

# FLASH FLOOD

- A Resilience approach to Flooding
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# Worldwide rise in flooding

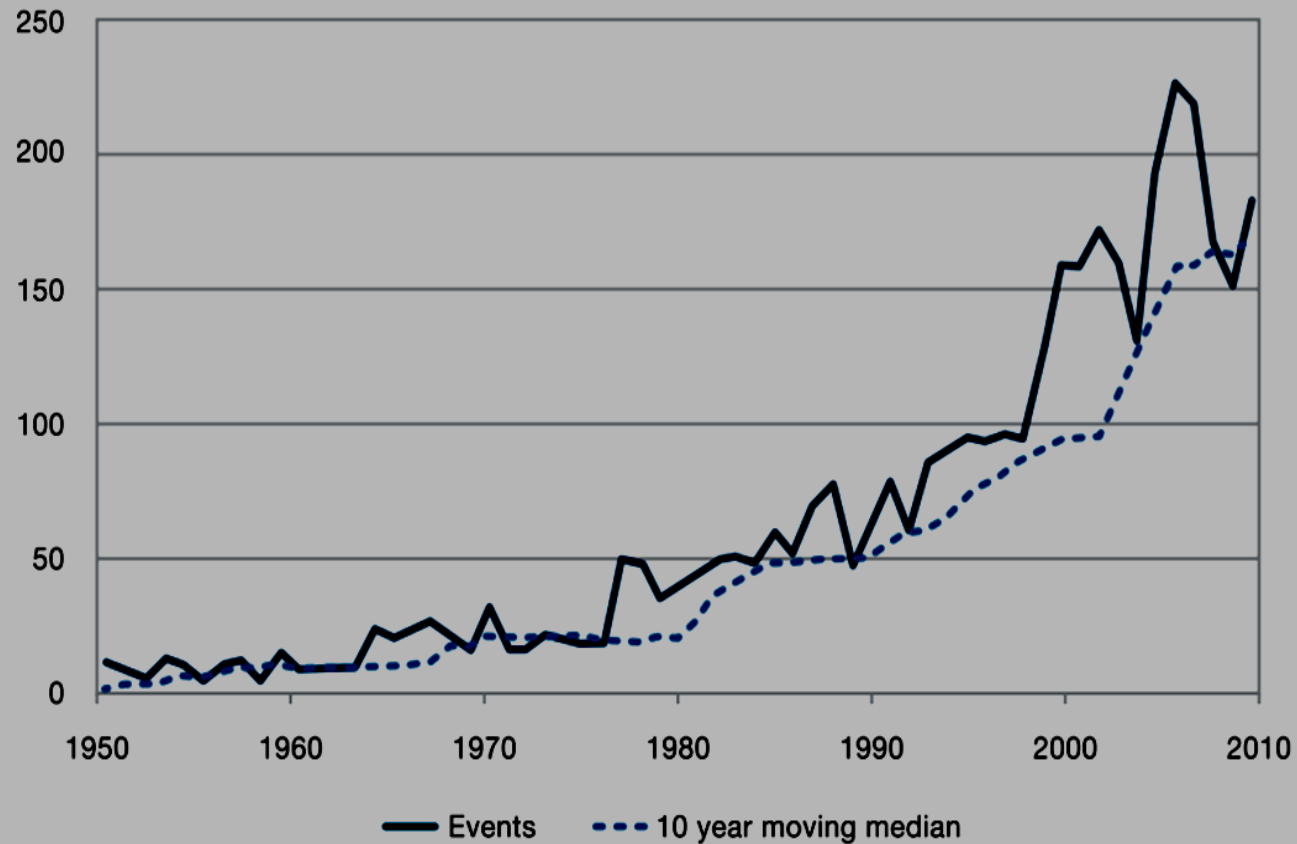


Figure 1: Number of reported flood events. Source: based on EM-DAT/CRED

Average Global  
Damage per year **9**  
**billion US Dollar**

**Third largest Natural  
Disaster** after **storm**  
and **earthquake**

# What is flash flood?

- Excessive rainfall in short period
- Flood develops suddenly



# Flash flooding and flooding differences


- Little time is left for issuing warning: minutes to hours
- Little time to prepare, protect and run



# Range of impacts

- Hundreds of kilometers downstream



A photograph showing a severe flash flood on a city street. The water is murky and deep, reaching up to the windows of a white van and a colorful, decorated bus. Several people are wading through the water, some pushing carts. In the background, more vehicles and people are visible on the flooded street. The scene is chaotic and depicts the impact of a sudden flood event.

