

# **MANAGING AND REDUCING SOCIAL VULNERABILITY IN THE CONTEXT OF FLOOD RISKS IN MUMBAI**

S. S. Shinde

Jt. Municipal Commissioner

Municipal Corporation of Greater  
Mumbai



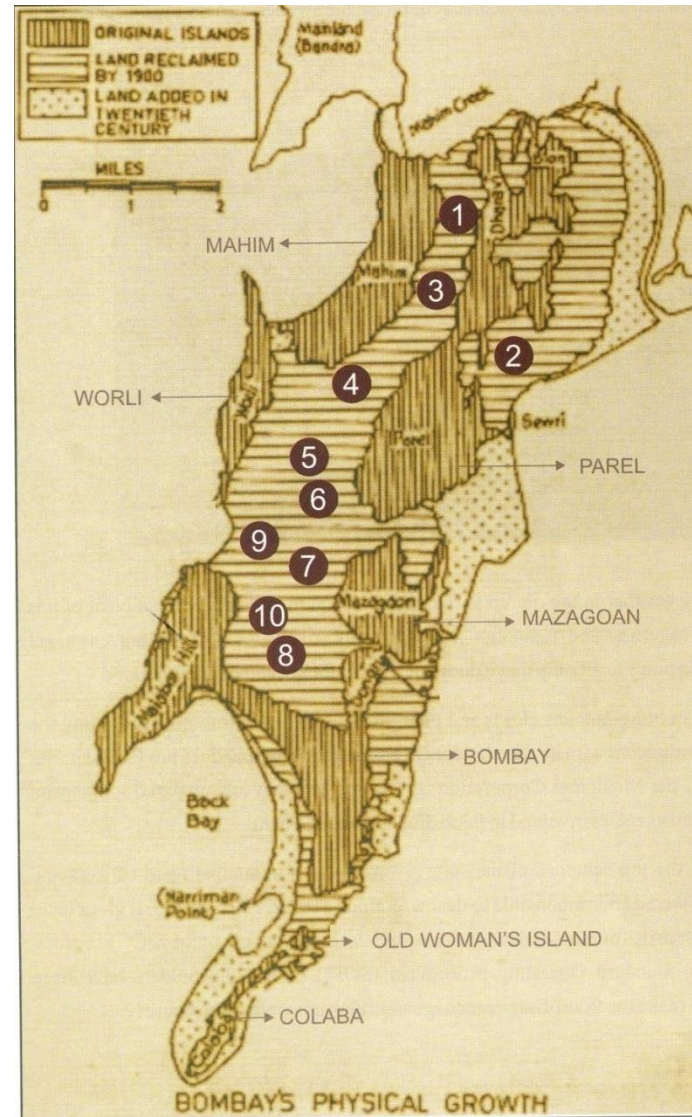
# HAZARDS THAT HAVE IMPACTED OR CAN POTENTIALLY IMPACT MUMBAI CITY

<p><b>1) Hydrological &amp; Climatological Disasters</b></p> <ul style="list-style-type: none"><li>• Floods</li><li>• Cyclones</li><li>• Cloud Bursts</li><li>• Sea Erosion</li></ul>	<p><b>4) Accident Related Disasters</b></p> <ul style="list-style-type: none"><li>• Fires</li><li>• Oil Spills</li><li>• Major Building Collapses</li><li>• Festival related Disasters</li><li>• Air, Road &amp; Rail Accidents</li></ul>
<p><b>2) Geological Disasters</b></p> <ul style="list-style-type: none"><li>• Earthquakes</li><li>• Landslides</li></ul> <p><b>3) Chemical, Industrial &amp; Nuclear Disasters</b></p>	<p><b>5) Epidemics</b></p> <ul style="list-style-type: none"><li>• Dengue</li><li>• H1N1</li><li>• Malaria</li><li>• Gastroenteritis</li></ul>

Chlorine gas leak on 14<sup>th</sup> July 2010

# VULNERABILITIES OF MUMBAI CITY

- Insular Location
- Physiographic constraints- city is confined to 35° Wedge
- Large tracts of reclaimed land
- Extreme population and structural density



# VULNERABILITIES OF MUMBAI CITY

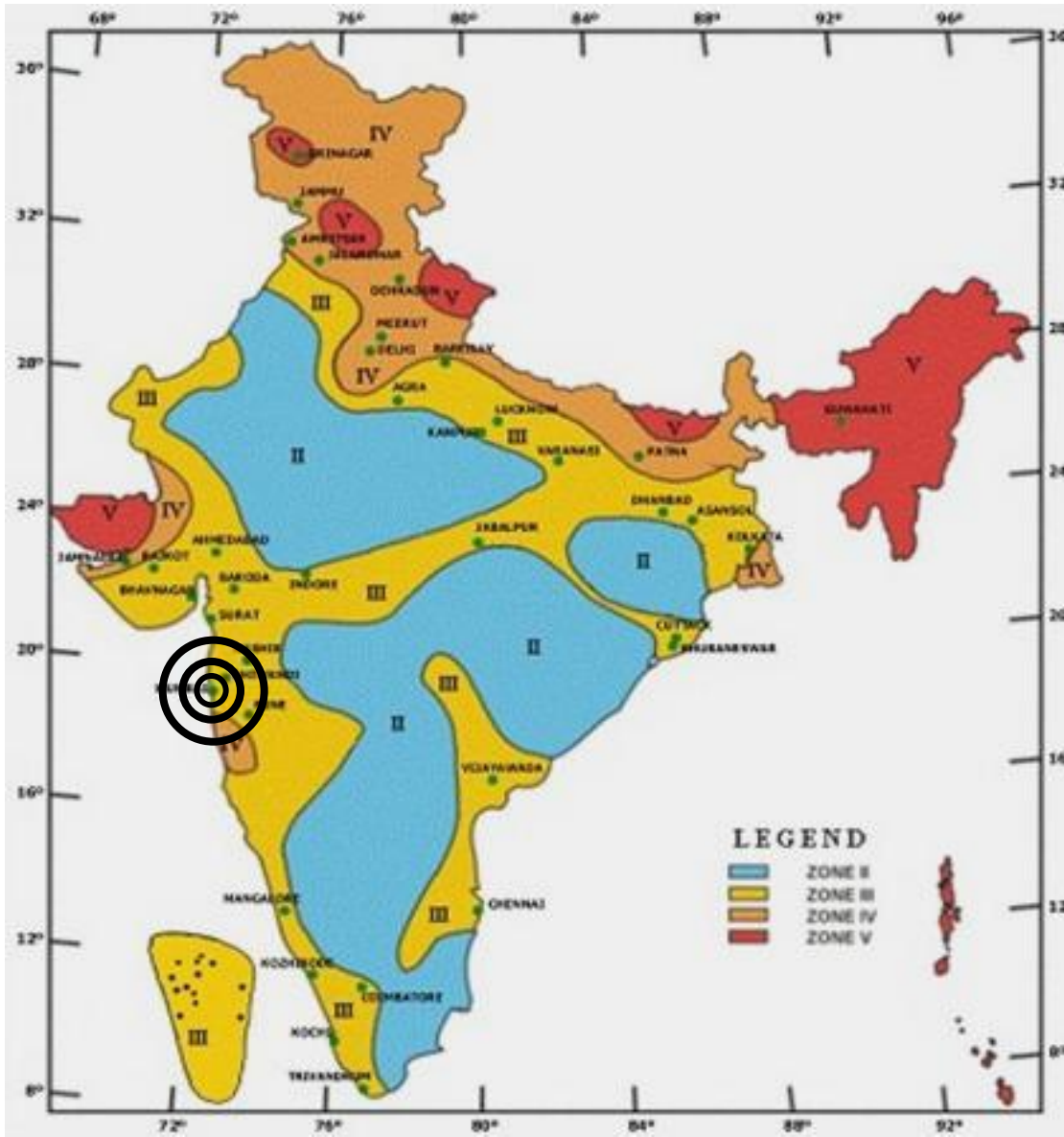
- Rainfall characteristics - average 2363 mm/year
  - Almost 60% of Average rain falls during 2 months in a year
  - Often **35-40 % in 2-3 events**

Percentage of Annual Rainfall

Year / Month	June	July	August	September
2004	13.2	38.4	40.0	8.4
2005	21.0	43.7	10.2	25.1
2006	16.7	40.3	31.3	11.7
2007	37.0	20.4	25.7	16.9
2008	37.5	29.5	19.5	13.4
2009	14.8	48.7	13.4	23.1
<b>Avg.</b>	<b>23.4</b>	<b>36.9</b>	<b>23.4</b>	<b>16.4</b>

# VULNERABILITIES OF MUMBAI CITY

- Located in seismological zone III.



