Community based Flood Risk Assessment

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What is disaster …

A serious disruption of the functioning of a community or a society causing widespread human, material economic or environmental losses which exceed the ability of the affected community/society to cope using its own resources.

A disaster results from the combination of hazards, conditions of vulnerability and insufficient capacity or mitigation measures to reduce the potential negative consequences of risks.

What is Hazard ?

Any natural or man-made event or process that has potential to cause damage to Life , property, environment

- *Can be few seconds to minutes (Earthquake, Tsunami)*
- *Few days (Cyclones, Floods)*
- *Seasons to years (Droughts, Epidemics)*

Predictability depends on types of hazard

Long term and - short term impact to incomes, increased vulnerability

Disrupt the development process and puts back years of work and assets

Hazard can damage to …

People:

Death, injury, disease, stress

Goods:

Property damage, Economic loss

Environment:

Loss of flora and fauna, pollution loss of amenities

Availability of services:

Water, electricity, communications, road, health

Livelihoods, Loss of work opportunities

What is Hazard & Risk ?

- Hazard is the potential to cause harm; Risk on the other hand is the likelihood of harm
- The chance of something happening that will have an impact upon different elements.
- It is measured in terms of consequences and likelihood
- Can be measured in terms of frequency of occurrence and impacts (Probability of any event of given magnitude)

Hazard

_ _ _ _ _ _

Risk

WWW

Risk Assessment ⟷ **Risk Communication**

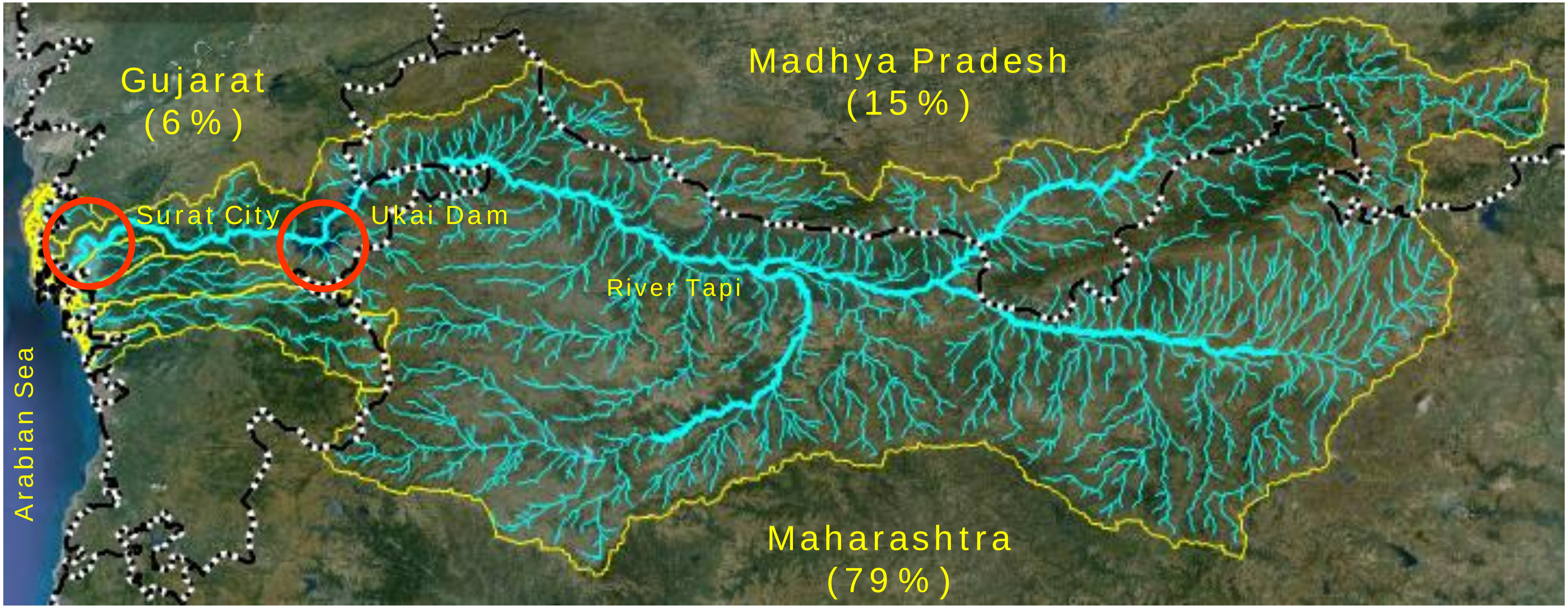
Purpose of Study (Aim & Objectives)

Aim

To assess flood risk from community point-of-view and to set up an *End-to-End Early Warning System* to reduce the intensity of floods and resultant flood damage to Surat city.

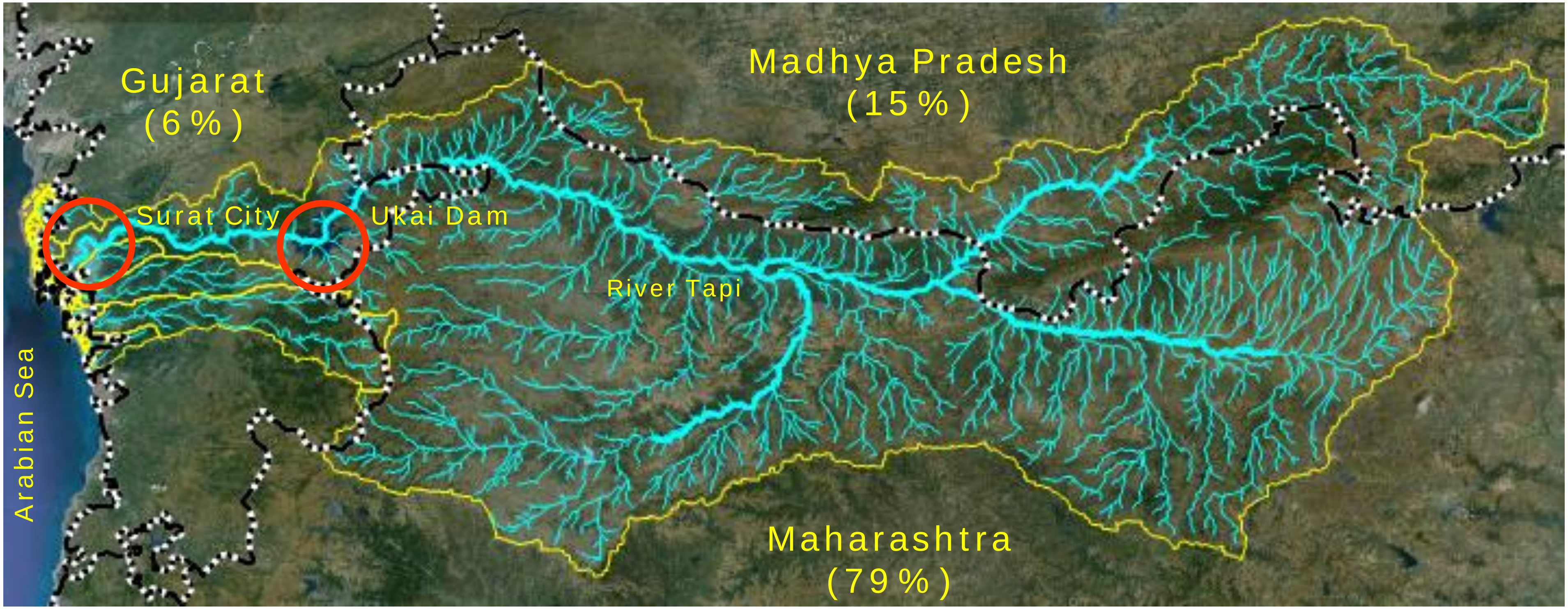
Objectives

1. To improved reservoir operations to minimize peak floods caused by extreme precipitation events in Upper and Middle Tapi basin.
2. To better prepare institutions and society to handle flood emergencies (including tidal creeks floods).



- Area: 326.5 Sq. Km (*Source: SMC*)
- Population: 2.8 Million (*Census 2001, Source: SMC*)
- Avg. Rainfall: Avg. 1143 mm *(Source: CDP)*
- Major River: Tapi River
- Slum Pockets: 312 (Nos.)

