

CORFU

Case study: Mumbai

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Background

- **Catchment area -**
- **Population**
- **Drainage system**
- **Recipients**
- **Rainfall patterns**

City Profile : Mumbai



Western Suburb

Eastern Suburb

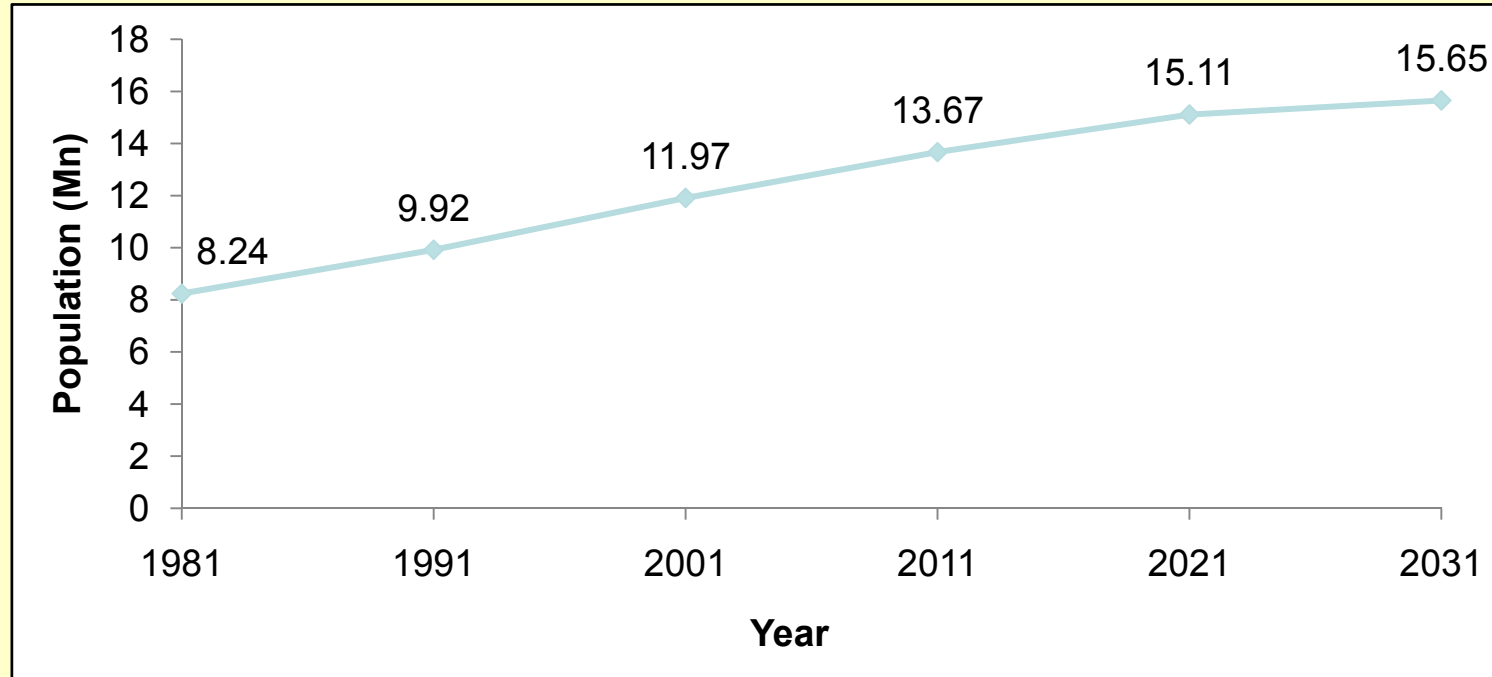
City



- ❑ City area : 437.71 Sq.Km.
- ❑ Financial Capital of India
- ❑ Population - 11.91 Million (2001 census)
- ❑ Average population density: 27,209 per Sq.Km.
- ❑ Approx. 60 % population reside in informal settlements (slums)
- ❑ Annual average rainfall 2300 mm (Santacruz)
- ❑ 30 % to 35 % rainfall occurs in 2-3 events
- ❑ Annual flooding is a regular feature