Zon e	Magnitude
Zone V	Very High Risk Quakes of Magnitude 8 and greater
Zone IV	High Risk Quakes upto Magnitude 7.9
Zone III	Moderate Risk Quakes upto Magnitude 6.9
Zone II	Seismic Disturbances upto Magnitude 4.9



# VULNERABILITIES OF MUMBAI CITY

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Large number of old Dilapidated buildings



**299 A - BOTAWALA BLDG., Mazgaon**



# VULNERABILITIES OF MUMBAI CITY

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Large number of vulnerable informal settlements





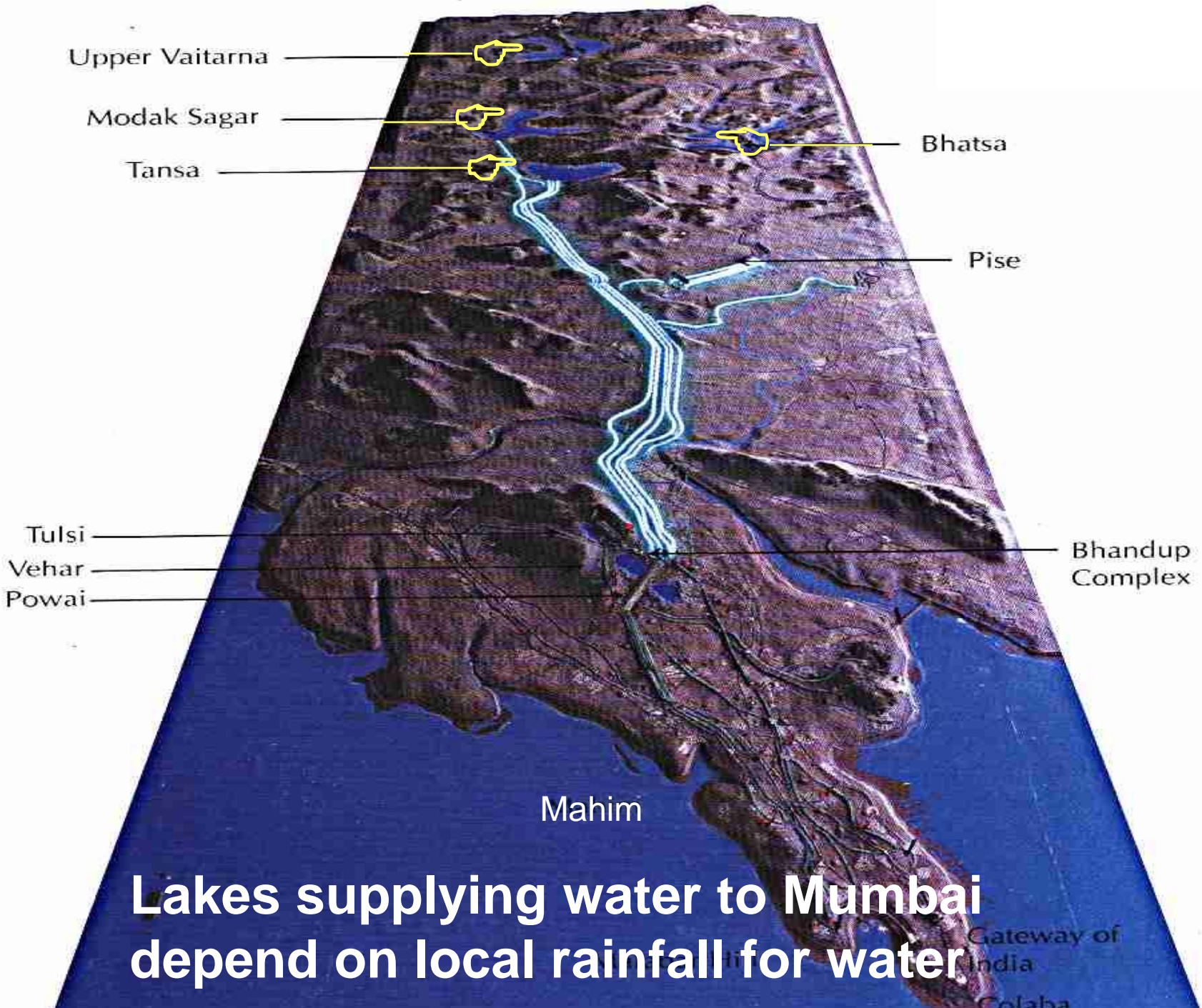
# VULNERABILITIES OF MUMBAI CITY

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- Inadequate transport facilities
  - Overcrowded trains - 6.3 million commuters daily which is the highest passenger density in the world
  - Extremely congested roads - more than 2 million vehicles plying on the road
  - No redundancy in existing system
  - Transport network comprises of long unidirectional corridors- Few East-West linkages







Upper Vaitarna

Modak Sagar

Tansa

Bhatsa

Pise

Tulsi

Vehar

Powai

Bhandup Complex

Mahim

**Lakes supplying water to Mumbai depend on local rainfall for water**

Gateway of India

Colaba



## CAUSES OF FLOODING IN MUMBAI

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- Rainfall Characteristics
- Flooding of Rivers
- Inadequate Storm Water Drainage System
- Increase in Impermeable Surface Cover



# AREAS VULNERABLE TO FLOODING

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- Flooding Spots: 266
- Chronic Flooding Spots: 55
- Slum localities within high tide line: 57





# COAST VULNERABLE TO INUNDATION

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- Length of coastline: 170 km





# Landslides

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- Landslide Prone Areas: 127



# MEASURES INITIATED TO MITIGATE FLOODING OF RIVERS

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## Widening and Deepening of Rivers in the City

Mithi River – the largest drainage system in the heart of the suburbs

- Excavation of over 300,000 cubic meters of silt and almost 500,000 cubic meters of hard rock from the river bed.
- Construction of 7.4 km long RCC retaining wall.
- Construction of a 25 meter long and 4.5 meter high weir to discharge water slowly from the river during periods of heavy rainfall.
- Creation of a holding pond for flood protection in its micro-catchment.
- Demolition of about 5000 structures for widening the river.
- Total expenditure incurred till April 2010 – INR 4308 million

# MEASURES INITIATED TO MITIGATE FLOODING OF RIVERS

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## Dahisar River:

- Training of 1800 meters of the river at a cost of INR 280 million.

## Poisar River:

- Training of 3550 meters of the river INR 670 million.

## Oshiwara River

- Widening and training of three watercourses at a cost of INR 275 million.





# MEASURES INITIATED TO MITIGATE FLOODING

## AUGMENTING THE STORM WATER DRAINAGE SYSTEM

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### Implementation of BRIMSTOWAD project

- SWD system is being augmented four times - design for rainfall of 50 mm/hour with run-off coefficient of one.
- Since 2006, the SWD system is being cleaned/desilted to the bottom-most level. Annual expenditure incurred -over INR 500 million.
- Widening, deepening and training of major watercourses.
- Rehabilitation of old drains, particularly in the Island City.
- Installation of 9 storm water pumping stations to discharge incoming Storm Water flow in the Sea. In addition, 196 smaller pumps have been provided at 189 locations on storm water lines to overcome invert problems and flat gradients.

## MEASURES INITIATED TO MITIGATE URBAN DECAY

**1999:** Development Control Regulation **33(7)** amended for buildings constructed before 1950 and those declared as dangerous, prior to monsoon of 1997.

**February 25, 2009:** DCR **33(9)** rules amended for repairs and reconstruction of cessed buildings and urban renewal schemes.

- Notification for use of Cluster Approach for redevelopment of cessed buildings, buildings belonging to Government, Semi Government and Municipal Corporation of Greater Mumbai, buildings that are declared dangerous or injurious to health and slum areas.

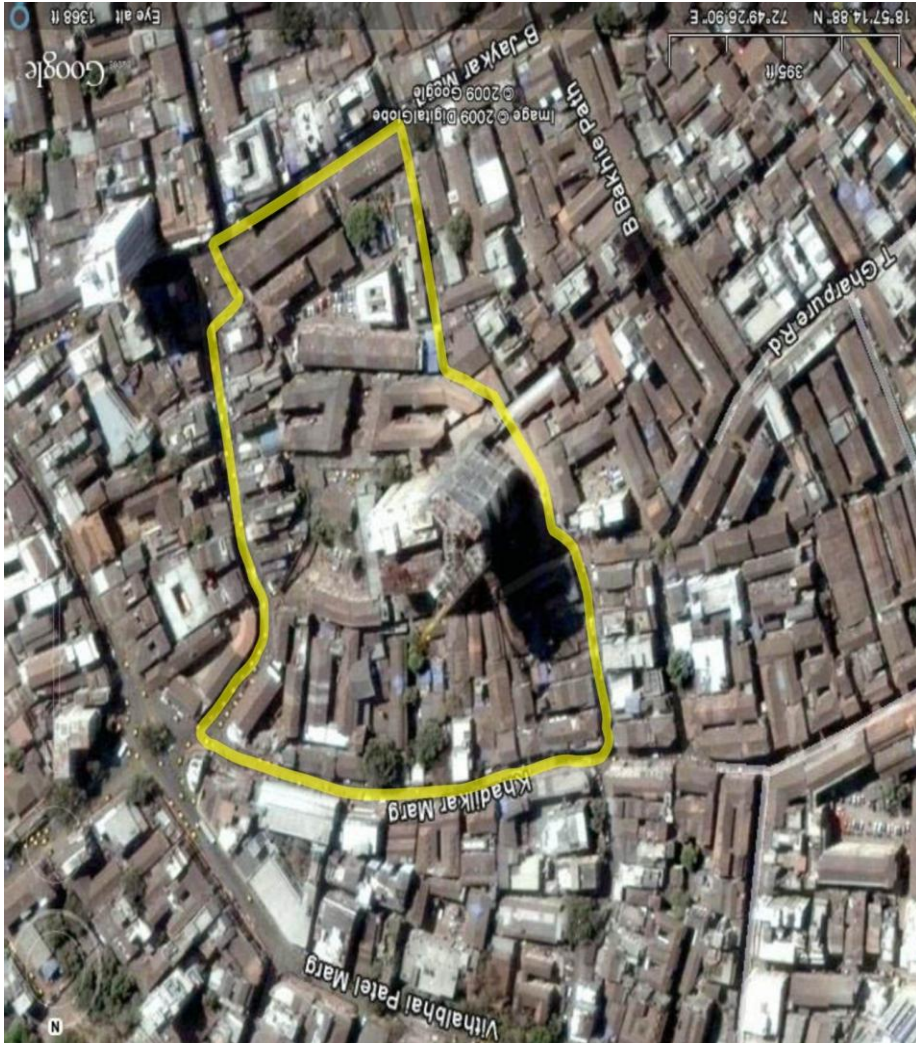
# DEVELOPMENT OF INDIVIDUAL BUILDINGS DCR 33(7)