Tapi River & Ukai Reservoir



River Length	724 Km before falling in the Arabian Ocean
Reservoir Type	Earthen & masonry dam
Distance from Surat	90 Km (Upstream of Surat)
Total Catchment	65,145 Sq. km
Command Area	4.11 Lac Ha. (2007-08)

History of Flood in Surat

Sr. No.	Flood Event	Discharge (Lakh Cusecs)	Water Level at Hope Bridge (M)	Period
1	1883	10.0	11.0	July
2	1884	8.4	10.0	September
3	1894	8.0	10.3	July
4	1942	8.6	10.6	August
5	1944	11.8	11.3	August
6	1945	10.2	11.0	August
7	1949	8.4	10.4	September
8	1959	12.9	11.6	September
9	1968	15.5	12.0	August
10	1994	5.2	10.1	Aug.-Sep.
11	1998	7.0	11.4	September
12	2006	9.0	12.4	August

Source: Agnihotri , P. et al., 2008

Surat Flood Risk

Surat experiences two kinds of floods: Fluvial & Khadi Flood

– Tapi River Floods (Fluvial Flood): *Cause*

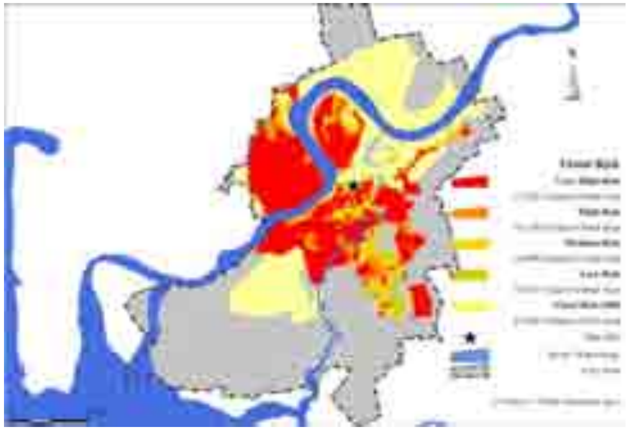
- Monsoon depression: From Bay of Bengal (travelling East to West) concentrating flow along Tapi Basin (very high variation),
- Need for managing maximum water level: To meet competing non-monsoon water demand resulting in minimal flood cushion in the dam,
- Settlements: either side of the river banks (major land-use change in last 2 decades) in Surat,
- Human induced topography and hydrological changes: industrial development, embankments, bridges and weir,
- Rise in river bed: Sedimentation load with slope and its deposition.

Surat Flood Risk

– Khadi (Tidal Creeks) Floods: *Cause*

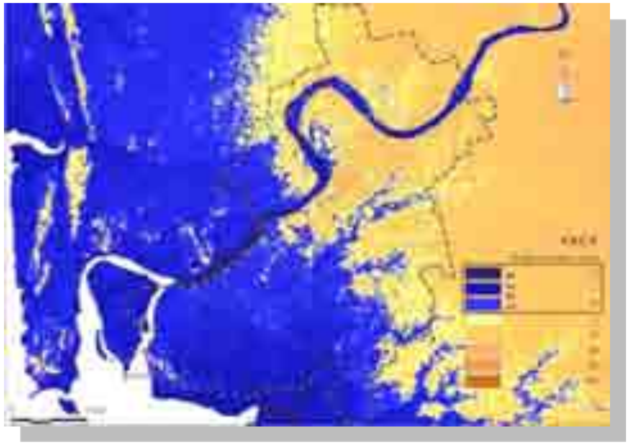
- Combination of Pluvial Floods, with
- Tide effect in Low Elevation Coastal Zone (10 m.)

Fluvial and Pluvial Flood



Khadi Flood

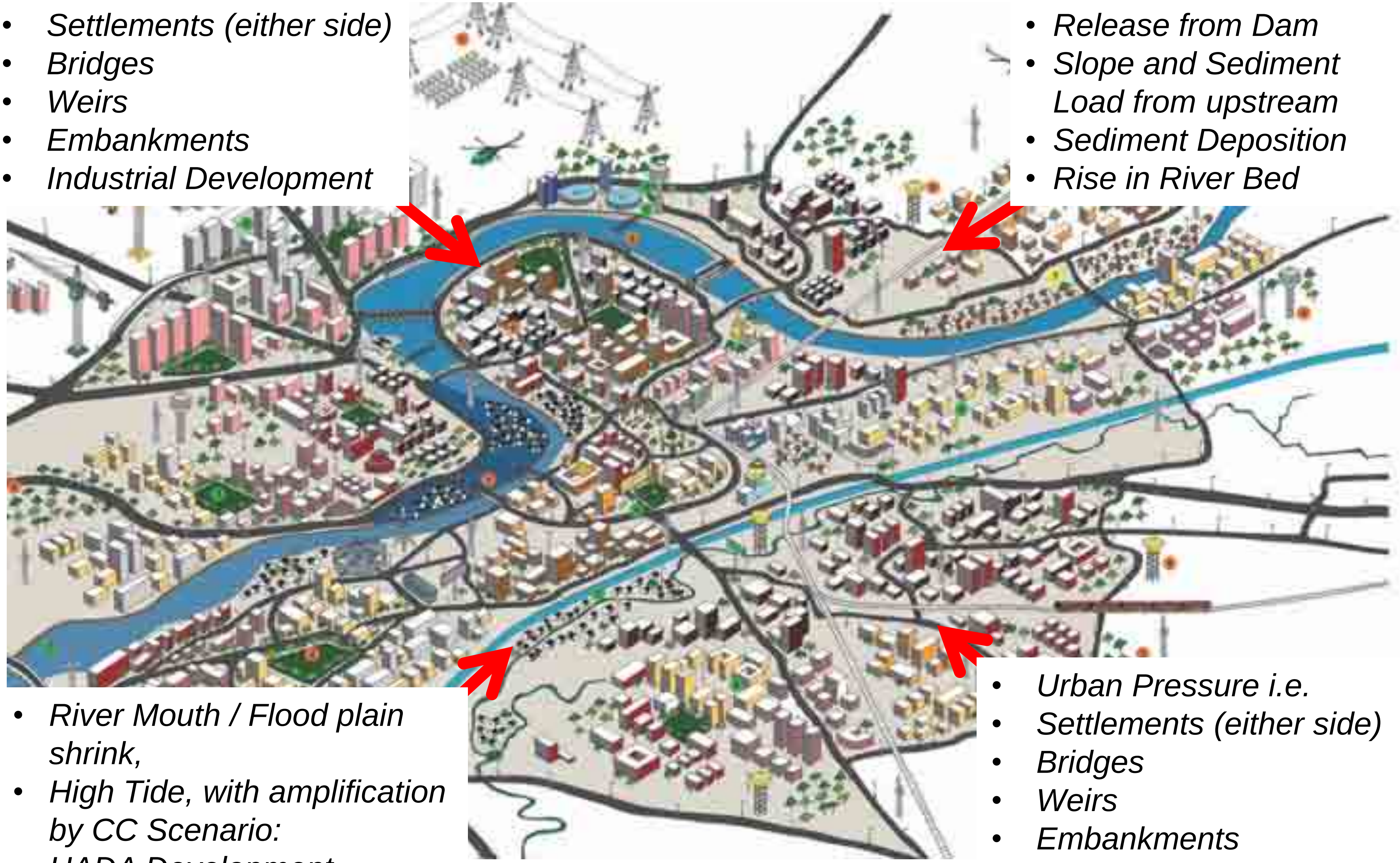
LECZ



Surat Flood Risk: Factors

- *Urban Pressure i.e.*
- *Settlements (either side)*
- *Bridges*
- *Weirs*
- *Embankments*
- *Industrial Development*

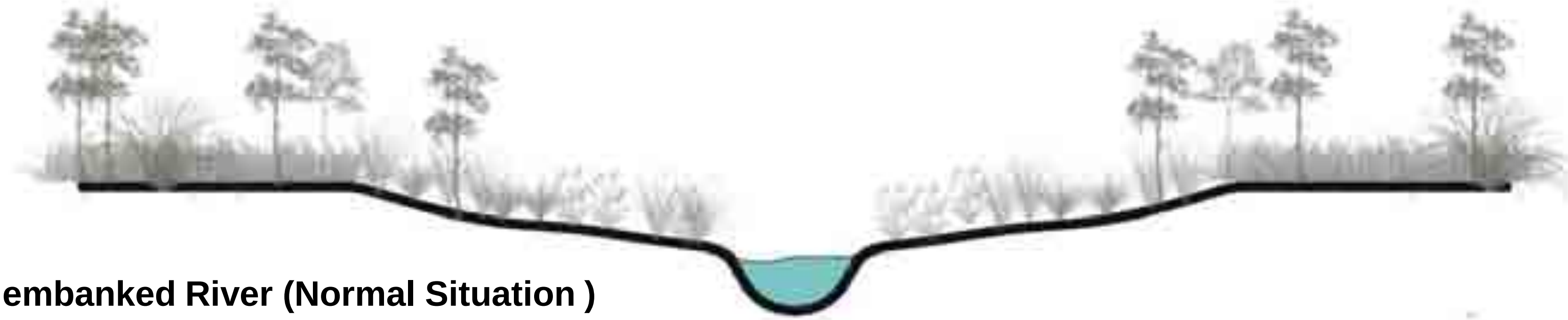
- *Extreme events in Basin*
- *Release from Dam*
- *Slope and Sediment Load from upstream*
- *Sediment Deposition*
- *Rise in River Bed*



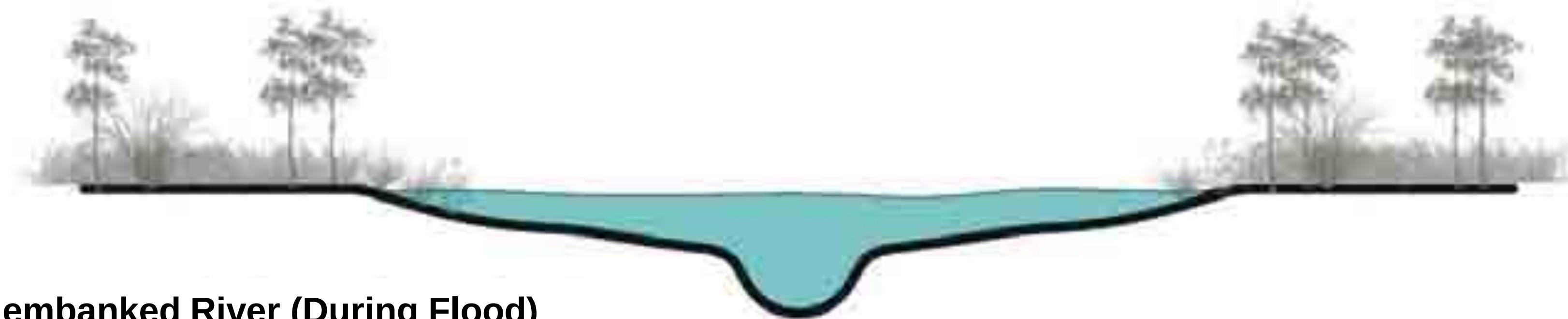
- *River Mouth / Flood plain shrink,*
- *High Tide, with amplification by CC Scenario:*
- *HADA Development.*