■ Symond's rain gauge

Urban Growth



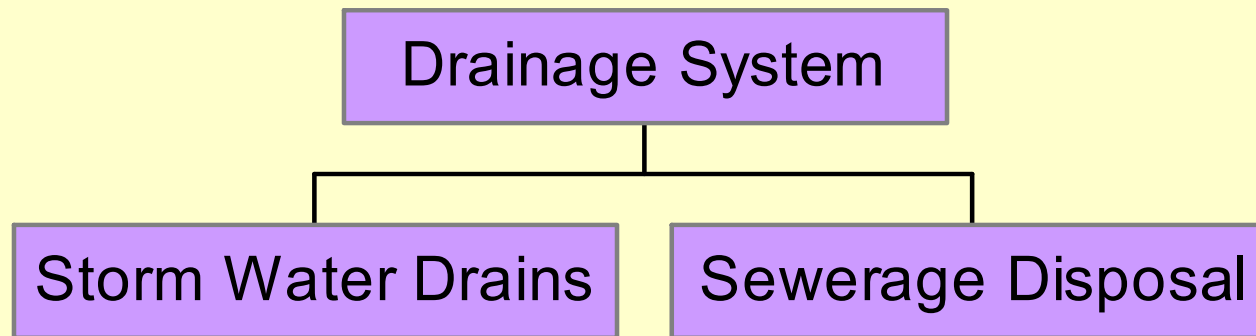
Population of Mumbai (2001 Census)

City:- 33.38 Lakhs

Eastern Suburb :- 35.08 Lakhs

Western Suburb.:-51.32 Lakhs

Total Population:- 119.78 Lakhs



- Sewage
 - Underground Gravity System
 - Collection, Conveyance, Treatment, Pumping discharging to Sea/Creek
- Storm Water
 - More than 150 years old in city area
 - designed for rainfall of 25 mm per hour and run-off coefficient of 0.5
 - Underground/open low gravity system
 - Collection, Conveyance and disposal to Sea/Creek

Existing drainage

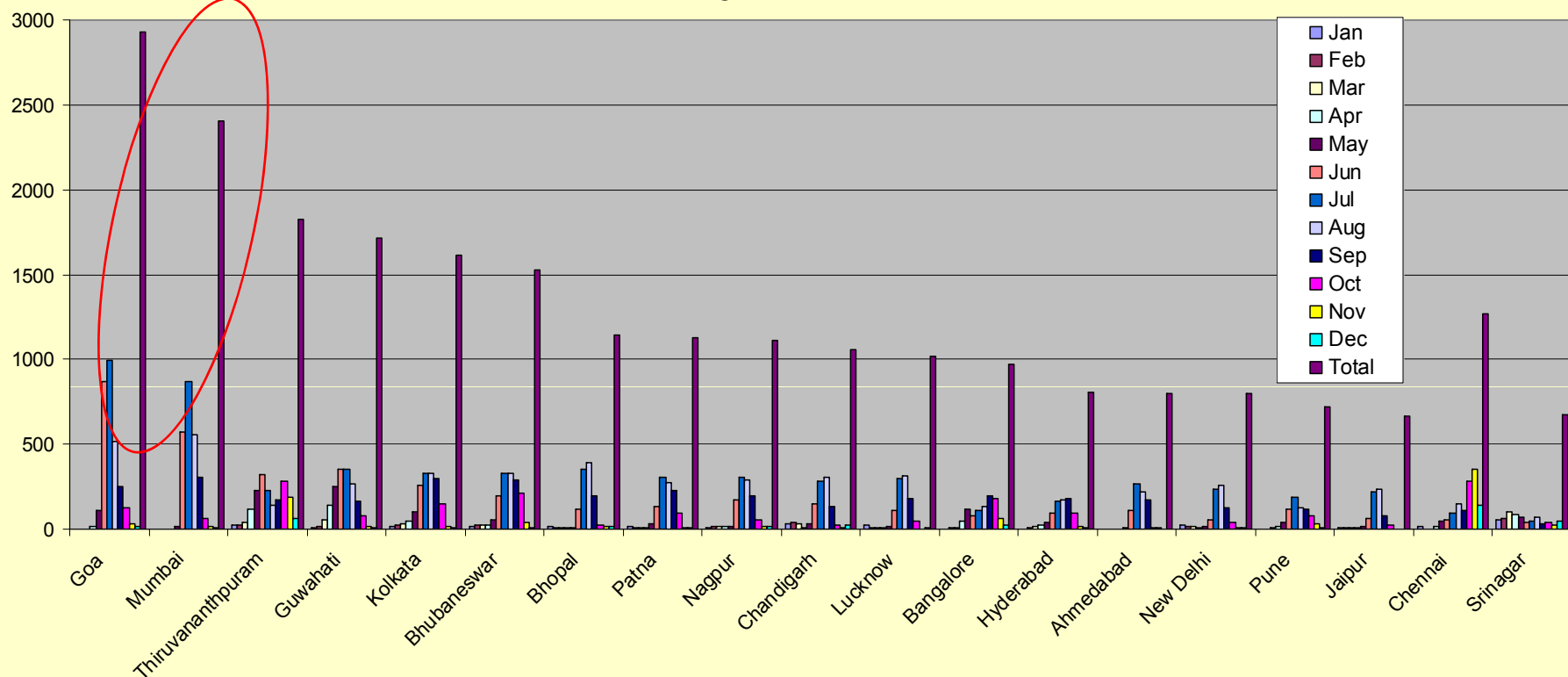
Over years old system designed for rainfall intensity of 25 mm/h