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# CLUSTER DEVELOPMENT





## OTHER MEASURES INITIATED

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### Construction of Cyclone Shelters

- Construction of Four Cyclone Mitigation Shelters with financial aid from World Bank
- Under normal conditions will be used as Municipal Schools
- Will benefit about 3000 Disaster affected persons



# INSTALLATION AUTOMATIC WEATHER STATIONS & FLOW GAUGES

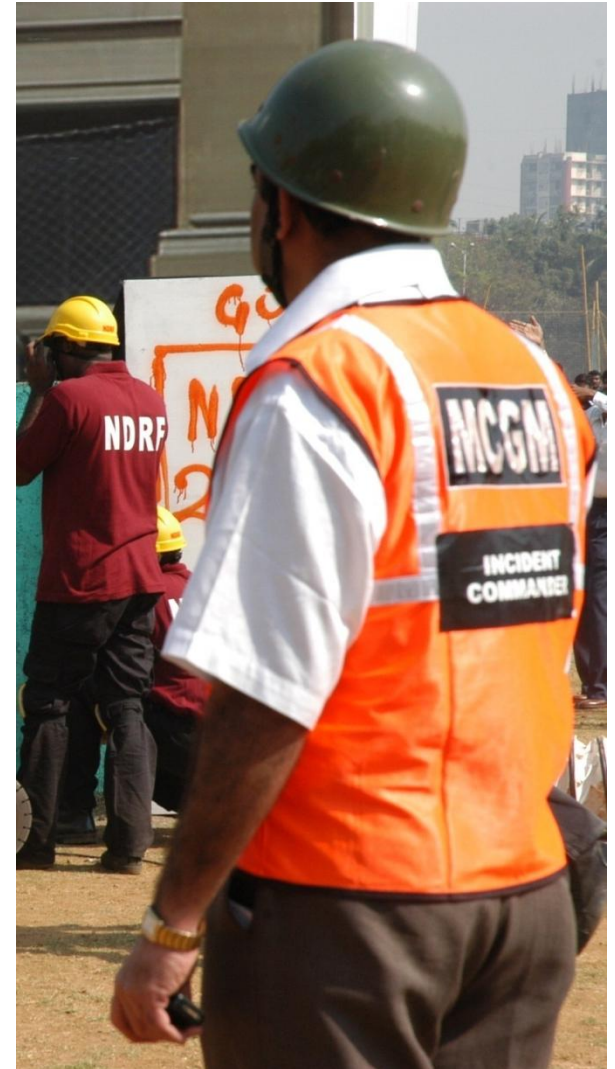
- 35 automatic weather stations have been installed throughout Mumbai to get real time intensity of rain fall.
- Rain fall data is transmitted every 15 minutes.
- The data is monitored, analyzed and the warnings are issued of flooding
- Flow Gauges have been installed upstream of Mithi River to monitor water flow and issue warning to the population living down stream.



# MCGM: INITIATIVES FOR DISASTER RISK REDUCTION

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MCGM, the local authority for Mumbai, is aligning itself with international standards conforming to Hyogo Framework for Action through reforms in its institutions, policies, and legal frameworks for disaster risk management.





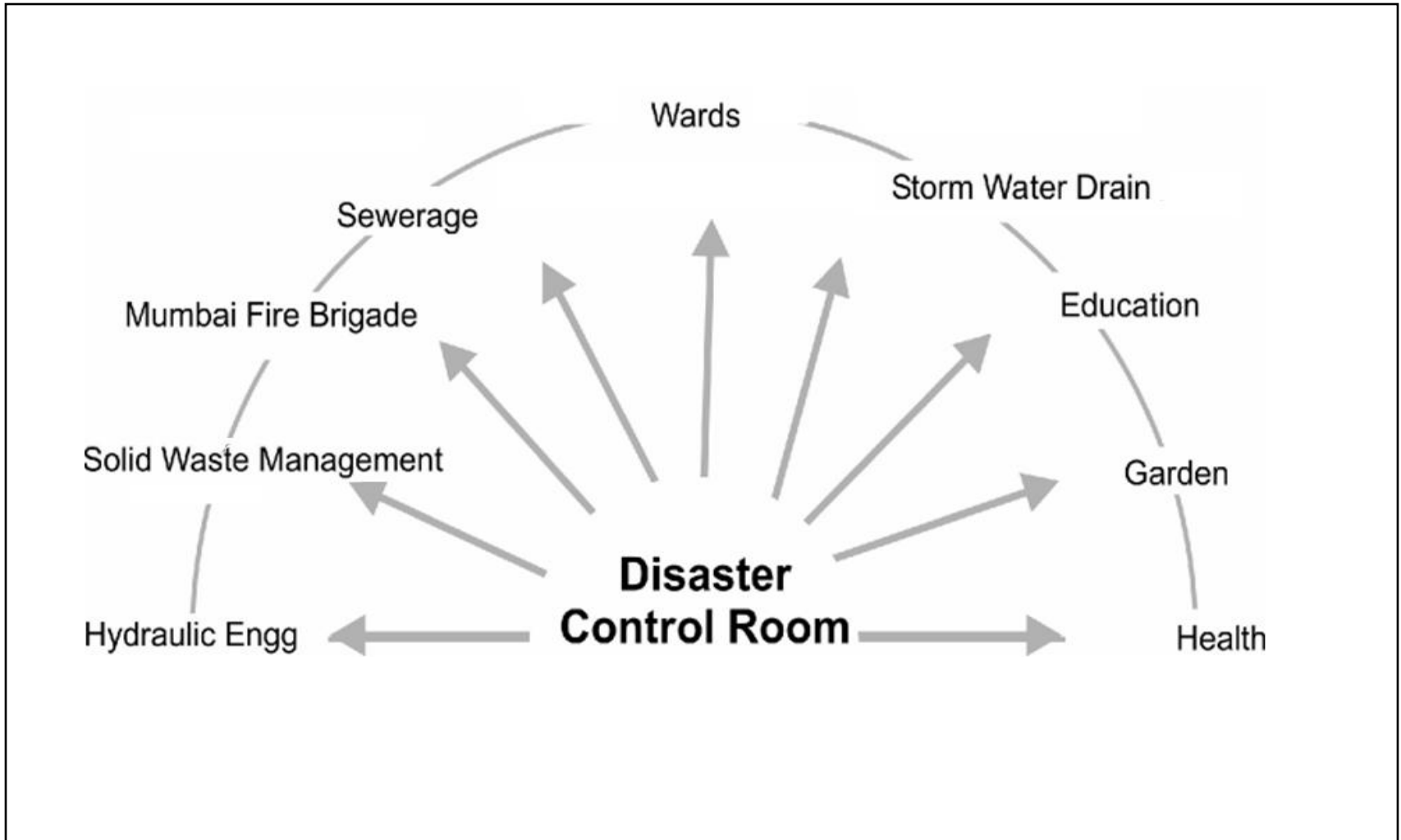
# ESTABLISHMENT OF EMERGENCY OPERATION CENTRES

- **State of the Art Emergency Operation Center at Municipal Head Office & at all Wards**
  - Operational 24 x 7
  - Array of latest Communication Systems
  - Computer system with Disaster Management & Early Warning Software