## Flash flood accounts for

- 85% of the flooding cases

# Flash flood

- Kills 5,000 people annually
- Highest mortality rate





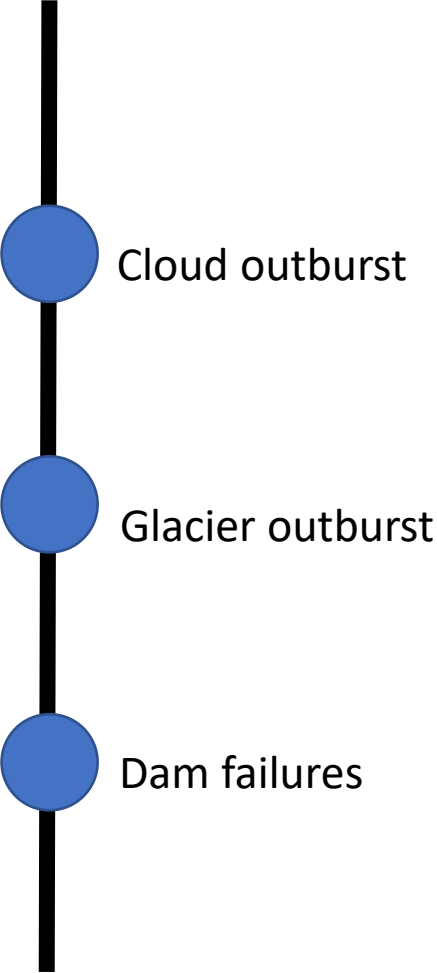




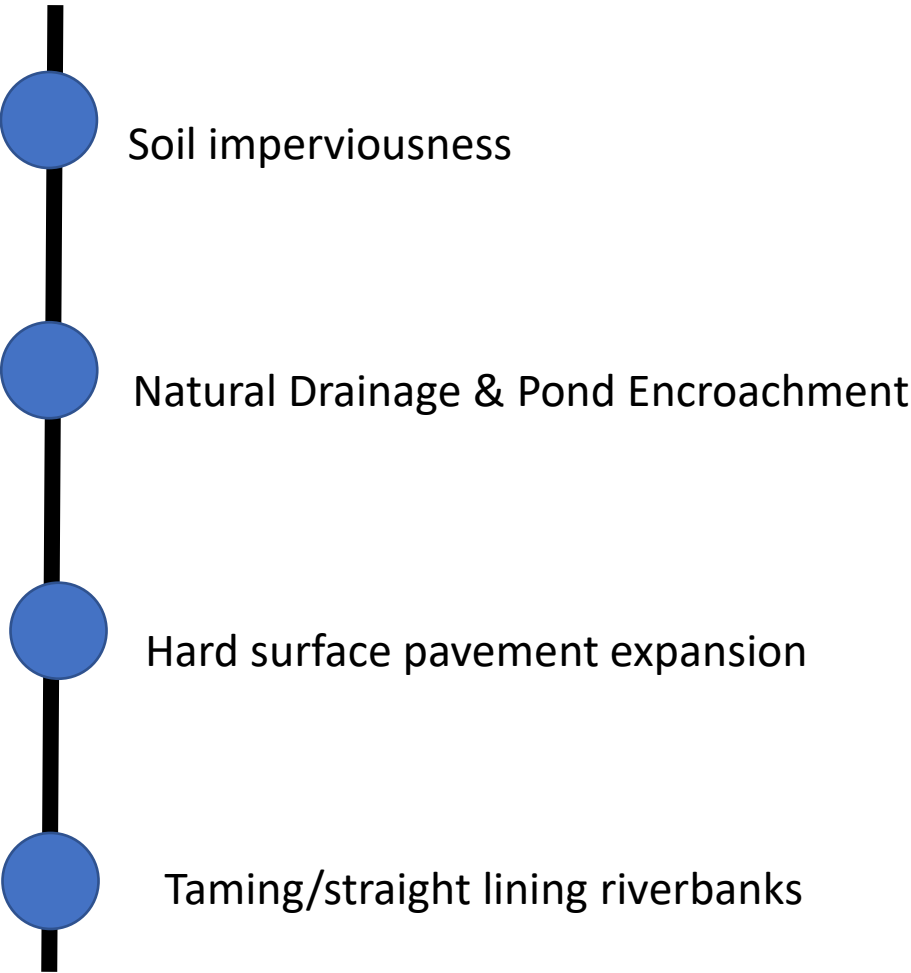


What  
causes  
Flash  
flood?