S. No	Drain Type	Length (km)
1	Major drain (width > 1.5 m)	200
2	Minor drain (width < 1.5 m)	87
3	Arch/Box drain	151
4	Road side open drain	1987
5	Closed pipe drain	565
6	Total	2990

Source: Mumbai City Development Plan

Rainfall Pattern

Rainfall in major Indian cities (mm)



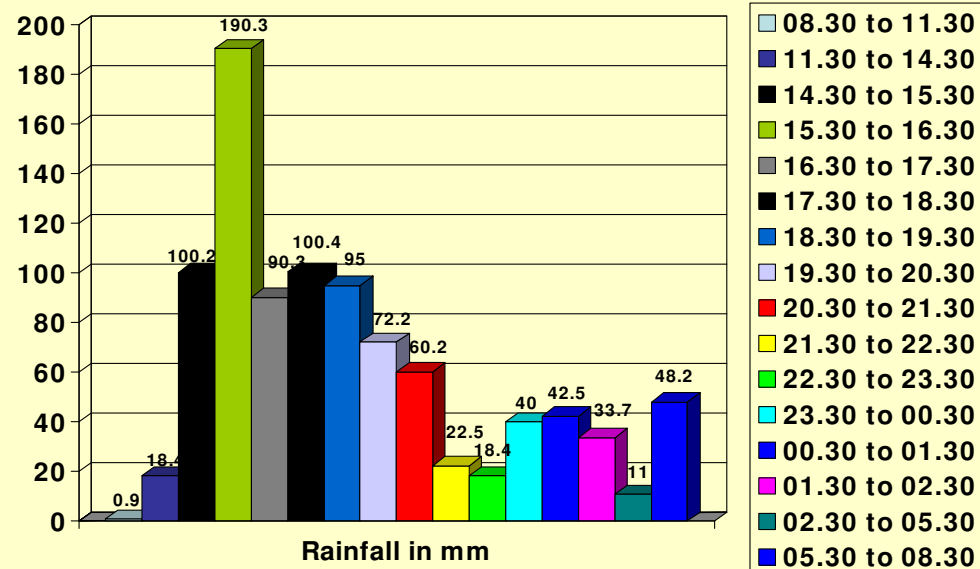
- Over 70 -95% rainfall in 4 months, but TN gets it over 6 months
- So well-planned approach required for managing urban flooding disasters in Indian cities