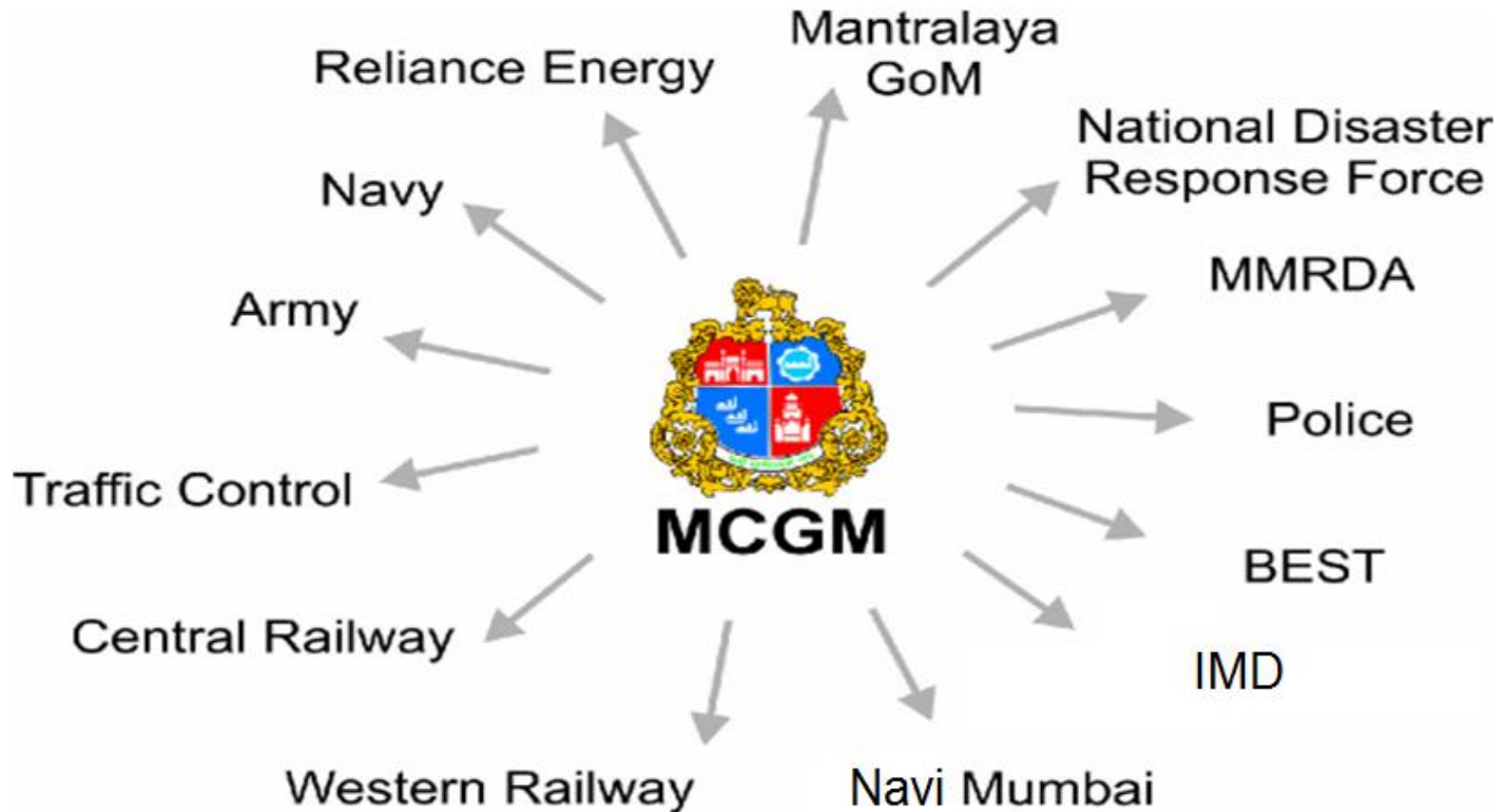




# COORDINATION WITH INTERNAL DEPARTMENTS



# COORDINATION WITH EXTERNAL AGENCIES



**Network of Stakeholders  
(External)**

# DRMMP Mumbai: Objectives

1. Establish a competent emergency management system within Greater Mumbai

2. Institutionalize a sound disaster risk management (DRM) practice for Stakeholders

3. Propose a coherent set of policies and actions to reduce disaster risk within Greater Mumbai

4. Make this project a model to other cities in India through knowledge sharing and participation



# Focus Groups

Focus Group 1 (FG1)

- Legal and Institutional Arrangements

Focus Group 2 (FG2)

- Hazard, Vulnerability and Risk Assessment

Focus Group 3 (FG3)

- Shelter and Disaster Risk Resiliency

Focus Group 4 (FG4)

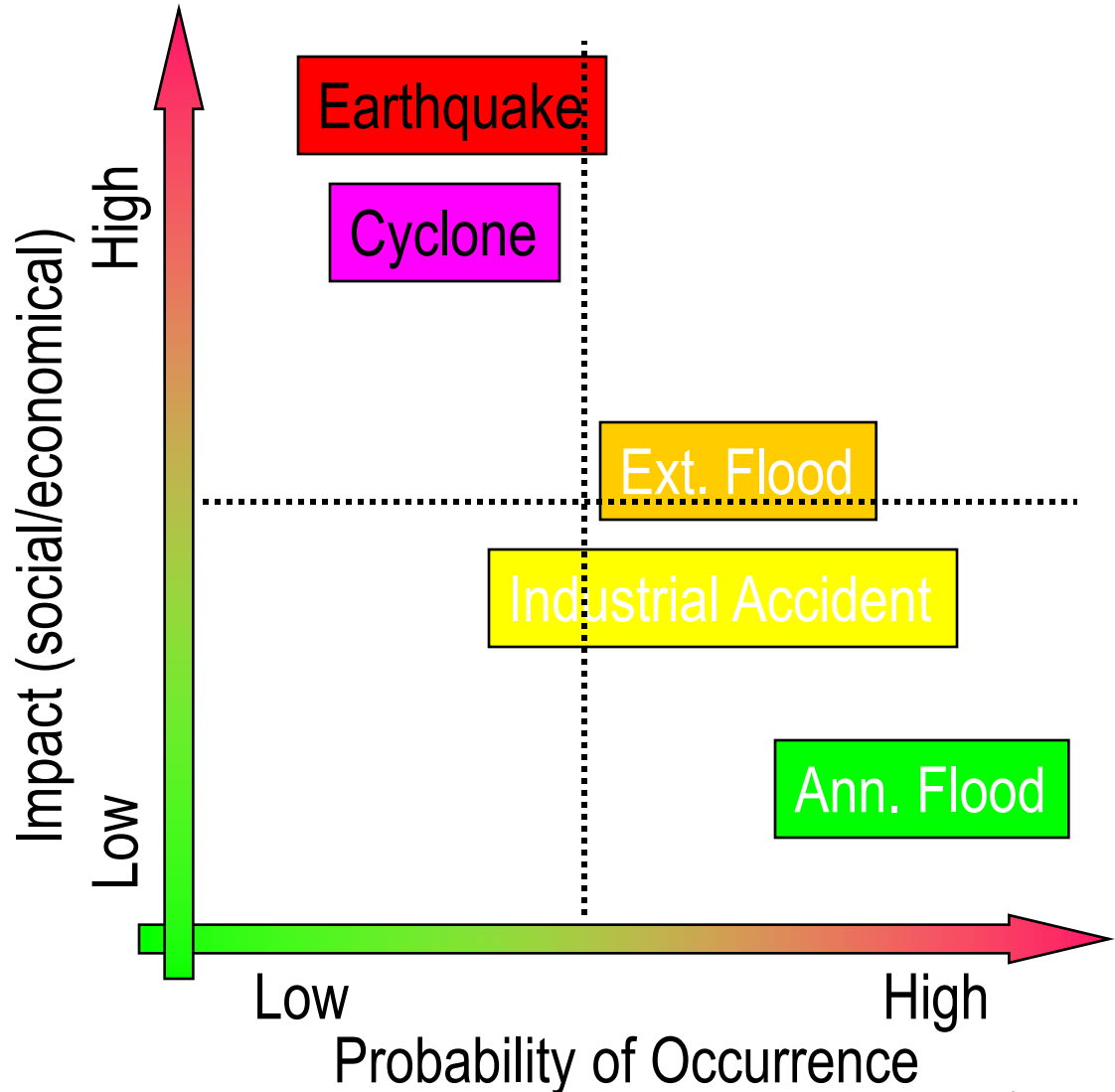
- Land Use Planning, Urban Development and Environmental Management

Focus Group 5 (FG5)

