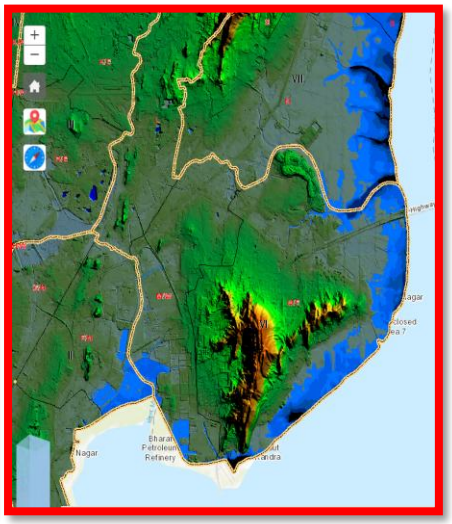
1.5 m Storm surge



2.0 m Storm surge



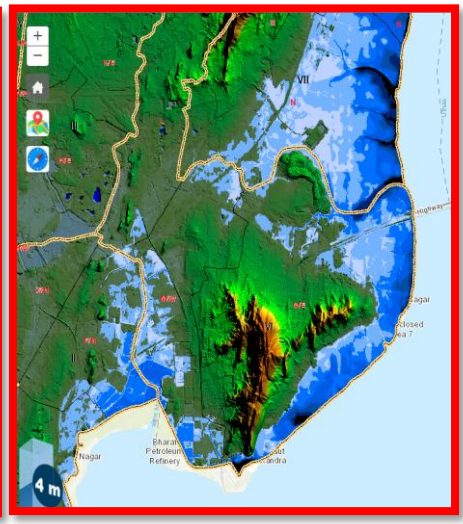
2.5 m Storm surge



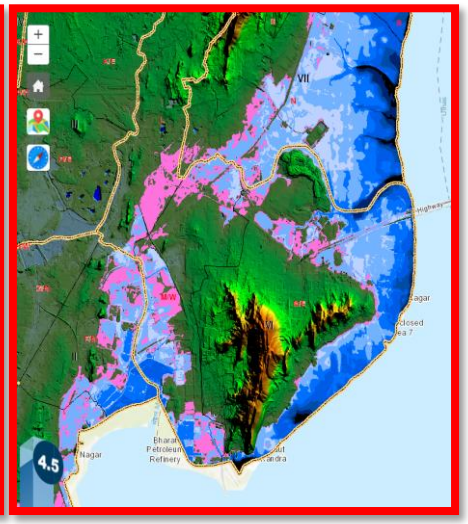
3.0 m Storm surge

3.5 m Storm surge

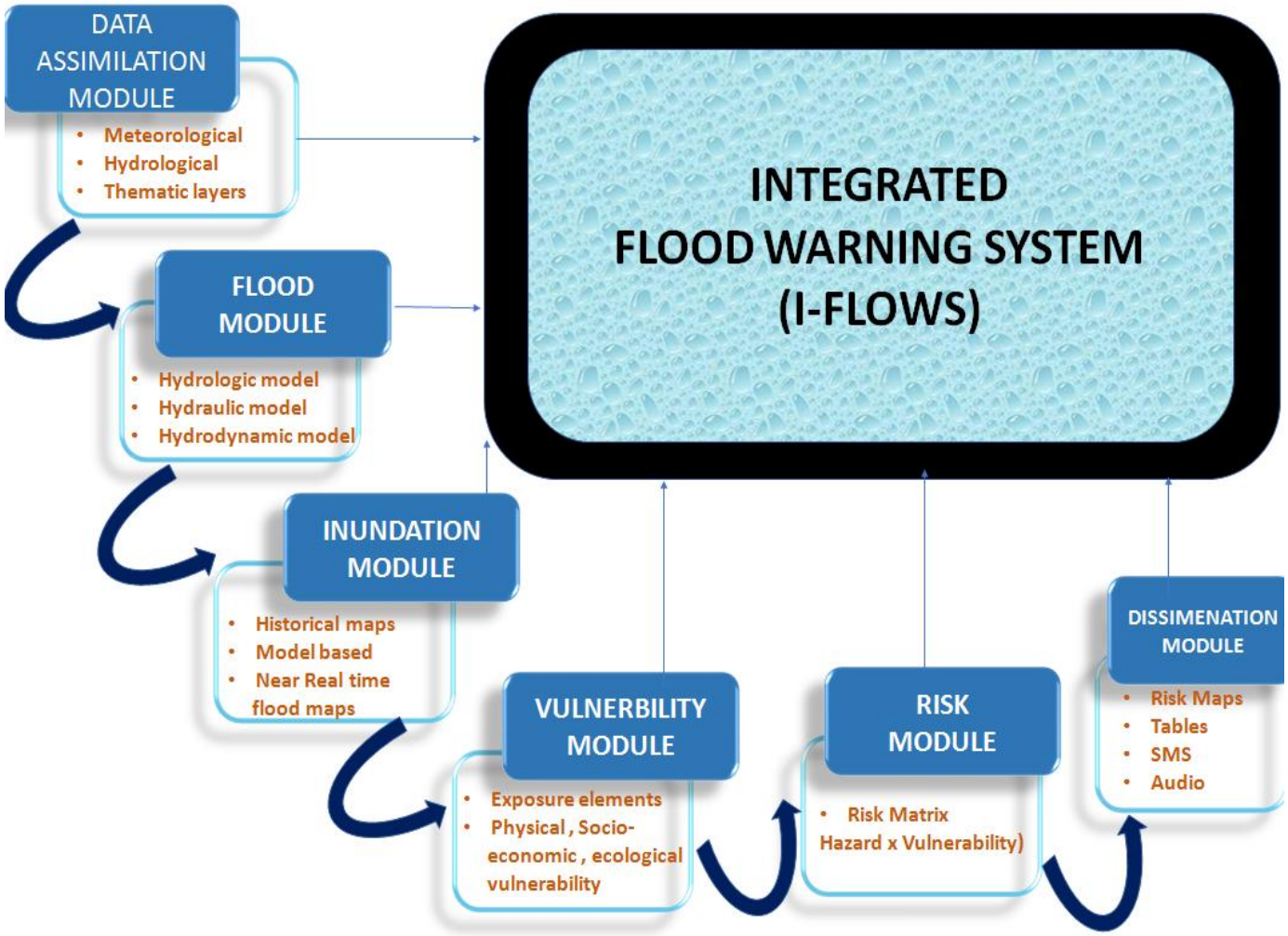
4.0 m Storm surge



4.5 m Storm surge

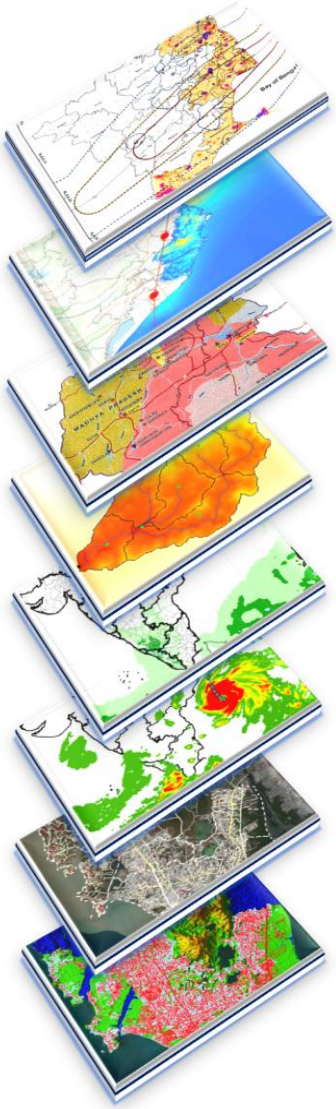