Flood types, causes and likelihood in Mumbai

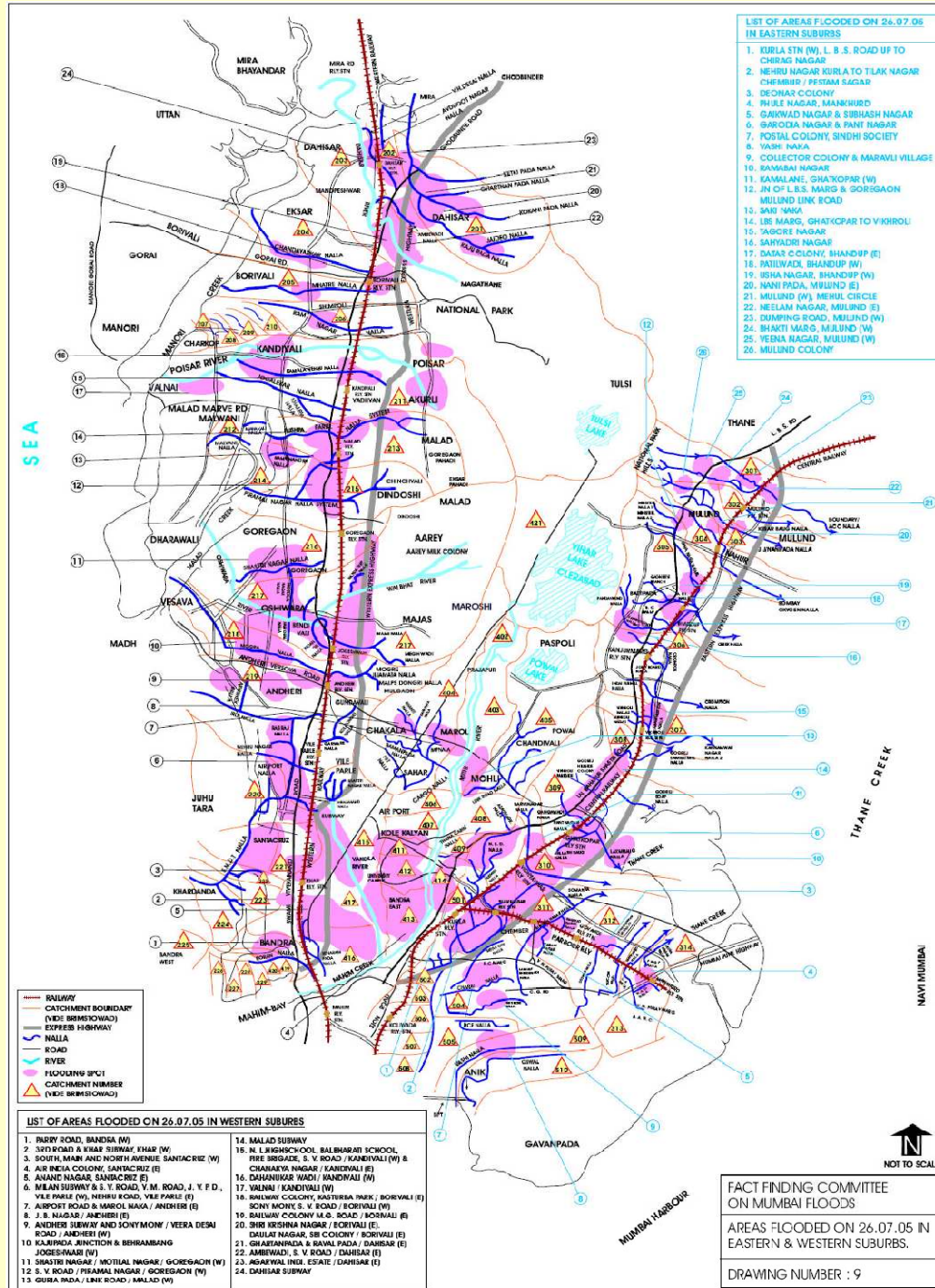
Flood Type	Causes	Minimum likelihood of flood per year
River floods	Natural	Once
Flash floods	Headwaters	Once
Coastal floods	Storms	Once
Storm surge	Storms	?
Drainage problems	Structural	2-3 times

Background: Floods in Mumbai

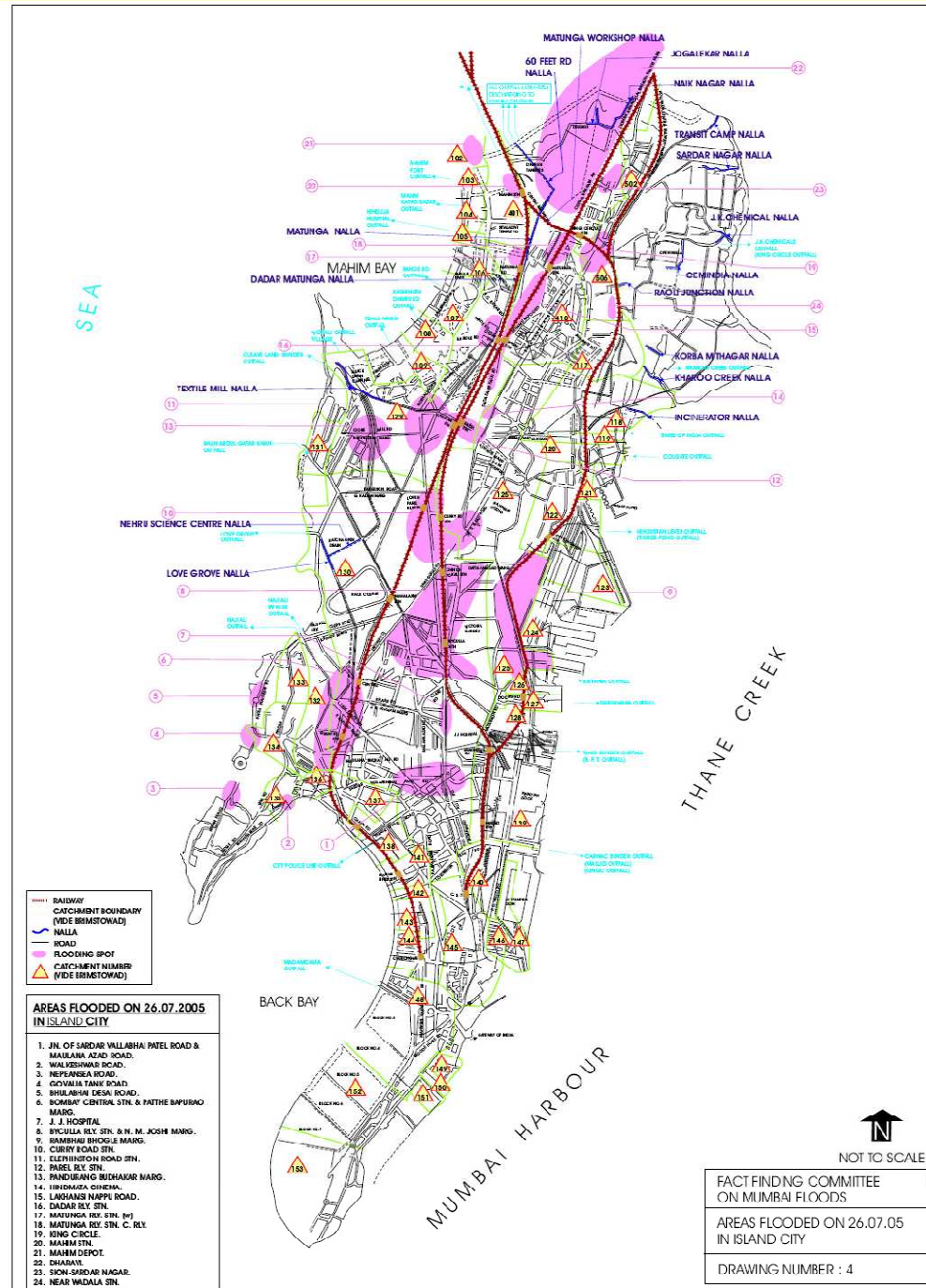
- 26th July 2005 – 944 mm in 24 h
- High tide (4.48 m) at 1550
- Inadequate drainage capacity