- Emergency Management, Social Mobilization & Public Awareness

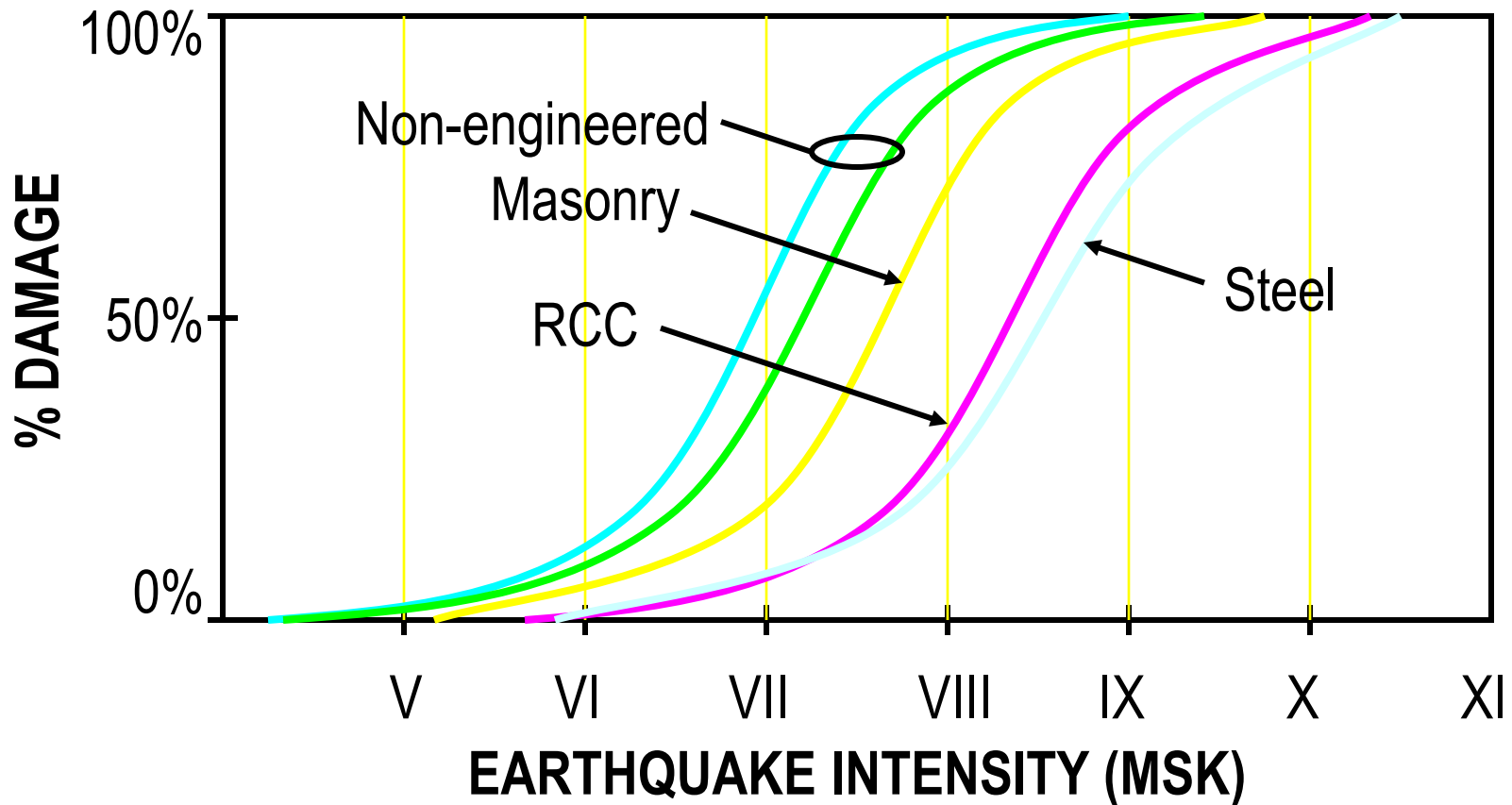
## Background

- A disaster-probability matrix is often used for this prioritising disasters
- Mumbai DRMMP considers earthquake and flood as the main hazards



## Structural Vulnerability

- Structural vulnerability can be expressed in terms of vulnerability curves





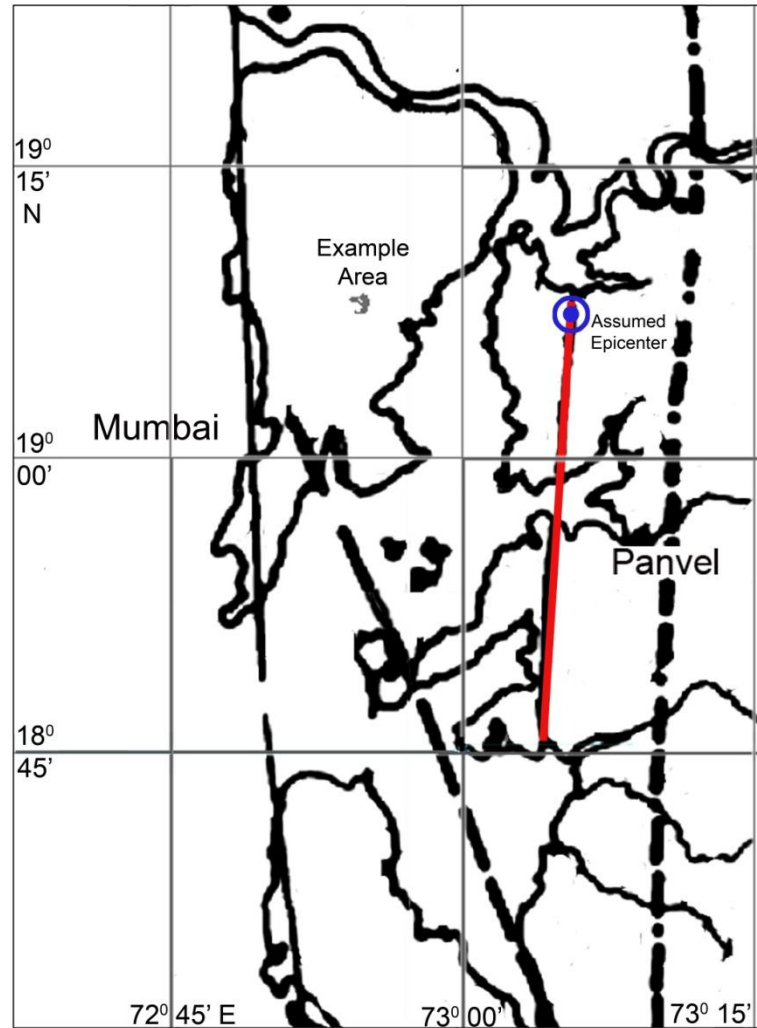
## Structural Vulnerability

- Must consider the consequences of very poor building stock – **example: Mumbai**

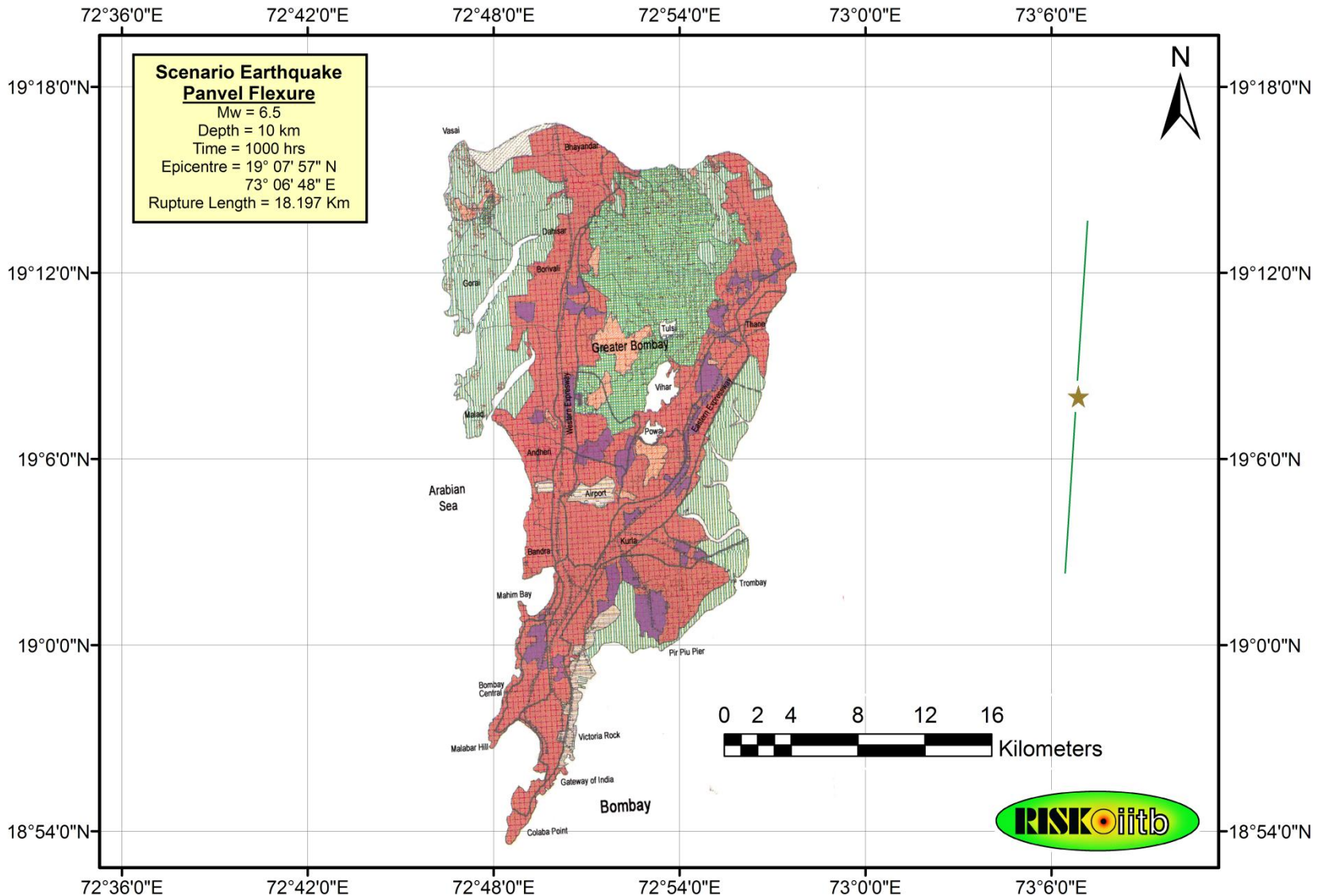
Year	Collapses
1993-94	236
1994-95	253
1995-96	224
1996-97	272
1997-98	259
1998-99	305
1999-00	154
2000-01	260
2001-02	273