- *Urban Pressure i.e.*
- *Settlements (either side)*
- *Bridges*
- *Weirs*
- *Embankments*
- *Industrial Development*

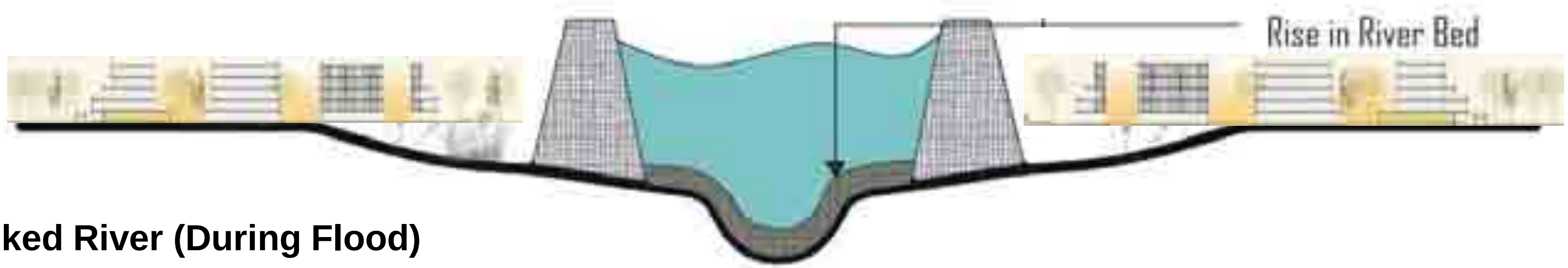
Floods and Human Induced Topography



Non- embanked River (Normal Situation)



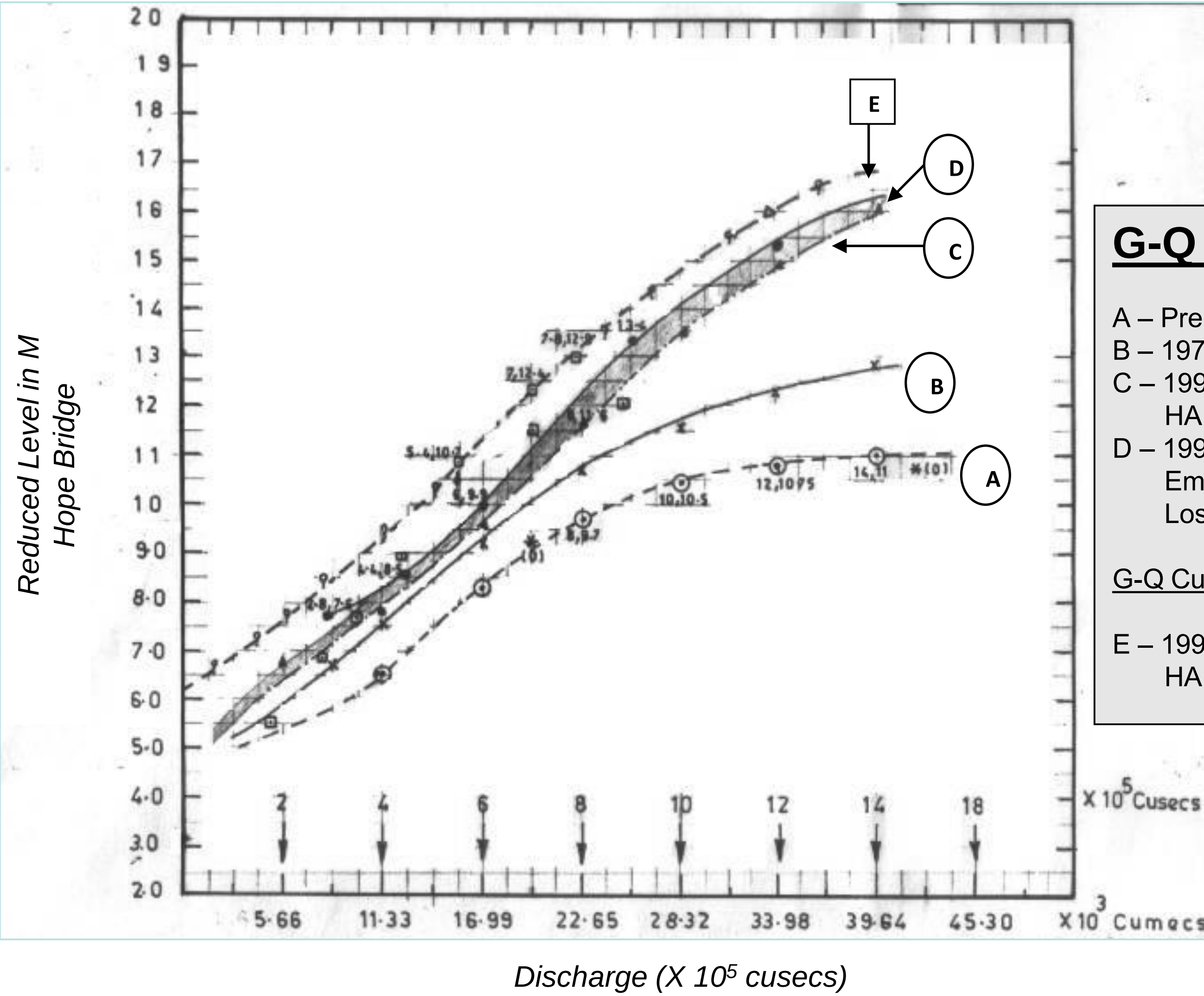
Non- embanked River (During Flood)



Embanked River (During Flood)

Surat Flood Risk: Change in Pattern

Location: Hope Bridge



G-Q Curve for Hope Bridge:

A – Pre 1970: Virgin River

B – 1974: River + Patches of Dykes (Pala)

C – 1994: River + 50 % Dykes + Infrastructure of HADA & land use in Right bank flood plain

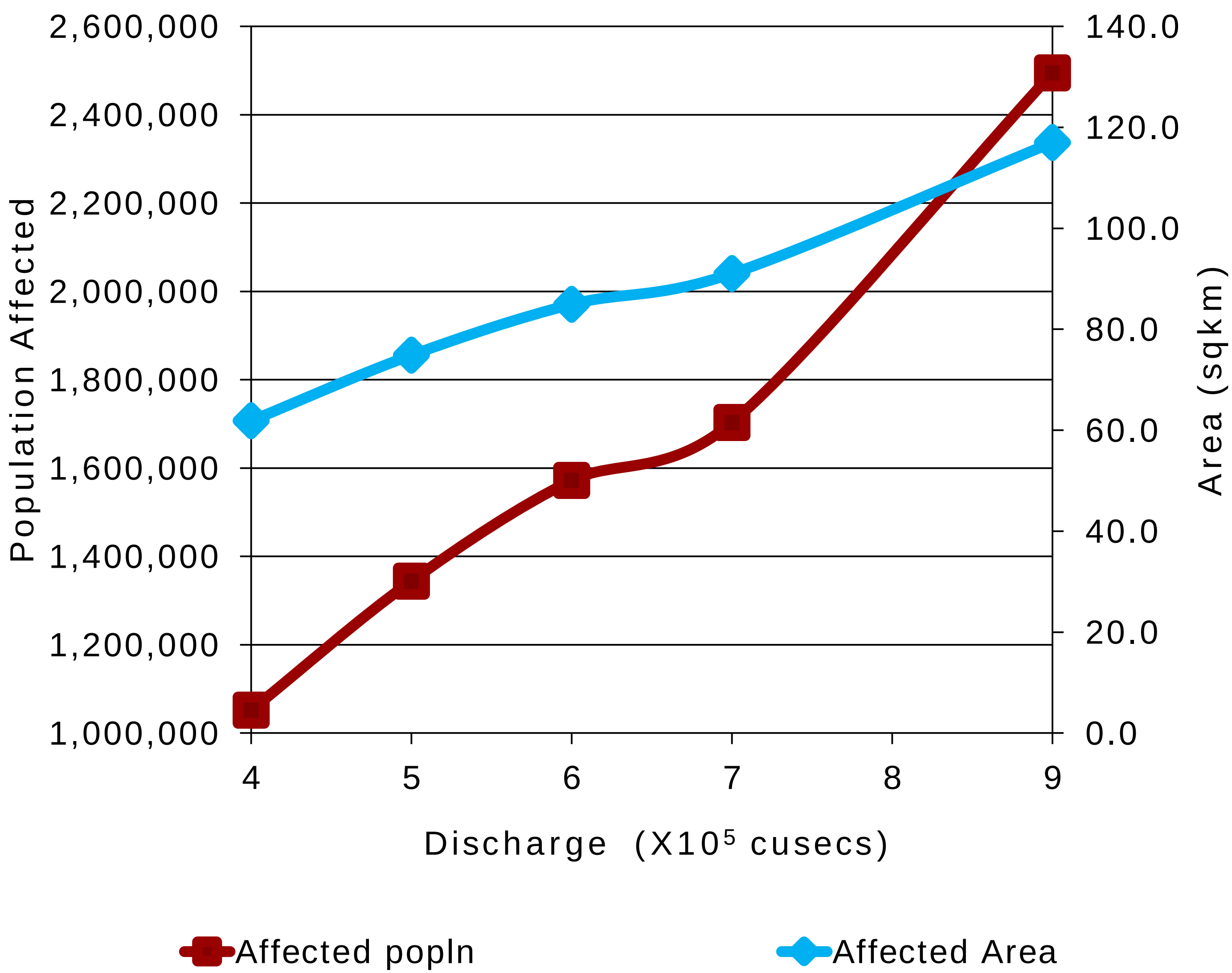
D – 1998: (-Do-) + Bridges + Railway & Road Embankment Hazira + Extension of HADA + Loss of natural drain etc.