Time	Rainfall in mm	Rainfall in mm/hr
14:30 to 18:30 (4 hrs)	481.2	120.3
14:30 to 21:30 (7 hrs)	708.6	101.23
14:30 to 02:30	865.7	72.15
02:30 to 08:30	59.2	9.86



Source: FFC



Source: FFC

Casualty and Damage : 26/07/2005 Floods

Loss of life

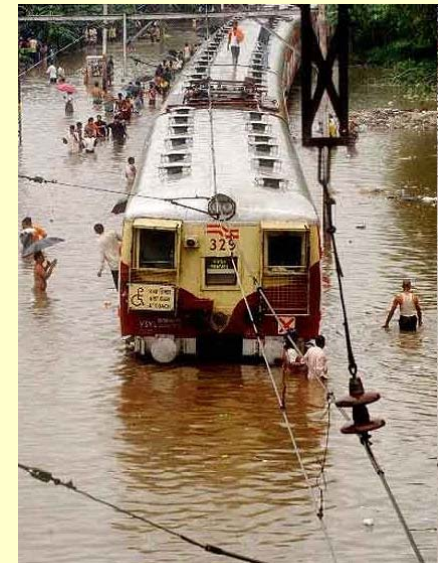
- ❑ At least 445 people lost their lives in the flashfloods and the landslides

Damaged Buildings and Vehicles

- ❑ Residential establishments - partly damaged: 50,000
- ❑ Residential establishments - fully damaged: 2,000
- ❑ Commercial establishments: 40,000
- ❑ Vehicles: 30,000

Impact on Roads

- ❑ Submergence of roads and traffic jams
- ❑ Most arterial roads and highways in the suburbs severely affected due to water-logging



Disruption : 26/07/2005 Floods

Medical Care and Hospitals

- ❑ 437 Primary Health Centers, rural hospitals, and residential premises for health personnel were damaged by flooding



Education and Schools

- ❑ More than 20,000 classrooms damaged and 97 school buildings collapsed



Communications and Information

- ❑ Telephone exchanges came under water the phones stopped working
- ❑ Amateur Ham Radio Operators helped established radio contacts during the emergencies