Number of building collapses in Mumbai –  
**without any earthquake**

# Seismic Risk of Mumbai

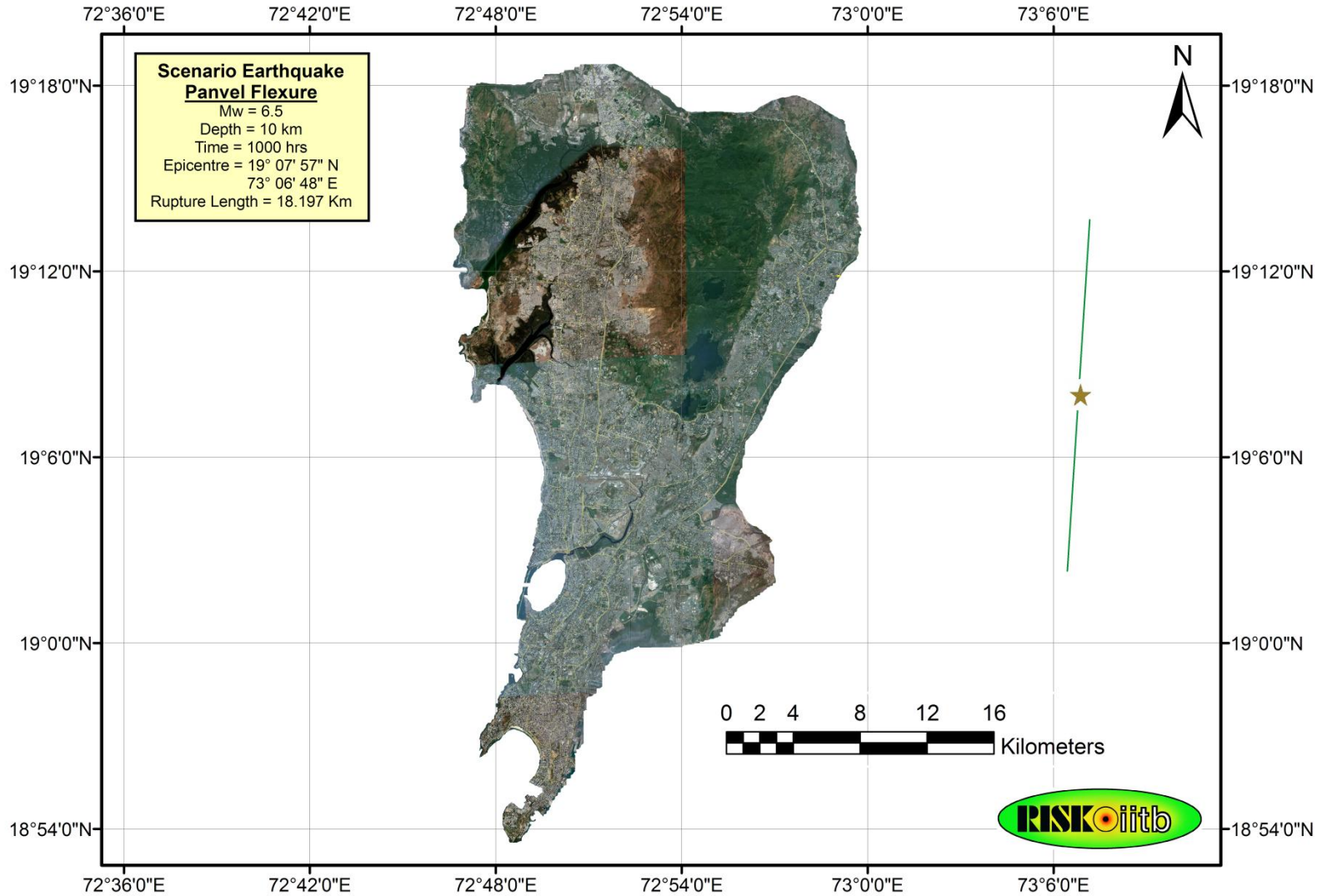


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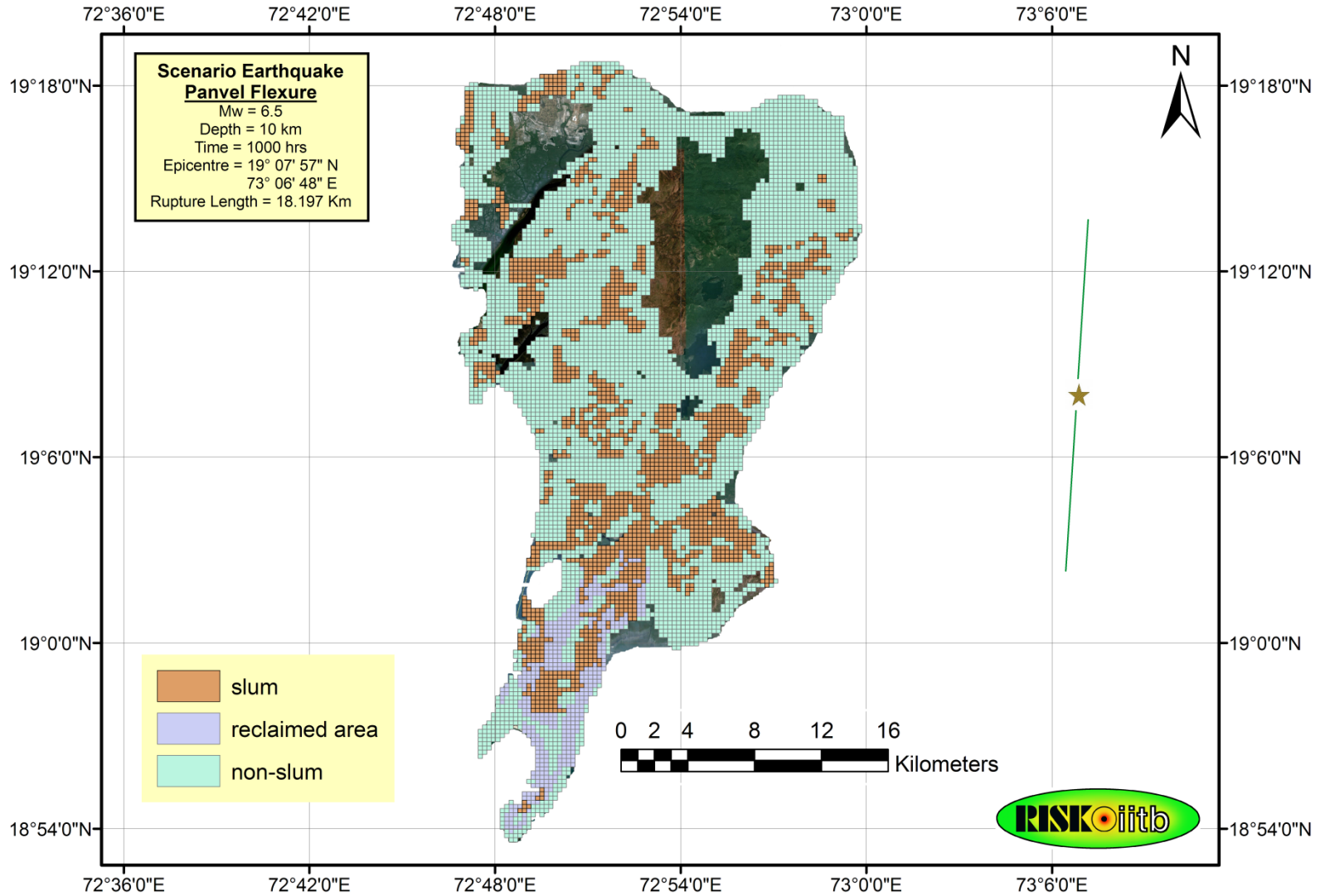