G-Q Curve for Weir:

E – 1998: Weir Singanpore 1998 + More Dykes + HADA + Right Bank City + Bridges

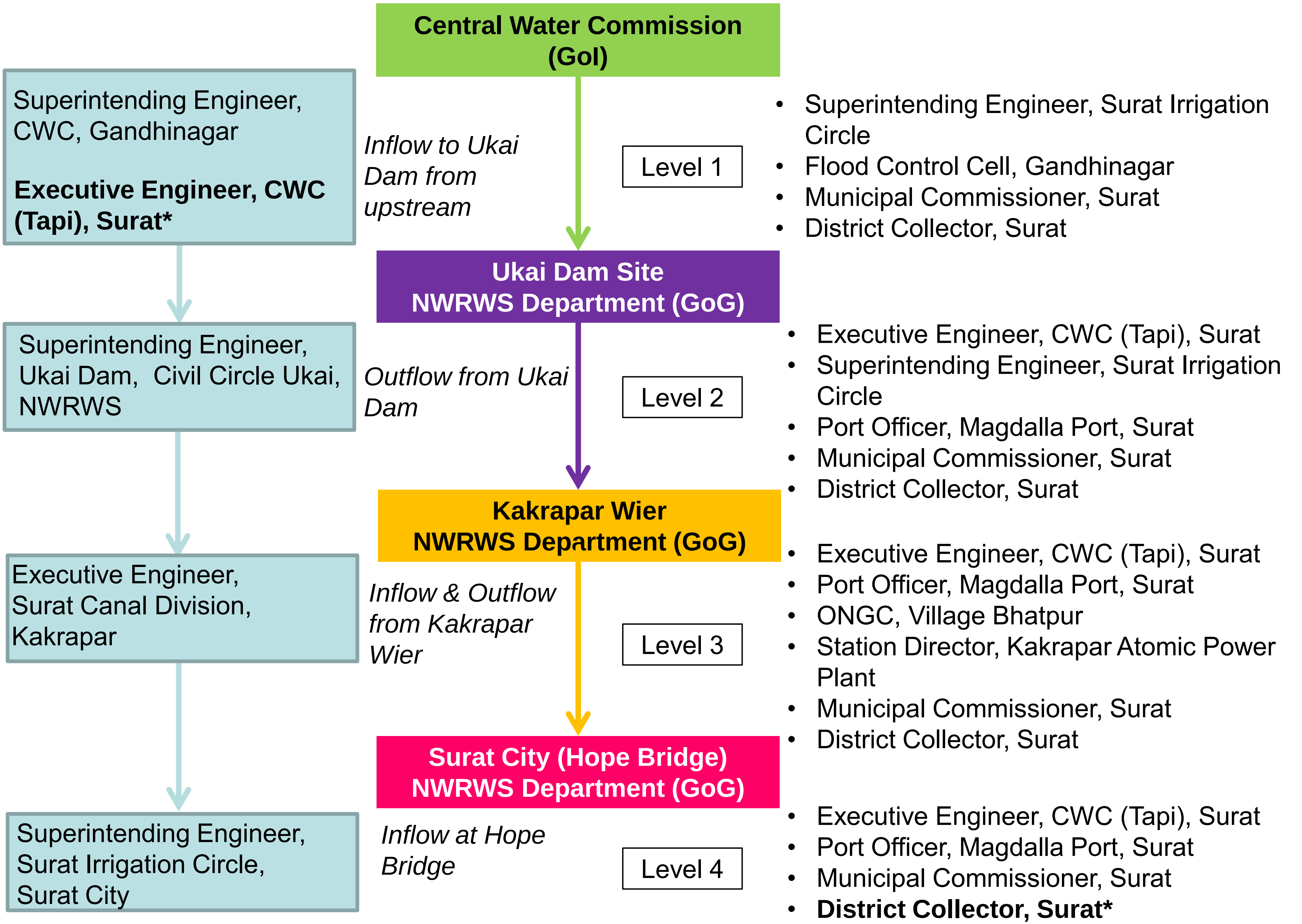
Source: ACCCRN Surat Flood Risk Management Report 2010

Surat: Flood Discharge *vs* Area & Population Affected



Source: TARU Analysis

Current Interstate Flood Warning System (CWC and NWRWS)



End-to-End Early Warning System

End-to-End EWS:

"Empower individuals communities and administration, threatened by natural hazards, to *act in sufficient time* and *in an appropriate manner* so that reduce the possibility of personal injury, loss of life and damage to property, or nearby and fragile environments". (UN, 2006)

Elements of effective and complete End-to-End Early Warning System:

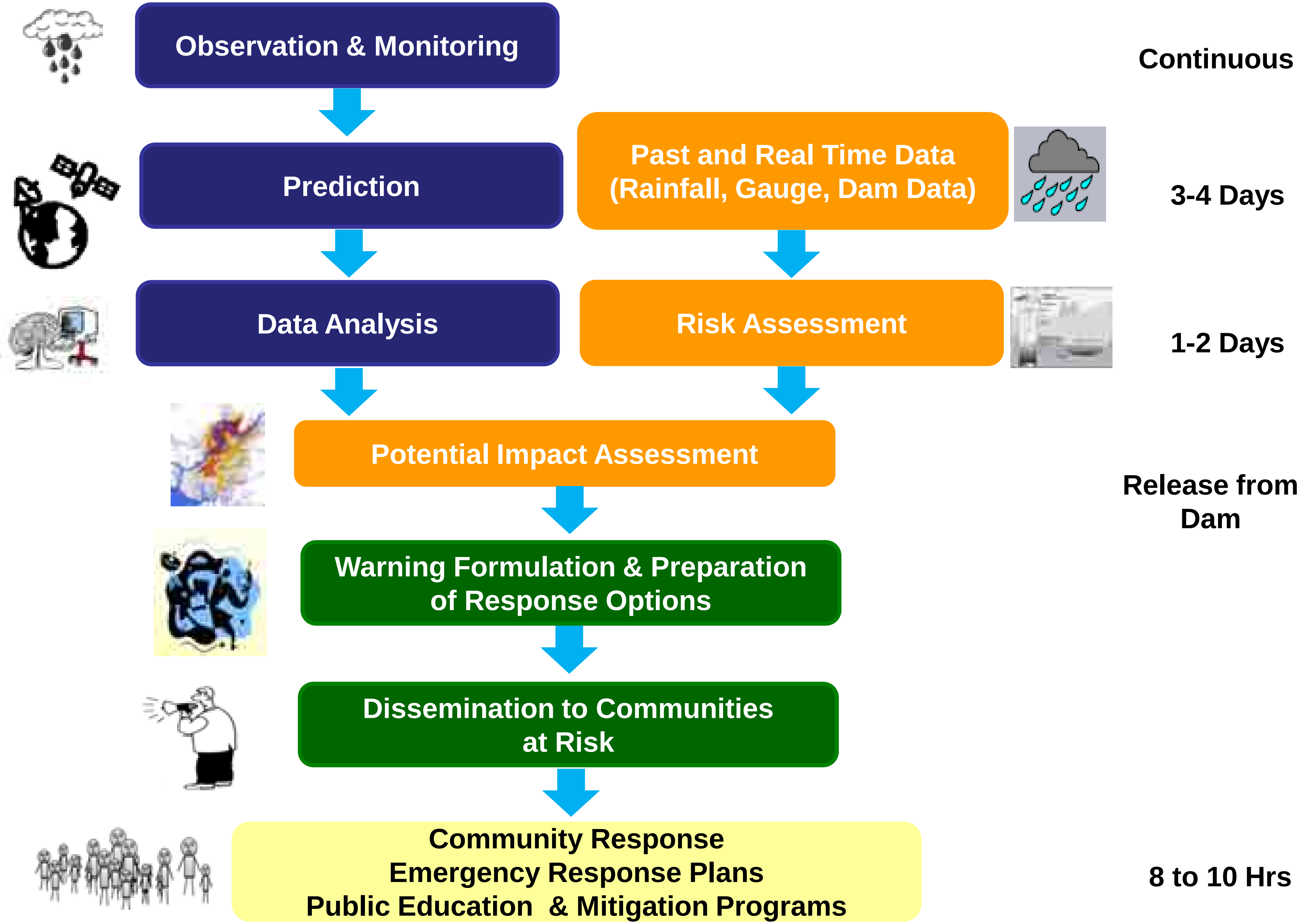
- Risk knowledge,
- Technical monitoring, risk assessment and warning,
- Dissemination & communication of meaningful warnings to those at risk,
- Response capability public awareness and preparedness to act.