CFLOWS to IFLOWS - Architecture



- CFLOWS was scenario based
- IFLOWS works in real time

Data Assimilation Module – from NCUM



Exposure Data
- Population
- Socio-economic data

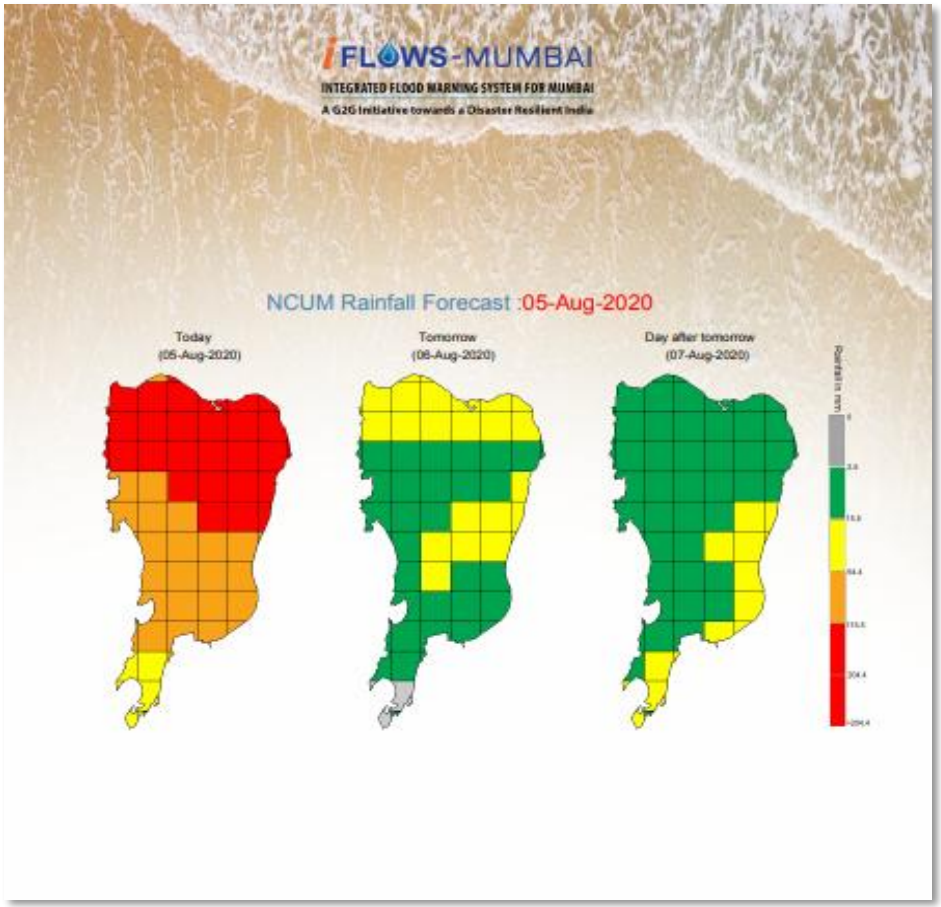
Hydrodynamic Data
- Tides
- Storm surges

Hydrological Data
Discharge
- Water level
- Rating curve