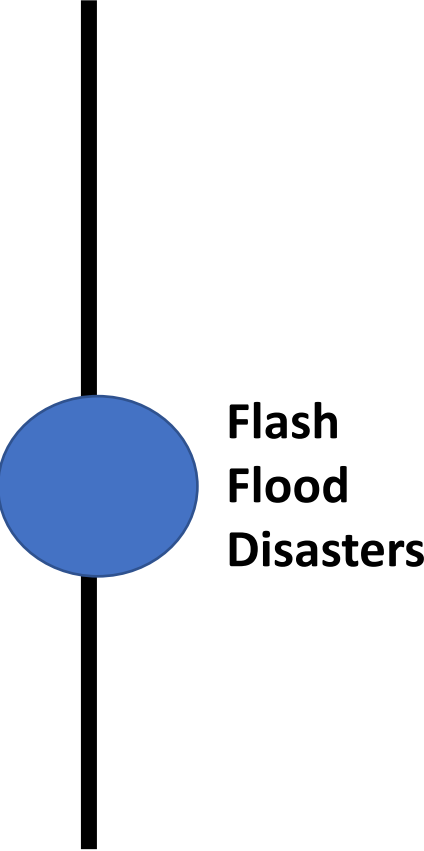
### Flash Flood Triggers



### Flash Flood Accelerators



### Flash Flood Impacts





# Flash Flood Triggers

# Cloud outburst

- Rainfall rate=> 100 mm per hour
- Heavy rain in the catchment area



One day in September 2021 the rainfall was 122 mm in 4 hours ) (2AM-6AM) Am the rainfall is the above the 12-hour average rainfall

<https://ekantipur.com/opinion/2021/09/16/1631797283974446.html>

[https://www.jagranjosh.com/general-knowledge/what-is-cloudburst-and-how-cloudburst-different-from-normal-rainfall-1507120587-1#:~:text=It%20is%20an%20extreme%20amount,\(4.94%20inches\)%20per%20hour.](https://www.jagranjosh.com/general-knowledge/what-is-cloudburst-and-how-cloudburst-different-from-normal-rainfall-1507120587-1#:~:text=It%20is%20an%20extreme%20amount,(4.94%20inches)%20per%20hour.)

# Glacier outburst







- 1. Precedent snow cover
- Heavy rain
- Snowmelt



- 2. Glacial lake drainage
- glacial deposit erosion



- 3. Old landslide
- Congestion of flow, overtopping,
- erosion dam toe cutting & collapse



- 4. New landslide
- Damming, overtopping, erosion
- dam toe cutting & collapse



- 5. River bank erosion and deposition
- on river channel
- Sediment deposition and filling up
- of Melamchi water supply intake