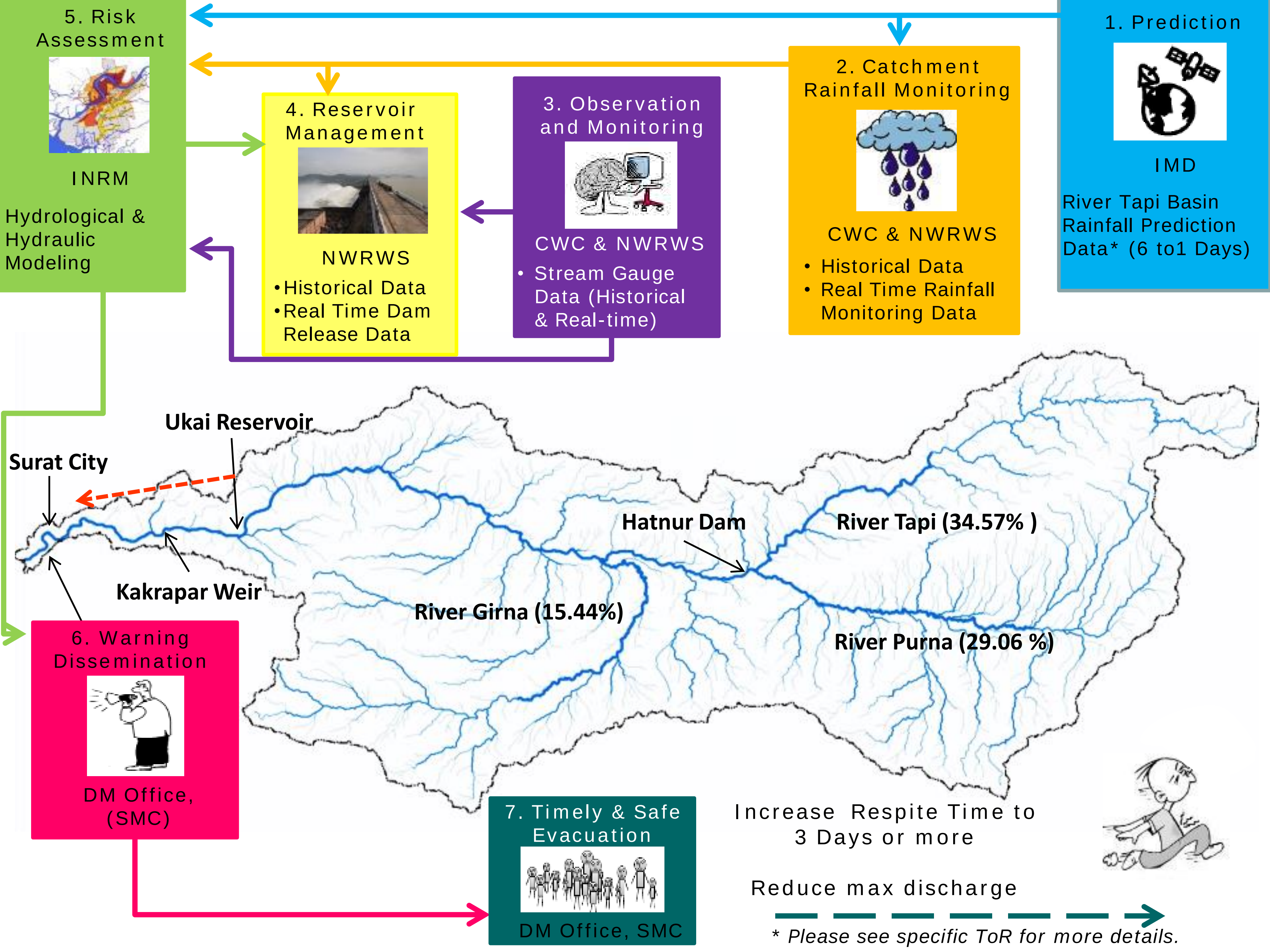
End-to-End EWS Surat: Benefits

- Increase respite time,

- Provides timely and effective information on flood hazard,
- Can reduce hazard intensity (by controlled release from dam),
- Can stop hazard convert into disaster,
- Reduce magnitude of disaster (timely evacuation, preparedness),
- Support administration to prepare for effective last mile response well in advance.

End-to-End EWS Surat: Methodology





1. Prediction
IMD
River Tapi Basin Rainfall Prediction Data* (6 to1 Days)
2. Catchment Rainfall Monitoring
CWC & NWRWS
• Historical Data
• Real Time Rainfall Monitoring Data
3. Observation and Monitoring
CWC & NWRWS
• Stream Gauge Data (Historical & Real-time)
4. Reservoir Management
NWRWS
•Historical Data
•Real Time Dam Release Data
5. Risk Assessment
INRM
Hydrological & Hydraulic Modeling
6. Warning Dissemination
DM Office, (SMC)
7. Timely & Safe Evacuation
DM Office, SMC
Ukai Reservoir
Surat City
Kakrapar Weir
Hatnur Dam
River Tapi (34.57%)
River Girna (15.44%)
River Purna (29.06 %)
Increase Respite Time to 3 Days or more
Reduce max discharge
* Please see specific ToR for more details.

Current Monitoring System: CWC

Tapi Division of the Central Water Commission (CWC) maintains:

- 18 rainfall monitoring (rain gauge) stations,
- 11 Gauge-discharge sites in Tapi catchment,
- 8 of the above sites have Sediment Observations,
- 3 flood forecasting stations in the Tapi basin.

Source: CWC, India

End-to-End EWS Surat: Main Steps

Main Steps

1. Engagement with city stakeholders to set up:

    - *Surat Climate Change Trust (SCCT)*

2. Climate change informed flood modeling,

3. Early warning and disaster management system,

4. Information and support to vulnerable,

5. Ensuring sustainability of the system beyond project period.

Ukai Inflow (cusecs) Forecast using IMD District Rainfall Forecast (MME)
Valid till 29 September 2013

Developed for SCCT Surat
INRM Consultants, New Delhi

Forecast released on experimental basis

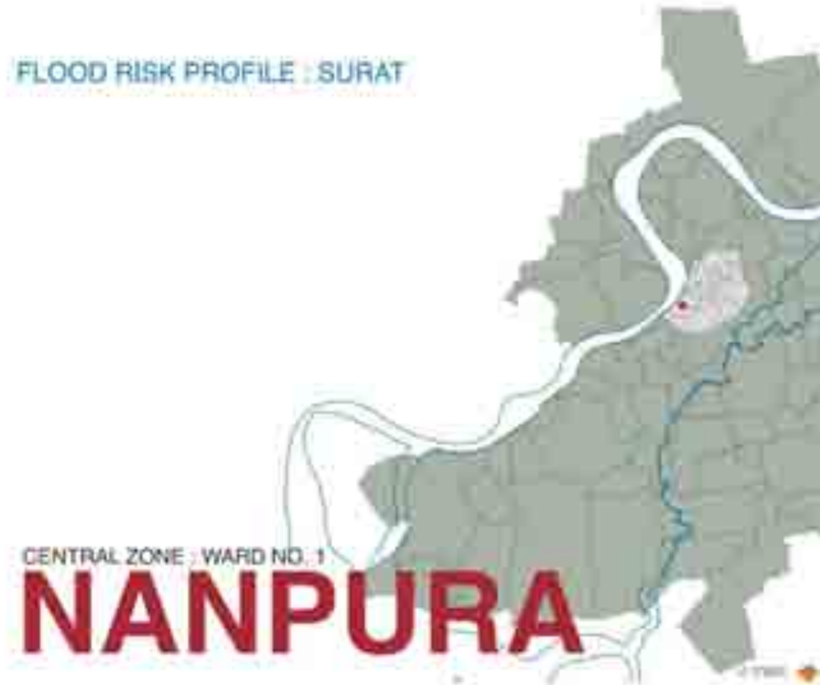
- **Caveat**
  - Simulated using SWAT Hydrological Model
  - Using Rainfall forecast from INDIA METEOROLOGICAL DEPARTMENT, NWP models based district level weather prediction (http://www.imd.gov.in/section/nhac/distforecast/INDIAct.htm)
- **Limitations in Model calibration:**
  - Observed Rainfall data from Maharashtra stations was not available (procurement still under processing)
  - IMD 9 km resolution WRF forecast data permission is awaited (IMD is processing the request)
  - there will be discrepancy between observed and forecast rainfall data in magnitude and timing
  - Calibration at Morane (on river Panjara) and Gidhade (Middle Tapi) could not be achieved for lack of /erroneous observed gauge data
  - Daily Calibration was not done for inflows to Ukai since inflow data was not made available
  - U/s reservoirs operations are not included (as operation policy is unknown)