Flood Frequency

Max. recorded rainfall in Mumbai in a day

05/08/1976- 265 mm

10/09/1991- 475 mm

10/09/1930- 548 mm

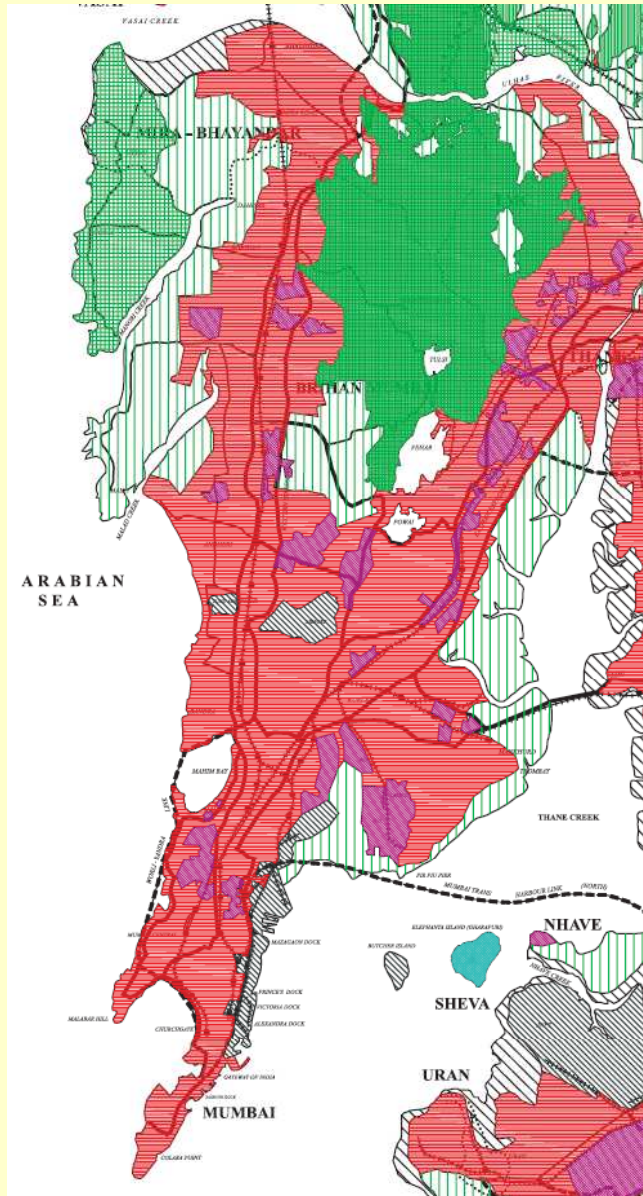
05/07/1974- 575 mm

26/07/2005- 944 mm (in first 6 hrs.- 0830 to 1430 hrs.

only 19.3 mm rainfall and in last 6 hrs. -0230 to 0830

hrs. only 59.2 mm rainfall)

Land Use Pattern



URBANISABLE ZONE - U1



URBANISABLE ZONE - U2



INDUSTRIAL ZONE - I



FOREST ZONE - F



GREEN ZONE - G1



GREEN ZONE - G2



NATIONAL PARK / SANCTUARY



RECREATION & TOURISM ZONE - RTZ



QUARRY ZONE - Q



AIRPORT AND HARBOUR



COASTAL WET LAND



WATER BODY



PROPERTIES WITH WAREHOUSING FACL.