- Channel and reservoir/ diversion hydraulic data

Meteorological Data
Model datasets
- NCMRWF : 10 days forecast, 19*13 km spatial resolution
- GFS : 11 days forecast, 14 km spatial resolution
- WRF : 3 days forecast, 9 km spatial resolution

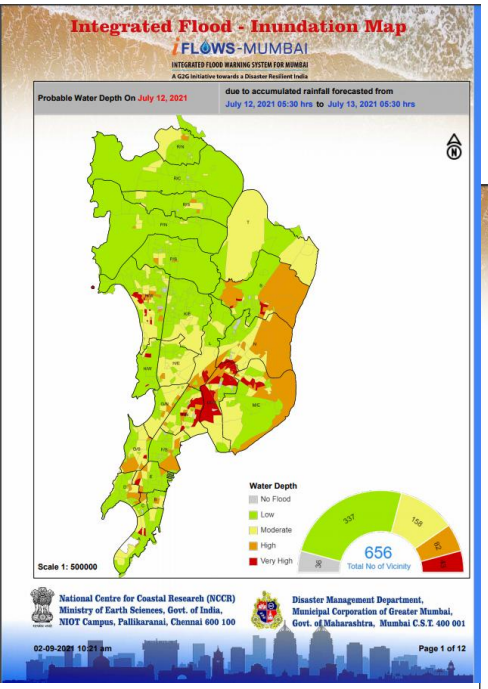
Observation data (Source : IITM, IMD, State Govt)