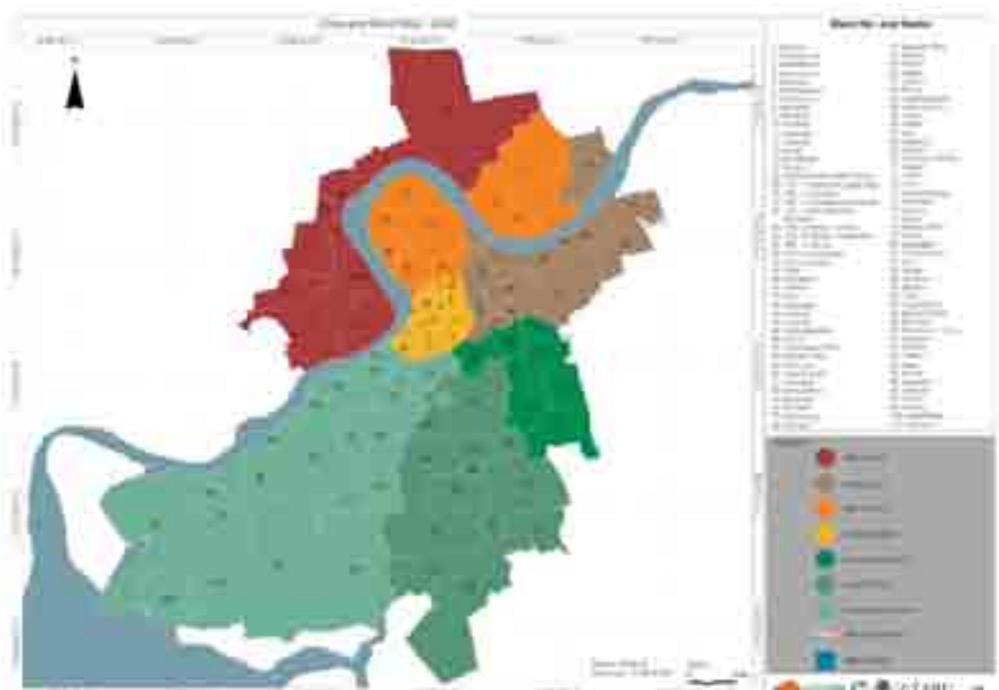
Average Catchment observed rainfall upto Ukai on 23-09-2013 Forecasted

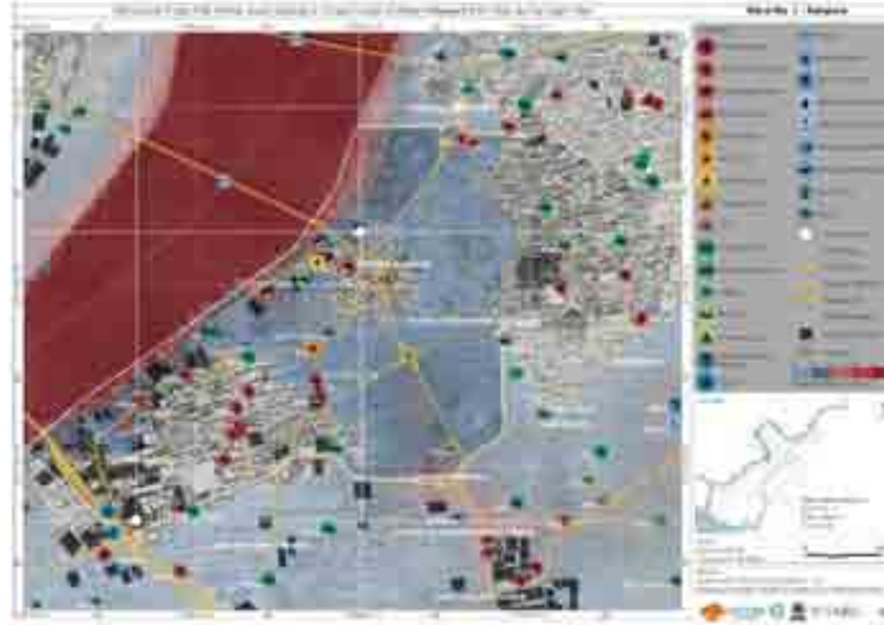
	23-Sep-13	24-Sep-13	25-Sep-13	26-Sep-13	27-Sep-13	28-Sep-13	29-Sep-13
Average Catchment Forecasted rainfall upto Ukai on 23-09-2013	53.7						
Average Catchment Rainfall upto Ukai (IMD district rainfall forecast)	[illegible]	32.8	20.6	13.8	0.4	2.6	1.2
Inflow Forecast in cusecs using IMD District Forecast (MME) Valid till 29 September 2013	568,213.0 686,870.3	470,391.4	356,325.0	251,723.0	172,724.1	161,034.9	154,466.4

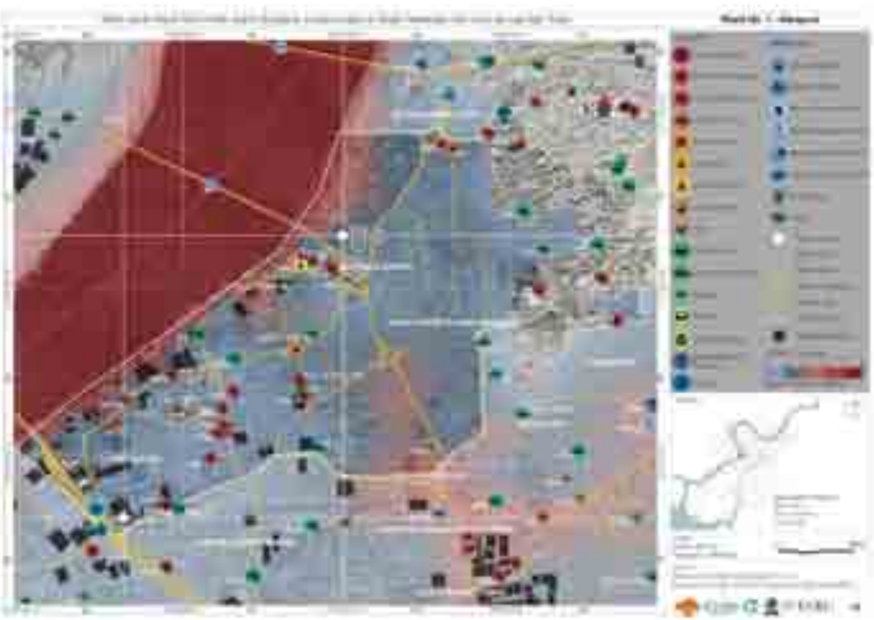
Simulated using SWAT Hydrological Model MME: Multi Model Ensemble(based District Level Weather Forecast)