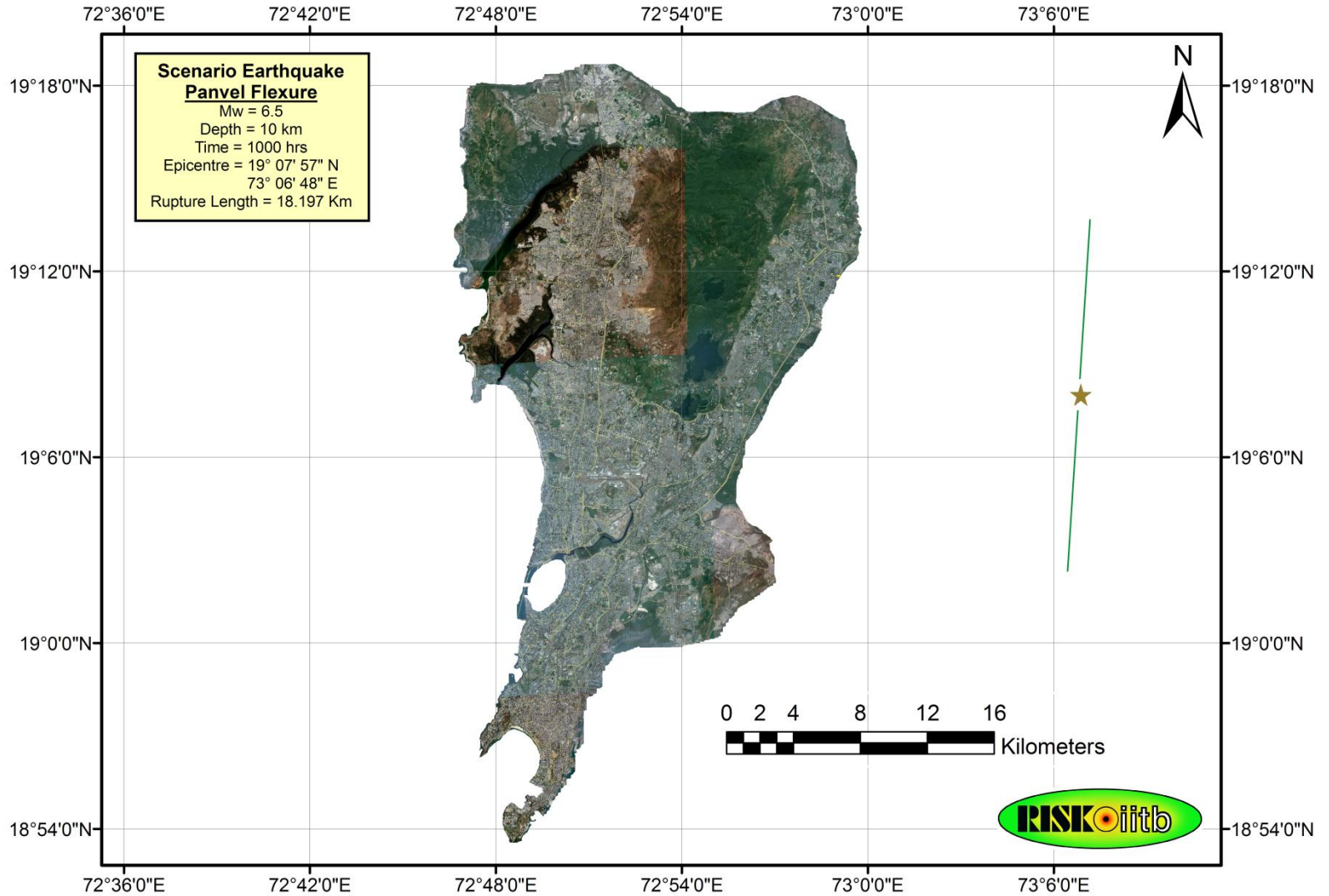
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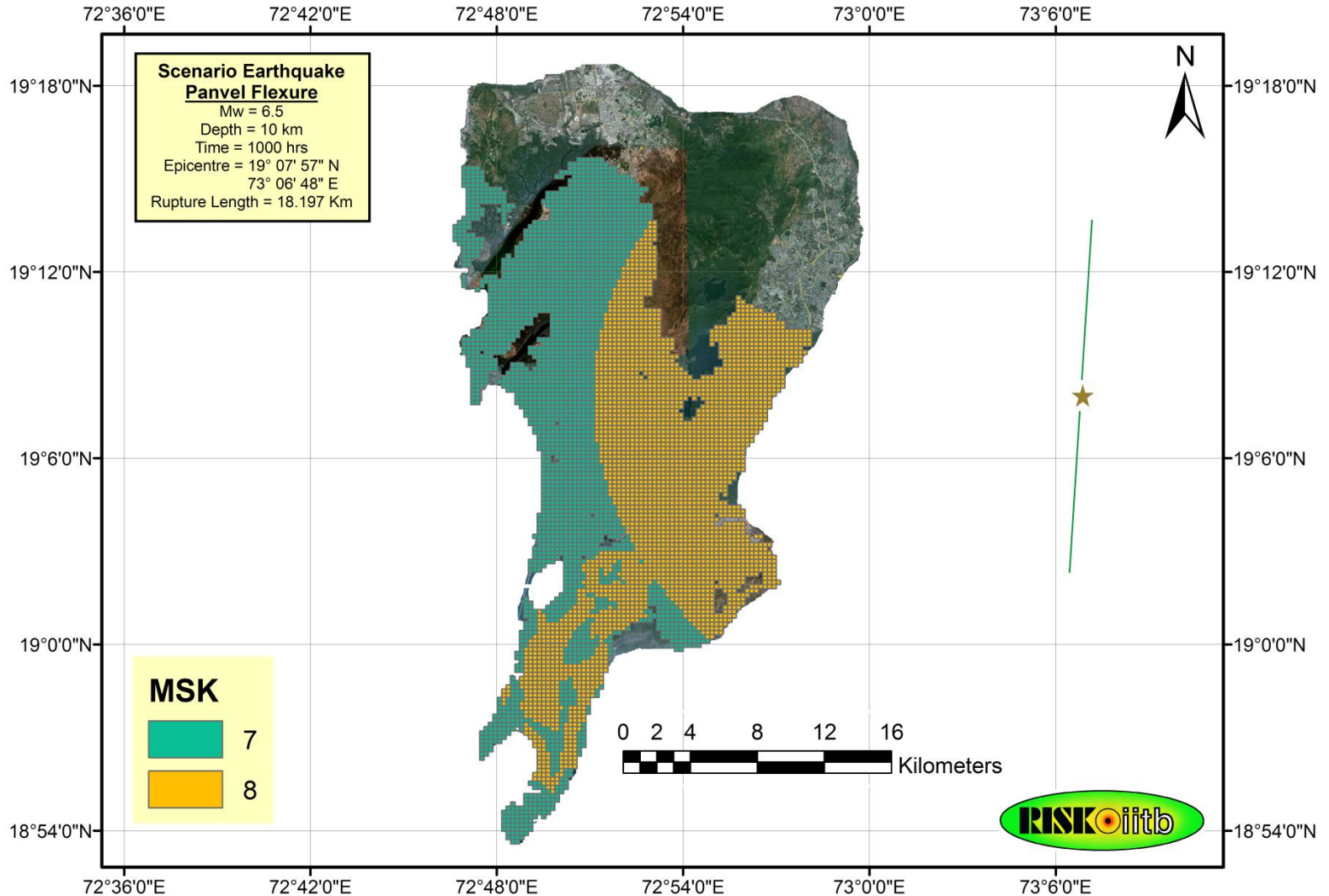


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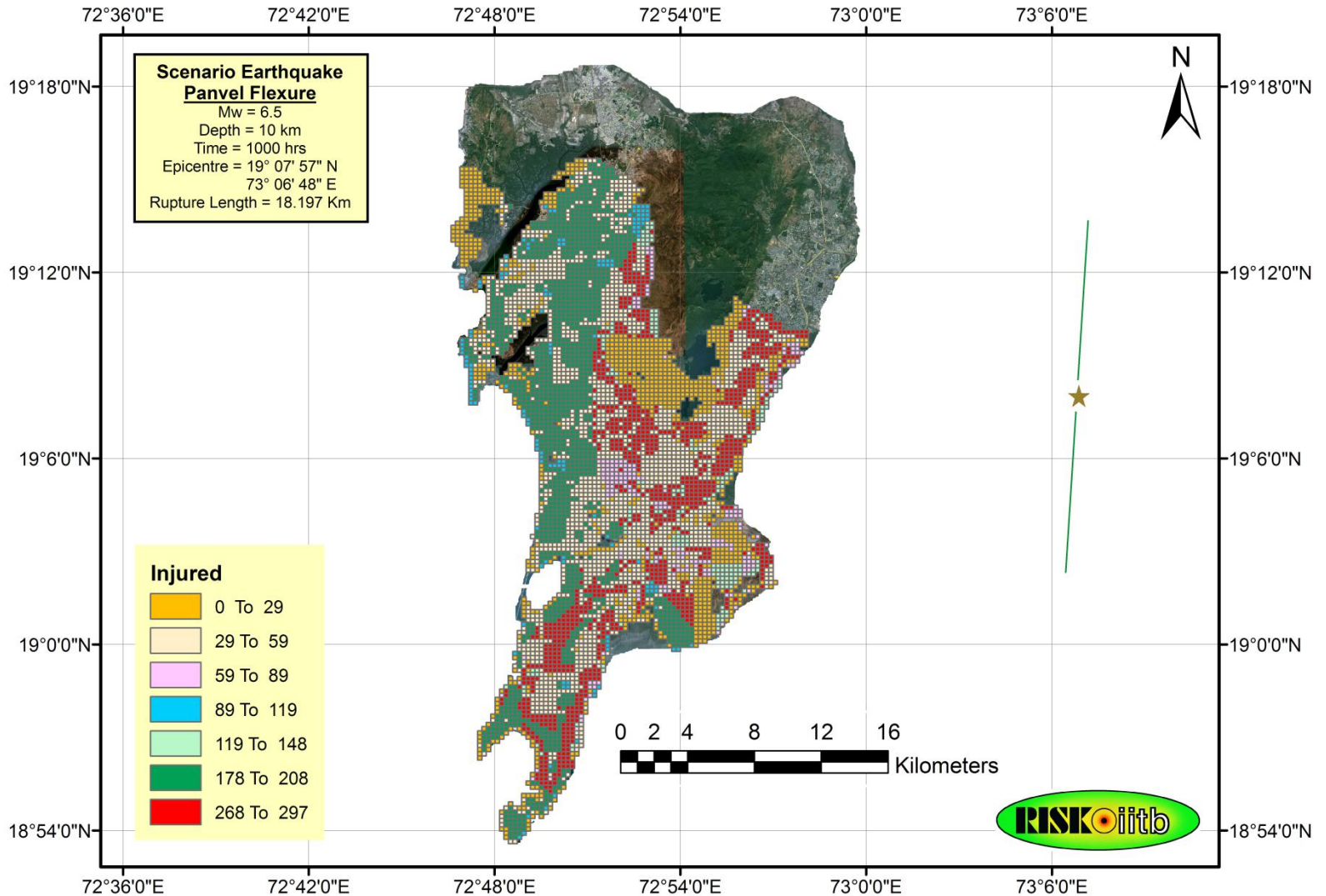