- 6. Debris deposition and
- inundation

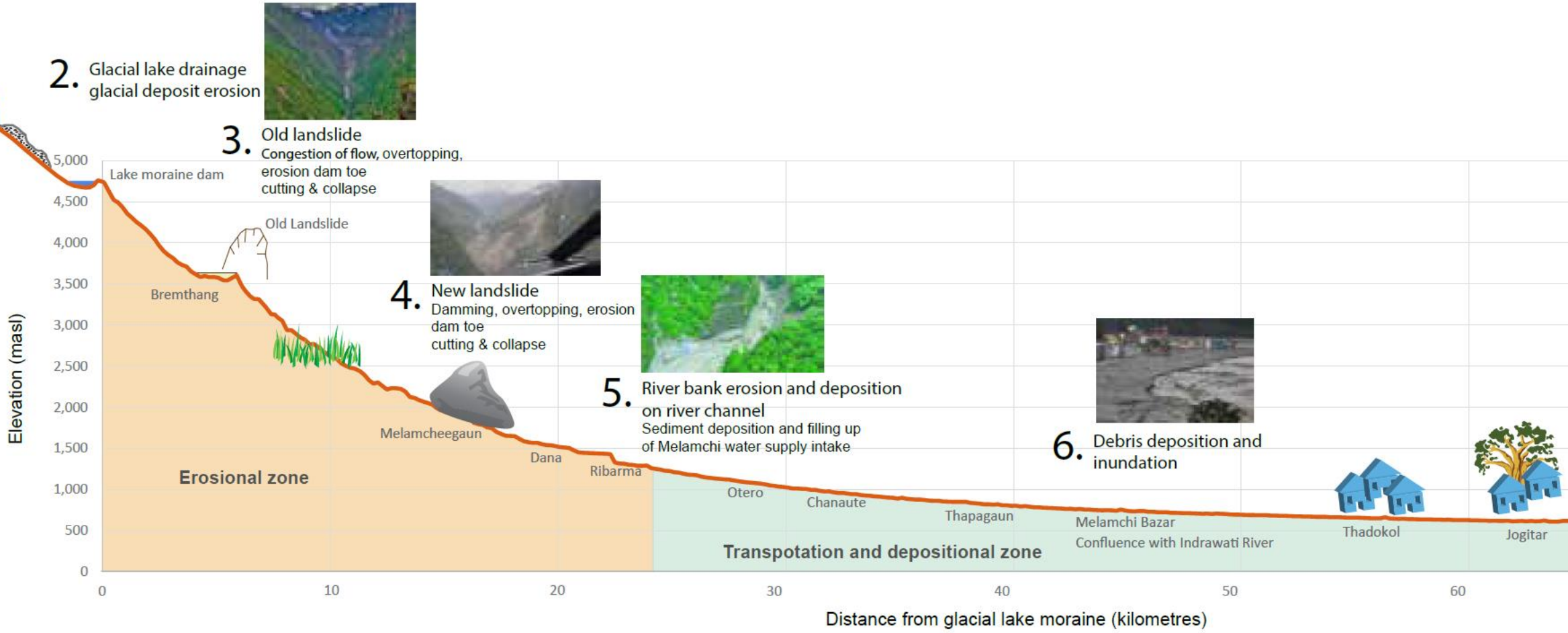


Figure 1: Longitudinal profile of the Melamchi-Indrawati River showing various processes leading to the disaster









# Damages due to Glacier outburst flashflood





# Dam or Levee Failure





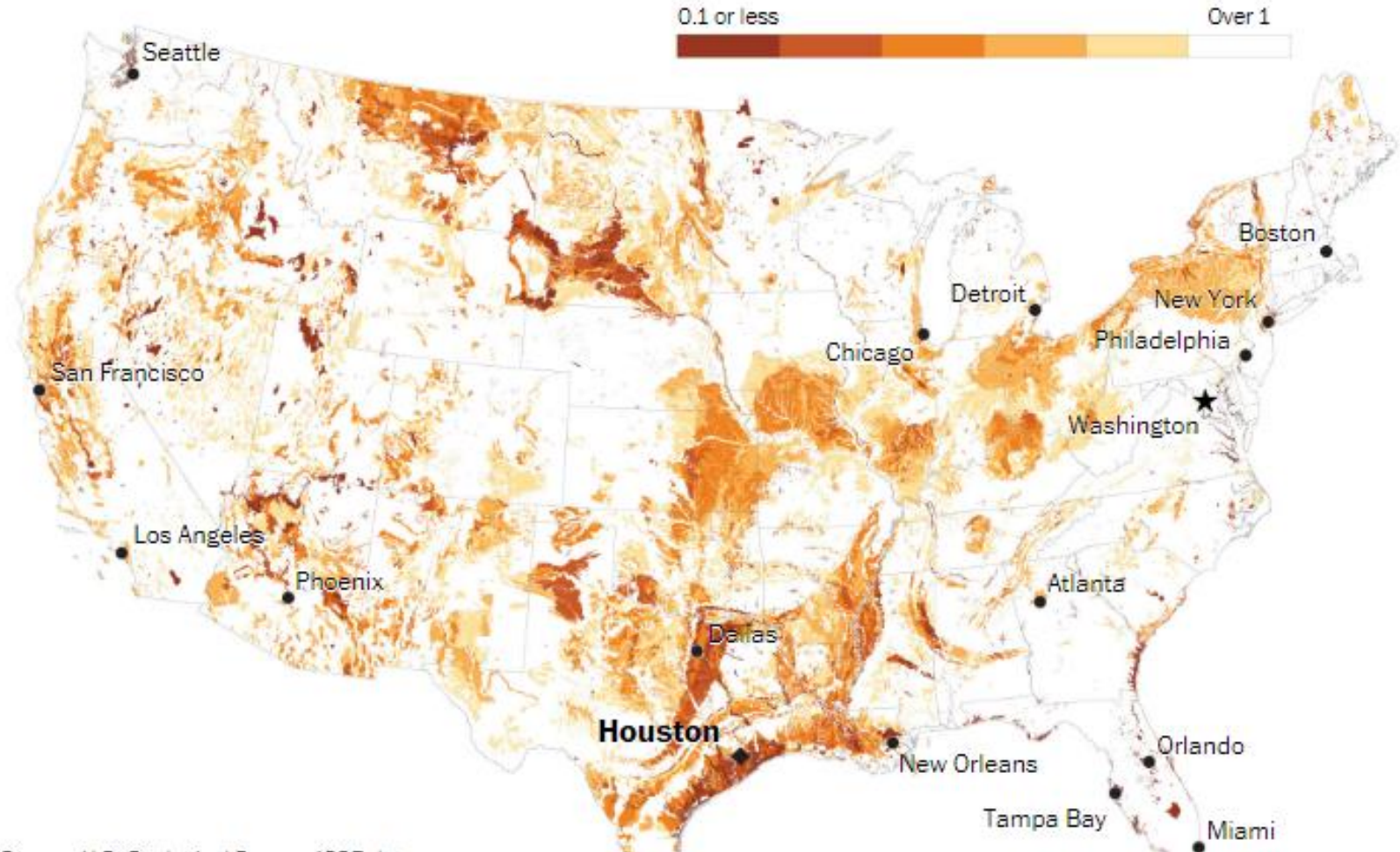
# Flash Flood Accelerators: City vulnerabilities