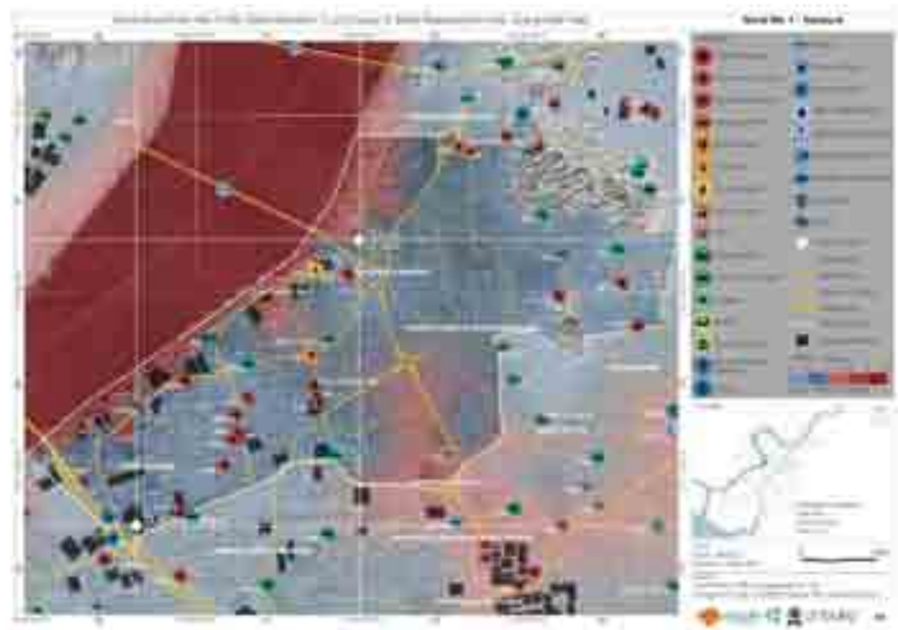
Ward Level Flood Risk Assessment











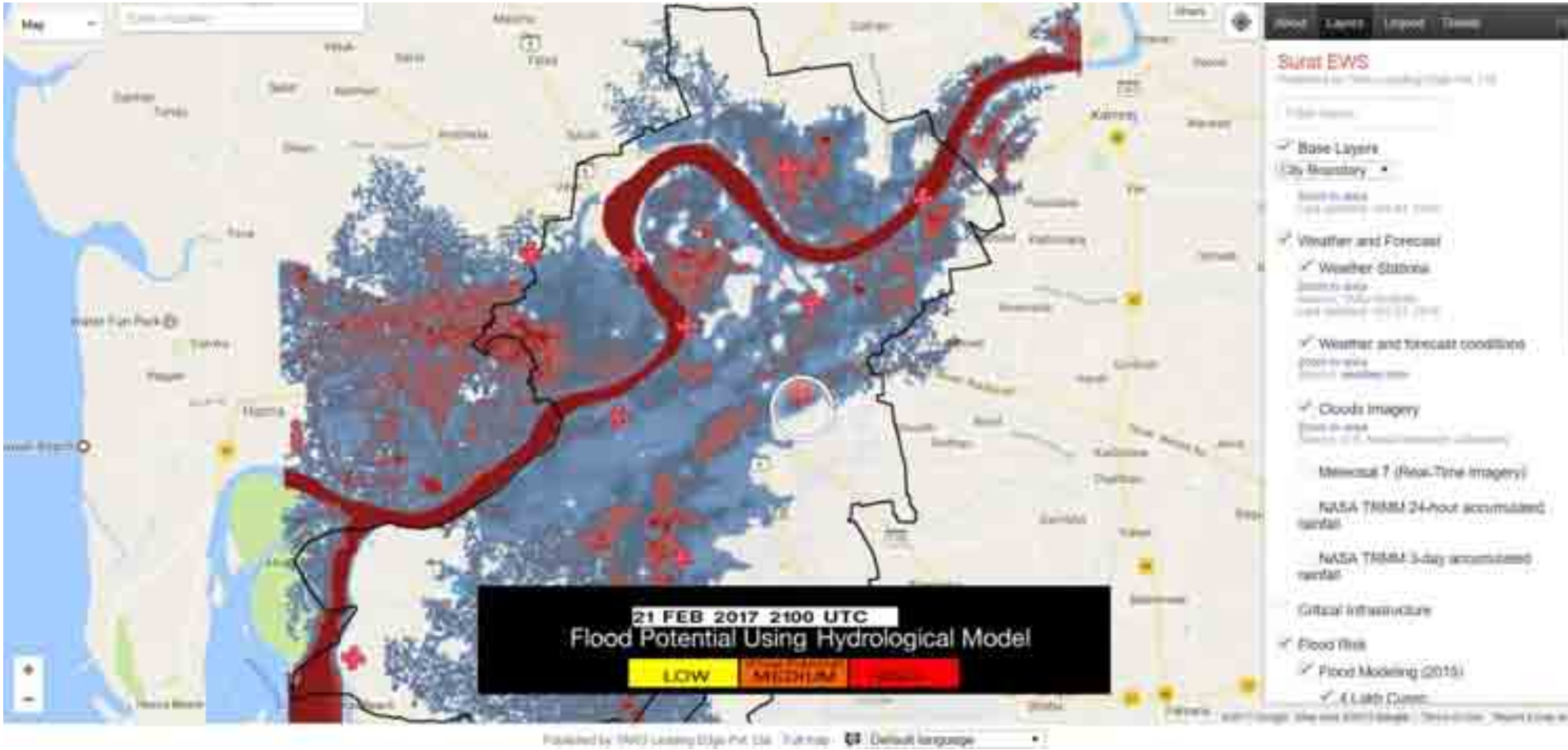
Flood Level Marking

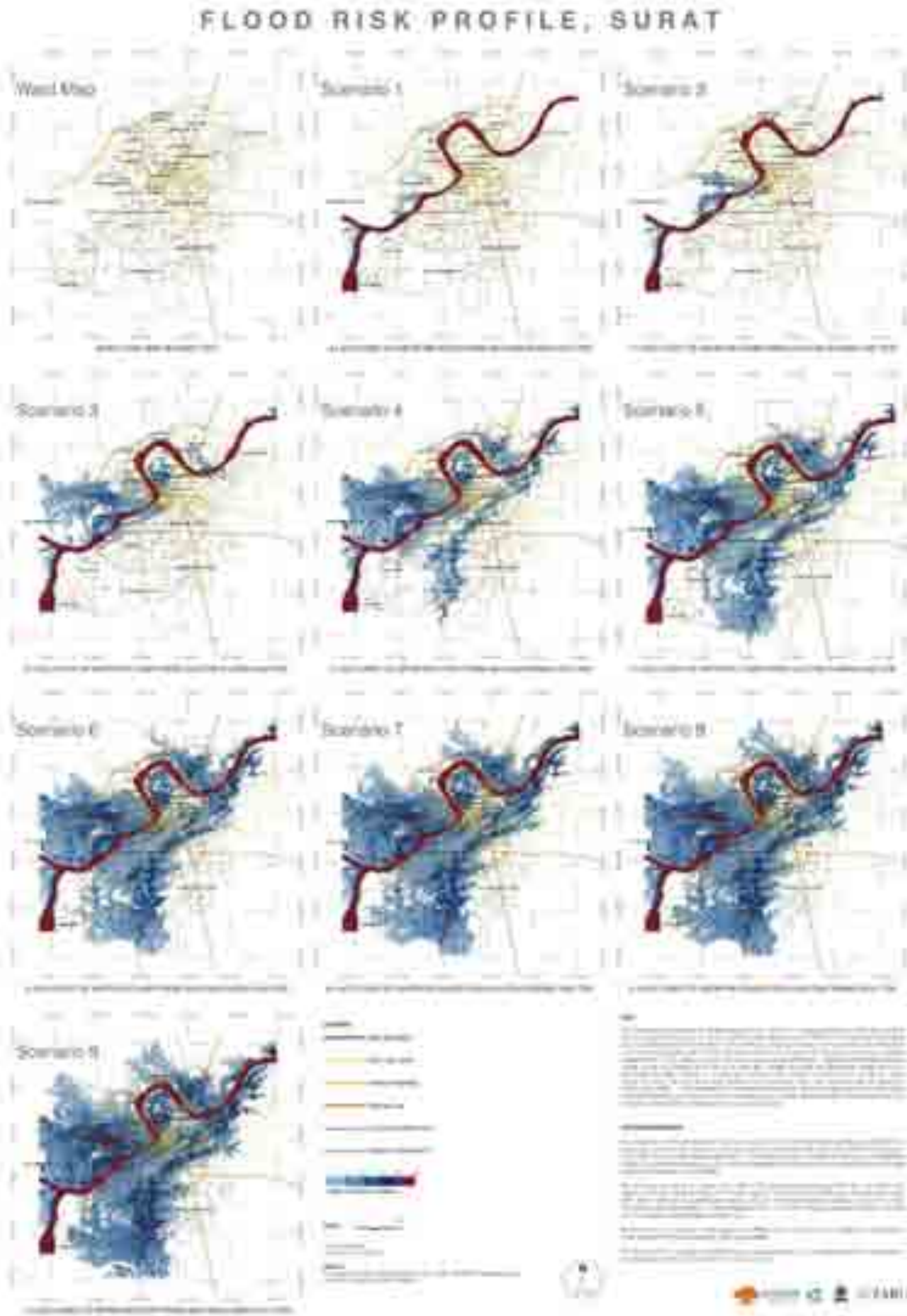
Lamp Post Number :MS17
(Surat Municipal Corporation)

Lat: 21.19982723
Long: 72.8205567

- 0-10 Lac Cusec
- 10.1-12 Lac Cusec
- > 12 Lac Cusec

Web Based DSS




FLOOD RISK PROFILE, SURAT

Lessons: Technical

- Urban floods are combined effect of
  - Precipitation
  - "*Hydromorphology*"
  - Human interventions
- Climate change may amplify/cause unforeseen impacts
- Look forward- look backwards
  - Antecedent build up of events important
    - Kedarnath Example* - build up over days
  - Tomorrows Precipitation should be seen in context of yesterday an today
- Adding human interventions perspective to meteorological events
  - Consequence of failure
    - Network integrity vs single road- Kedarnath
  - Drainage issues in Urban areas

Same event in different contexts can cause different outcomes
Efforts such as GDACS- Population in >X intensity area will help gain attention of decision makers

Thomson M &, Warburton M 1985 Uncertainty on a Himalayan Scale: Michael Thompson and Michael Warburton Mountain Research and Development Vol. 5, No. 2 (May, 1985)

Technical II

- Entry points for technical analysis in urban areas
  - Include Climate risk analysis in
    - urban planning & city management
    - Nature needs flood plains, Planners should know peak floods to develop options
- In-depth analysis of events to learn lessons
  - Research to go beyond the obvious (afforestation??)
  - Exploring real causes and feasible solutions
  - Paradigm shifts (Search for clumsy solutions to wicked problems*)
- Defining extremes for different contexts
  - Temperature, rainfall etc.
  - Defining area specific "droughts"
- Opportunities to directly serve users
  - Meteorology health linkages: Heat Action plans- HVAC advisories
  - Pluvial flood advisories for cities
  - Rainwater harvesting Technical support
  - Energy sector, esp. Roof top solar, Other major generating stations
  - Smart cities??>> Smart indoor climate management> Energy savings

*VerWeij, M. et al 2006 Clumsy Solutions For A Complex World: The Case Of Climate Change. Public Administration Volume 84, Issue 4, pages 817–843, December 2006