HERITAGE SITE



Catchment area of Mithi river

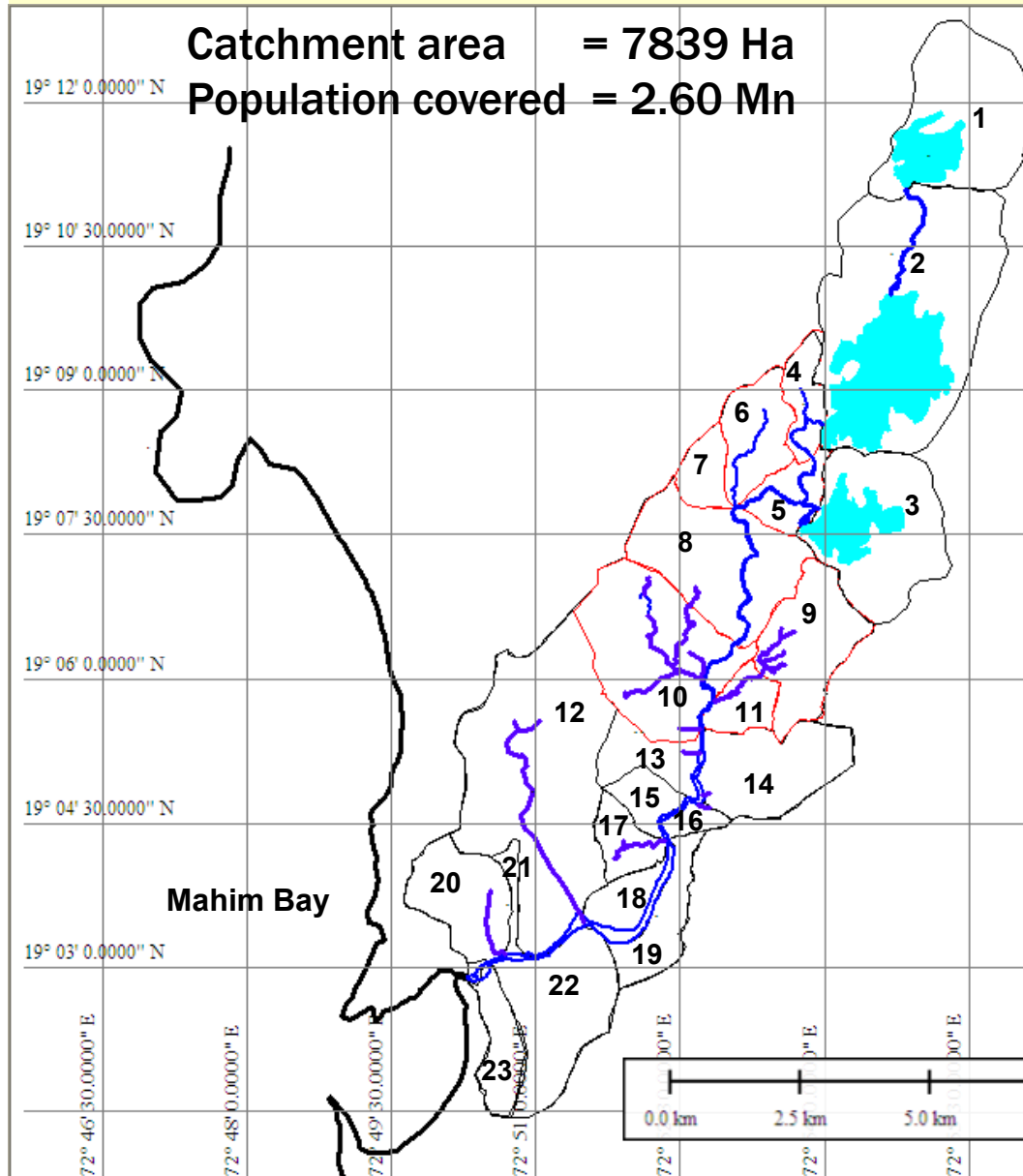
Legend

-  Mithi River
-  Lake
-  Basin Boundary
-  Basin Boundary up to Airport
-  Basin Boundary up to Mahim Causeway

Sub-basin

- | | | | |
|----|--------------|----|-------------------------|
| 1 | Tulsi Lake | 13 | Airport South |
| 2 | Vihar Lake | 14 | Thane Cabin |
| 3 | Powai Lake | 15 | Air India |
| 4 | Bangoda goan | 16 | Kalpana Kamran |
| 5 | Paspoli | 17 | Sunder Nagar |
| 6 | Royal Palms | 18 | BKC |
| 7 | JVLR | 19 | Sion |
| 8 | SEEPZ | 20 | Kherwadi |
| 9 | Chandavali | 21 | Western Express Highway |
| 10 | Airport | 22 | Matunga |
| 11 | Sakinaka | 23 | Mahim |
| 12 | Vakola | | |

Catchment area = 7839 Ha
Population covered = 2.60 Mn



Socio-economic data

Population	11.9 million as per 2001 census 1.2% of total Indian population and 12% of Maharashtra State population
Literacy rate	82.4% (national average is 65.38%)
Employment	3.43 lakhs (0.343 million) main workers and two-third in service sectors Jobs in manufacturing sectors are on a declining trend
Education	42 students per teacher at primary school level 35 students per teacher in secondary/higher secondary school level
Transport	2,145 local train services per day, 2,275 million passengers per day by local trains, 4.3 million passengers per day by BEST (Municipal road transport system)
Air traffic	25% of domestic and 38% of international passenger in India 26% of domestic and 40% international cargo in India