# Soil Permeability

## HOUSTON IS ON SOME OF THE NATION'S LEAST ABSORBENT SOIL

Permeability rating of underlying soil



Source: U.S. Geological Survey, 1995 data

[https://www.washingtonpost.com/graphics/2017/investigations/harvey-urban-planning/?dti=1036653513061197&fref=gc&utm\\_term=.83eb81399fe0](https://www.washingtonpost.com/graphics/2017/investigations/harvey-urban-planning/?dti=1036653513061197&fref=gc&utm_term=.83eb81399fe0)



# Natural Drainage Encroachment



<https://annapurnapost.com/news/186637>



# Pond and wetland destruction





# Expansion of impermeable surfaces in cities

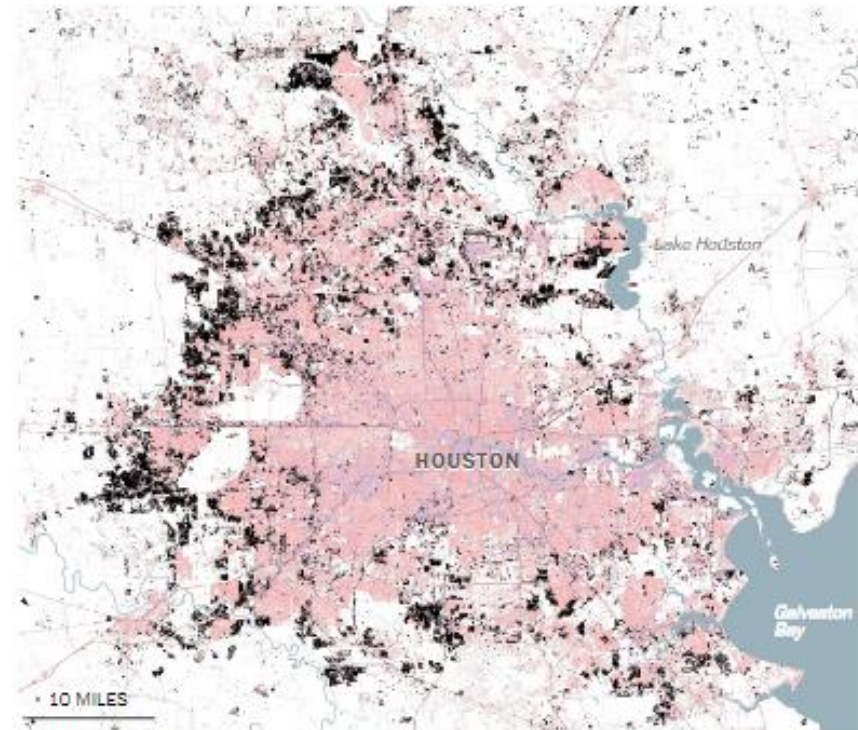
- Urbanization increases runoff by 2 to 6 times over