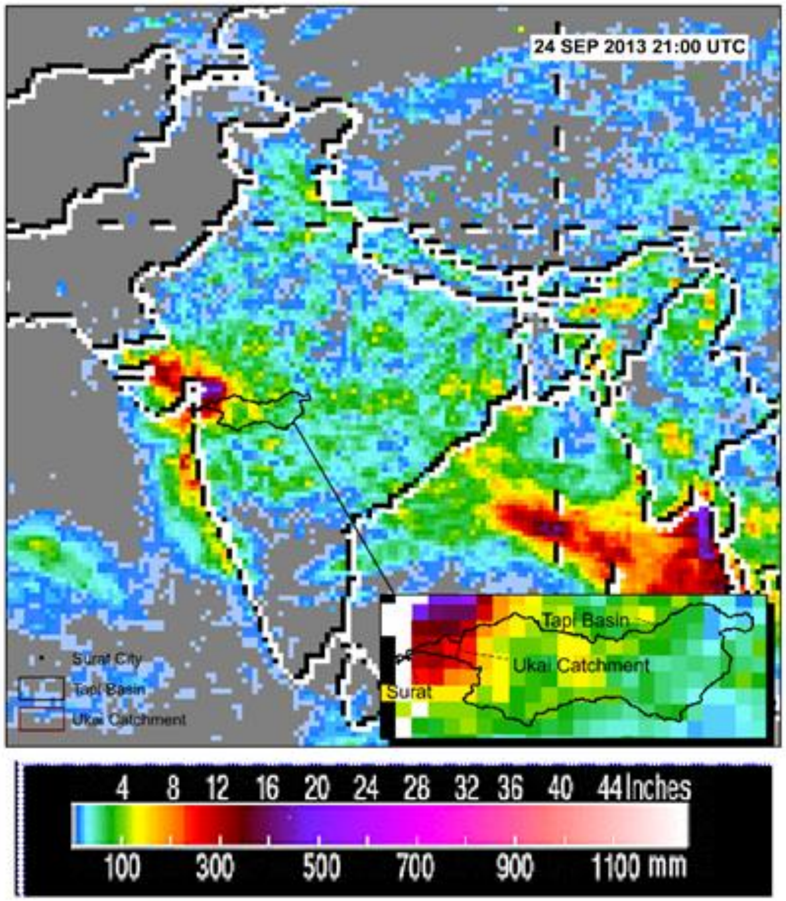
Lessons learnt: Institutions

- Understand stakeholders (Industry, Trade, Civil society, Academic insttns)
  - e.g. Maharashtra and MP govts. SMC DC IMD CWC NWRWS SVNIT, IITD, GSDMA, SGCCI, Citizens, Farmers, Hazira Industries, Kakrapar power station
- Build ownership among stakeholders,
- Create/strengthen multi-stakeholder institutions to own the work and ensure sustainability
- Build local capacities to
  - Understand multiple facets of the issue (flood is not just high flow, but results of pressures from various sources)
  - Read the advisories/warnings
  - Developing systems for "Living with floods": Buildings, preparedness
  - Transcending boundary of sectors and disciplines needed.
- Last mile reach and knowledge gaps
  - Capacity building of SDMA and ULBs
  - ULBs unable to understand (VH rainfall, unless one says, flooding possible/ how much?)
  - Breaking the silos
- Crowd sourcing a challenge and opportunity for fine-tuning thermal comfort models and health impacts (Smart city opportunities)

End-to-End Early Warning System

Satellite Image TRMM**

7 Day Rainfall Accumulation



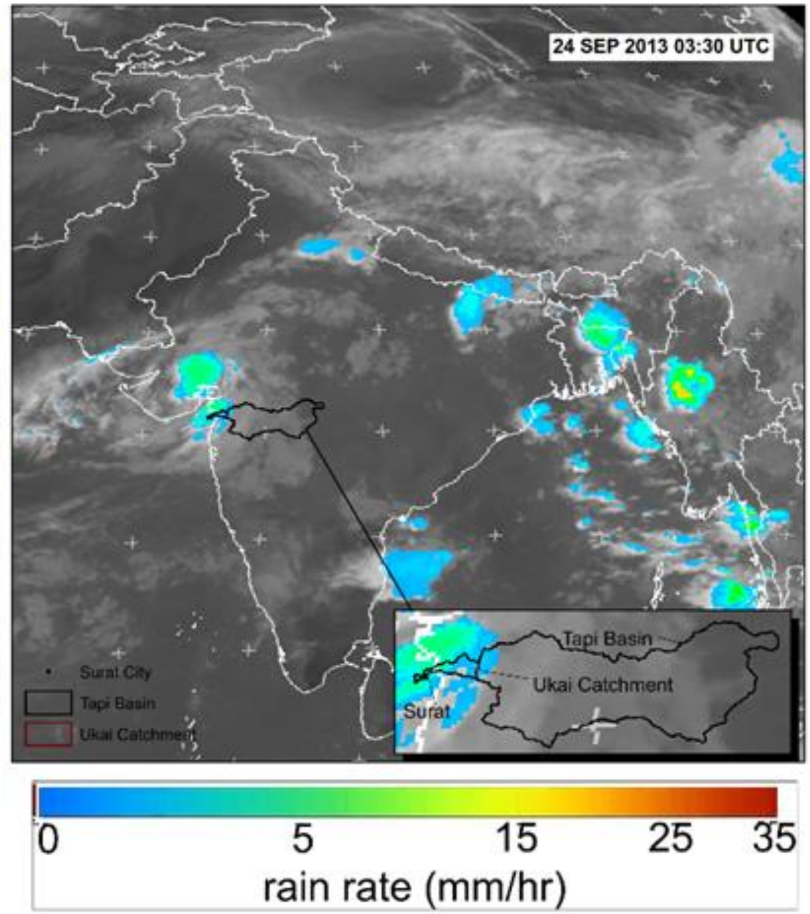
* Tropical Rainfall Measuring Mission

** UTC - Coordinated Universal Time (+5:30 IST)

http://trmm.gsfc.nasa.gov/publications_dir/regional_asia.html

Satellite Image EUMETSAT Meteosat**

Multi-Sensor Precipitation Estimate



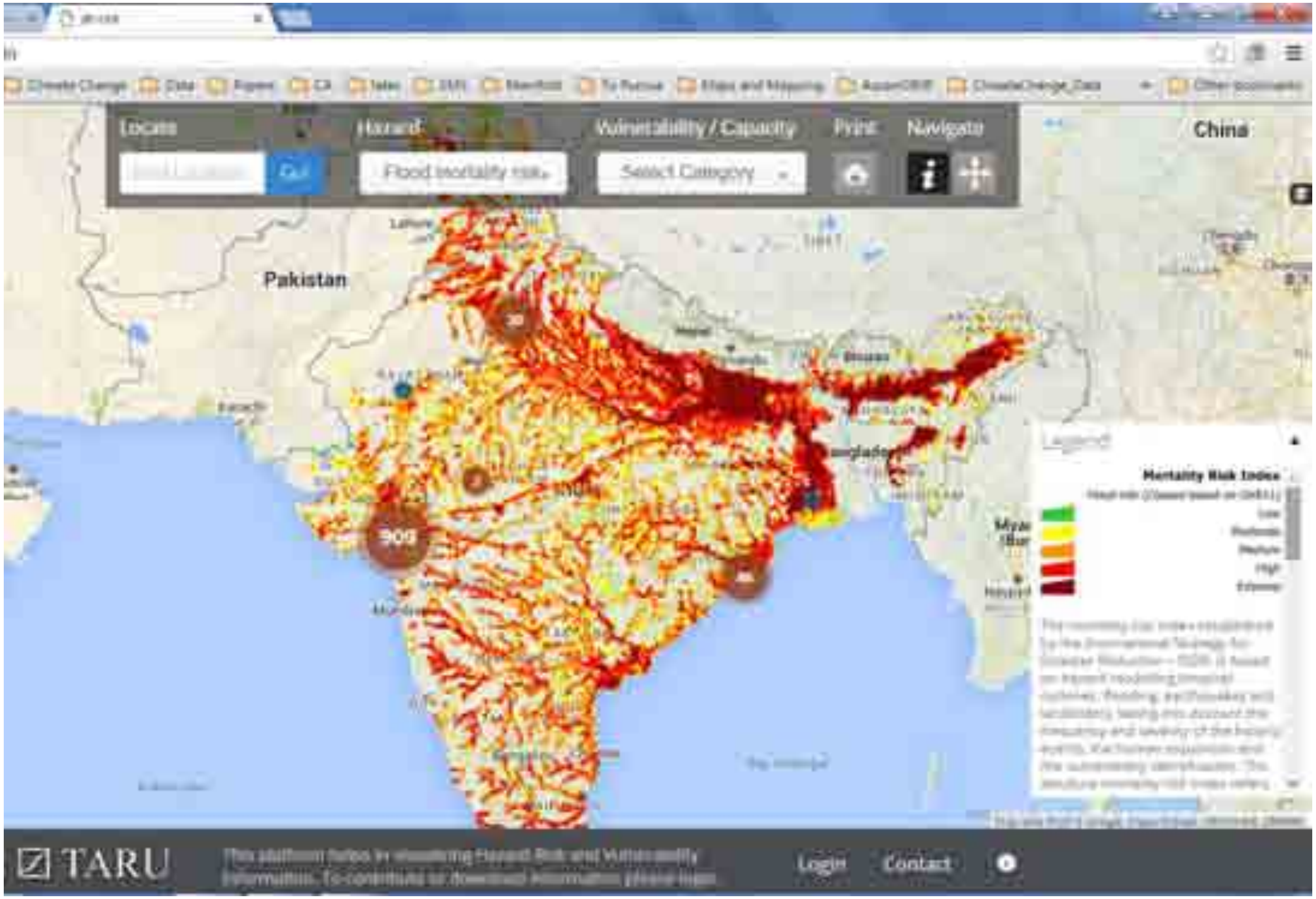
**EUMSTAT - European Organisation for the Exploitation of Meteorological Satellites *(Meteosat - Meteorology Satellite)*

http://oiswww.eumetsat.org/IPPS/html/MTP/PRODUCTS/MPE/SOUTHERNASIA/index.htm

End-to-End Early Warning System

- India's first urban early **warning system for floods**
- **More than 14 institutions are currently on board**
- **The warning system has been functioning since 2013 and did help in preventing 1 major disaster**
- **Currently mainstreamed within the city disaster management plan and monsoon preparedness activities**

Training on Risk



Was used as an interactive tool to providing training and awareness about hazard and vulnerability to Municipal corporation representatives

24 cities and 4 regional institutions did participate in the training program

Thank You

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