Spatial Data
- Elevation data, Bathymetry data
- Landuse / Landcover, Soil
- River cross section, Infrastructure, Physiographic datasets



Based on IMD SOP for IBF

flood inundation and statics



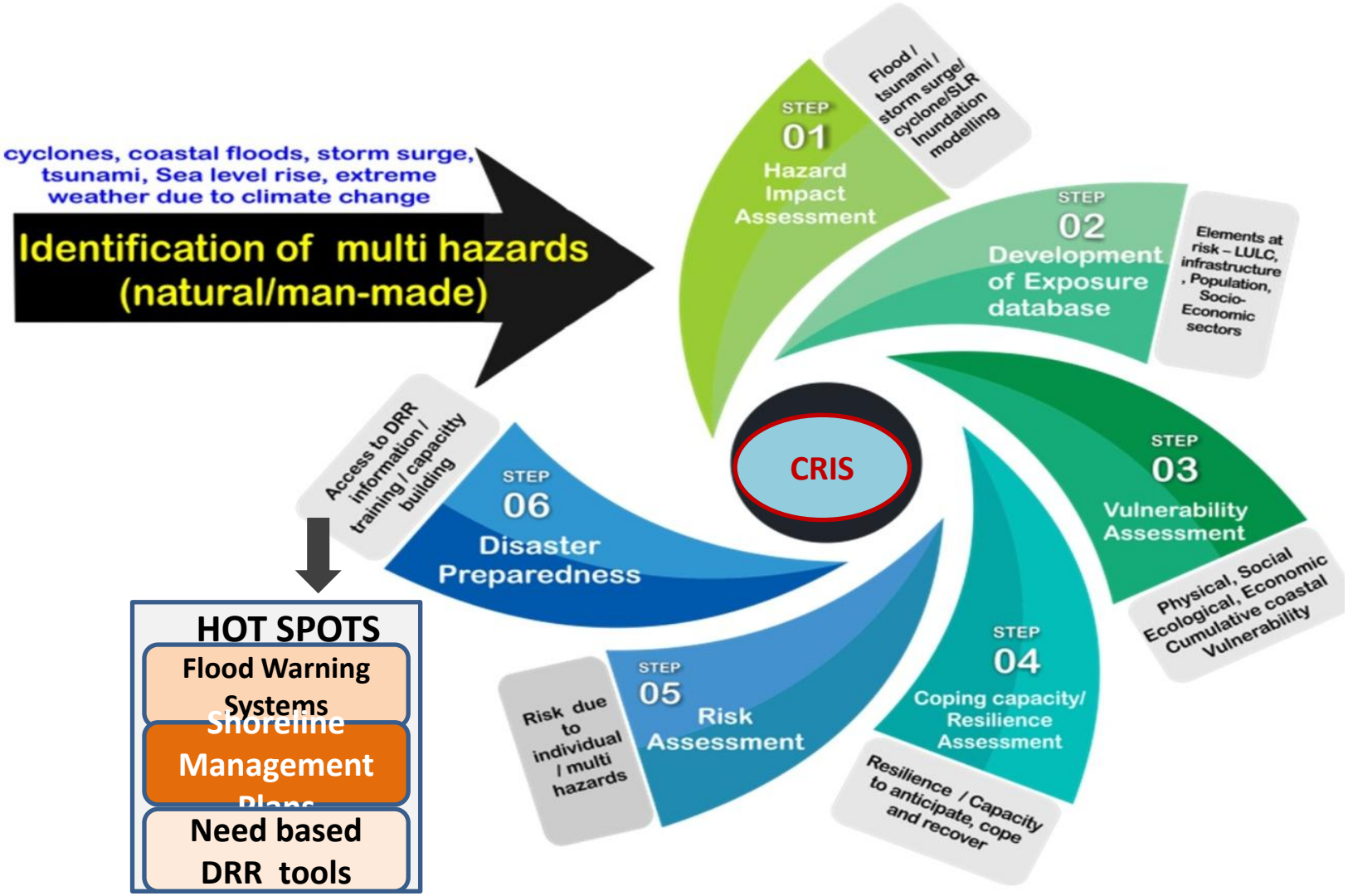
Ward level flood inundation Report

Street level flood inundation Report

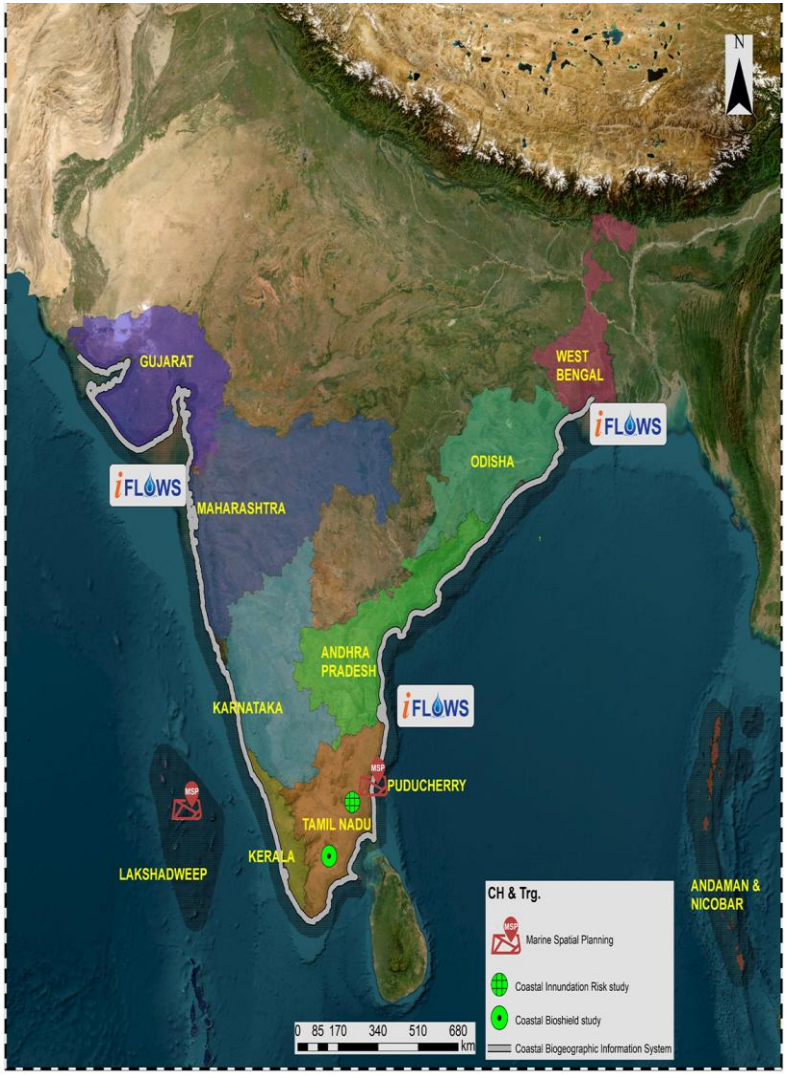
Impact and Action suggested

Climate Change and Coastal Hazards Risk Information System (CRIS)

The Climate Change and Coastal hazards Risk Information System (CRIS) being developed to provide access to usable disaster risk information and operational tools coastal hazards such as *cyclones, coastal floods, storm surge, tsunami, Sea level rise, extreme weather due to climate change*.



Footprints of the NCCR in understanding climate disasters: and Climate Resilient Studies



Coastal Erosion

- N-SAS (updated biyearly)
- Erosion hotspots
- Shoreline Management Plans
- G2G technical support

Coastal Inundation

- Coastal inundation Risk atlas
- Operation flood warning systems (iflows)

CRIS (Mission Mausam)


राष्ट्रीय तटीय अनुसंधान केंद्र | National Centre for Coastal Research
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