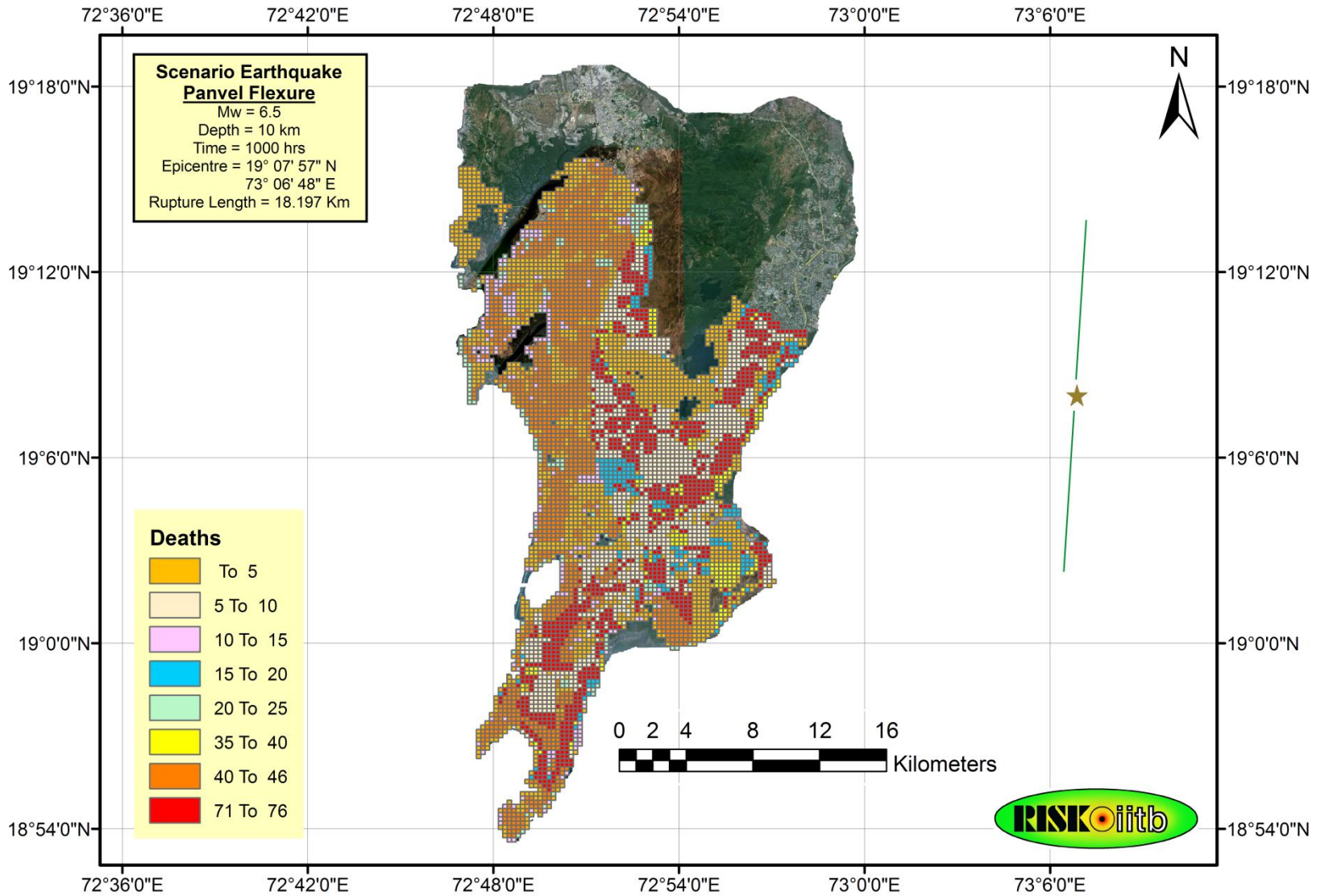
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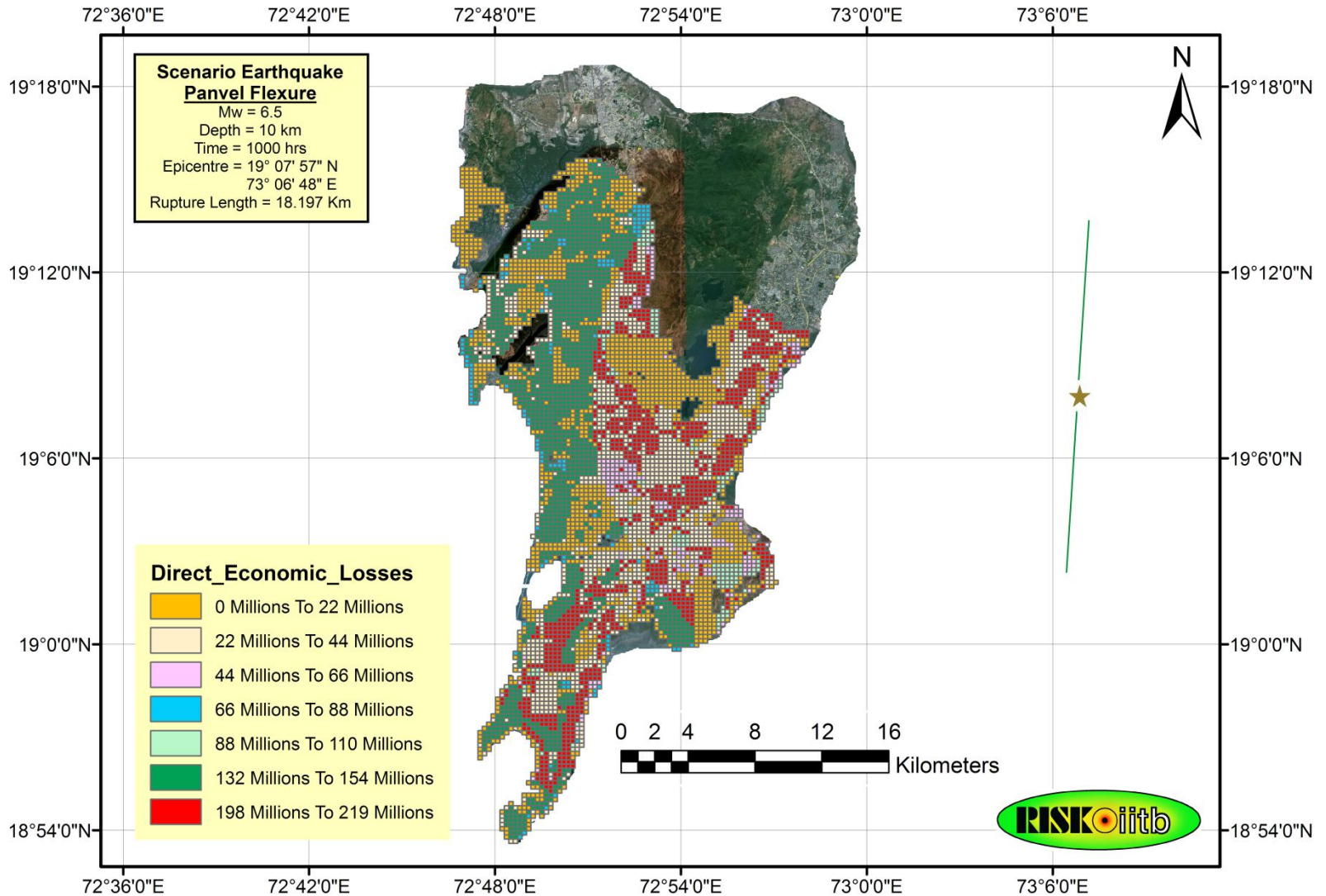


# Seismic Risk of Mumbai





# Seismic Risk of Mumbai



# Seismic Risk of Mumbai

*Scenario: Mw 6.5 earthquake on Panvel flexure at 10:00 AM*

Injuries	720,000
Deaths	169,000
Direct Economic Loss (Rs. Million)	501,000

# Emergency Support Function

ESF No.	Emergency Support Function
ESF 1	Communication
ESF 2	Public Safety and Law & Order
ESF 3	Fire Fighting
ESF 4	Search & Rescue
ESF 5	Transport
ESF 6	Public Health and Sanitation
ESF 7	Resource Management
ESF 8	Information Management
ESF 9	Mass Care Housing and Human Services
ESF 10	Relief Supplies
ESF 11	Energy (Power fuel and Gas)
ESF 12	Utility Services
ESF 13	Public Works and Infrastructure
ESF 14	Oil and Hazardous Material Response



## TASKS PROPOSED IN DRMMP

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- Analysis and Diagnosis
- Risk Analysis
- DRMMP Planning and Framework Development
- DRMMP Framework
- Strategic Planning and Implementation Work Outputs
- State-of-the-Practice Local Level DRM Organizational Structure
- Training and Capacity Building



International Strategy for **Disaster Reduction**

On June 8, 2010 Mumbai signed up for the  
2010 -11 World Disaster Reduction Campaign

**“Making Cities Resilient”**

**“My City is Getting Ready”**  
under UN- ISDR program





Municipal Corporation Of Greater Mumbai

**Thank You....**

***Making Mumbai a better and safe place to live in***