Source: Yedla, 2006

AWSRG locations

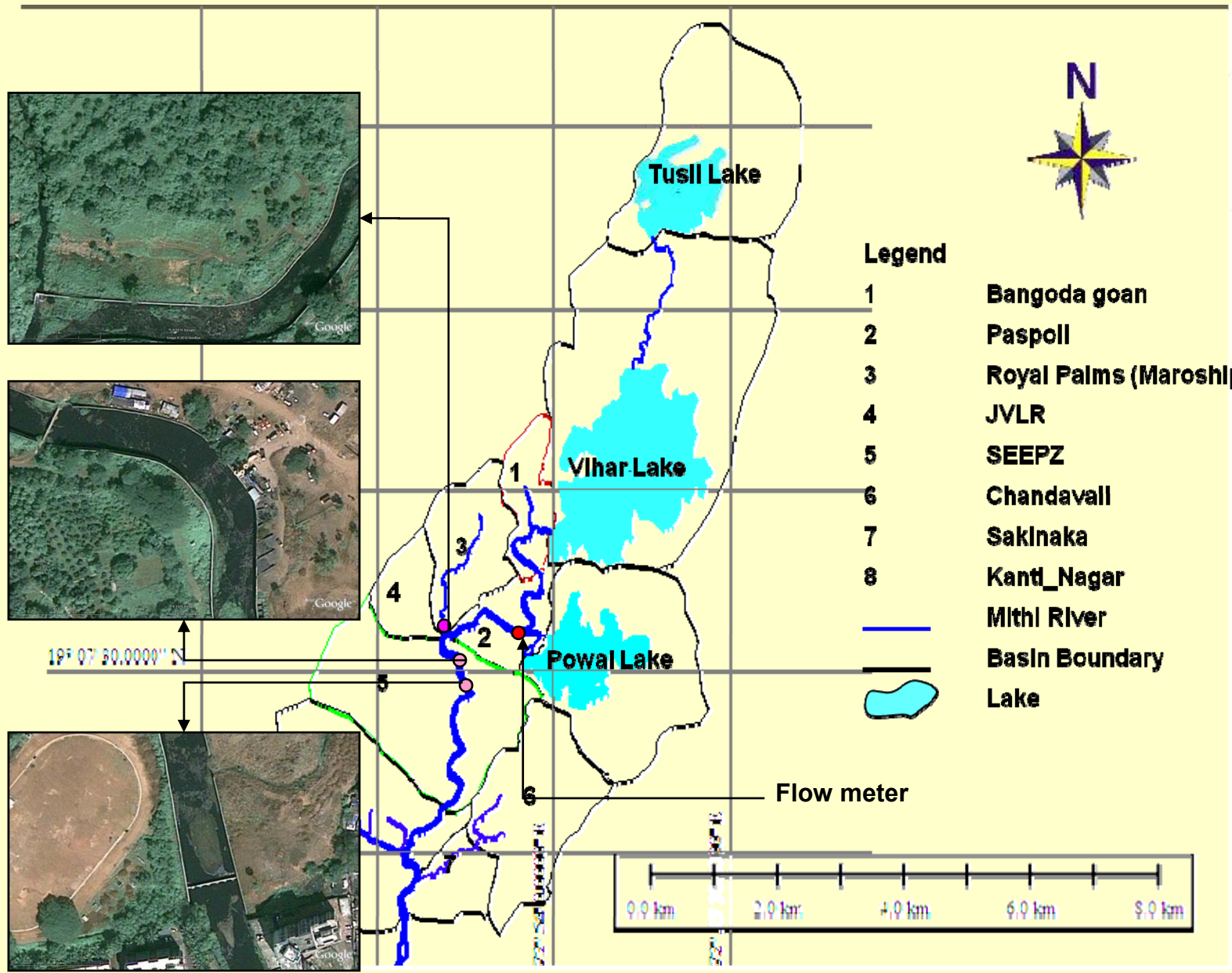


- ❑ Rainfall data collected daily by 2 Symond's rain gauges before 26th July 2005 flood
- ❑ 30 rain gauges installed since June 2006
 - ❑ average rain gauge density: 1 per 12.5 km²

- Symond's rain gauge
- Tipping bucket rain gauge

Data

- **Flow measurements**
 - **Ultrasonic level gauge**
- **Flood observations**
 - **One at Krantinagar bridge**
- **Insurance**
 - **Nil**
- **Difficulties in obtaining the data**
- **Confidentiality issues**
 - **Non availability of contour data**



Flood management strategies

- **Historical development**
 - Installation of 30 automatic tipping bucket rain gauges
- **Current strategies**
 - Development of rainfall forecast model
- **Adaptation to climate change**
 - Separate committee has been set by Government
- **Barriers for implementation**
 - Present institutional structure
- **Vision for the future**
 - Flood resilient Mumbai

Spatial scales

- Possibilities for looking at the city as a whole
 - ???
- Homogeneity of data across the city
 - Not homogeneous
- Areas that have been studied in more detail
 - Only one sub catchment
- Recommendations
 - Common methodology may be applied to all cities
 - Criteria: area?, population?, population density?, flood susceptibility, any other

Workshop in 2010

- Contents
 - issues to be analysed, objectives
- Format
 - presentations, discussion groups, ...
- Participation
 - local stakeholders, CORFU team members, ...
- Lead organiser
- Venue
- Possible dates