## THE EDGE OF HOUSTON HAS ADDED A LOT OF CONCRETE

Developed impermeable surfaces in greater Houston

Impermeable surfaces ■ As of 2011 ■ Added between 1996 and 2010



Sources: NOAA, U.S. Geological Survey

Taming the  
meandering nature  
of rivers





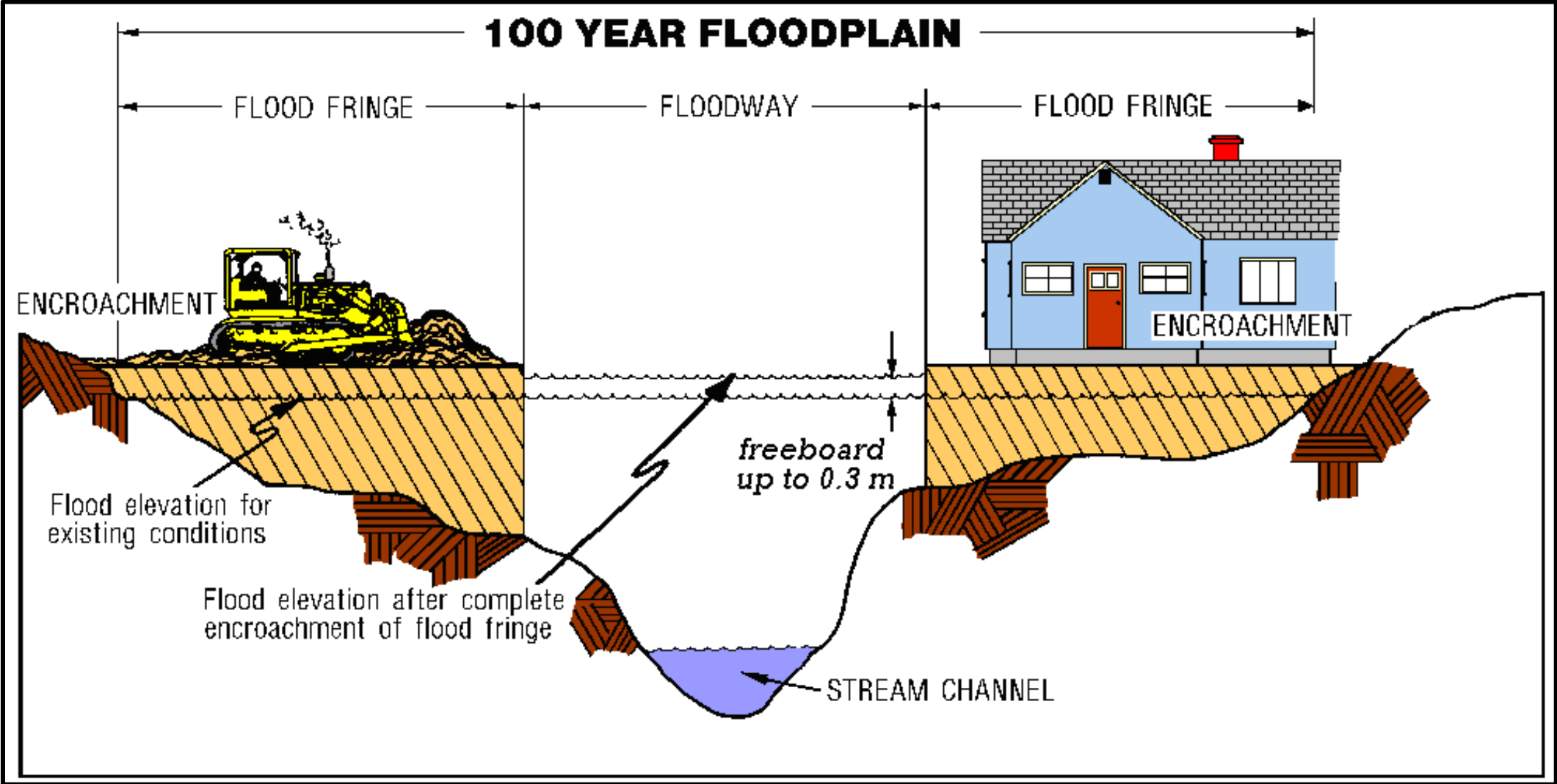
# Concretizing the natural drainage flow



shutterstock.com • 1835864662



# RIVER-BANK ENCROACHMENT



# Flash Flood Impacts

An aerial photograph capturing a catastrophic event in a mountainous region. A colossal wall of muddy, brown floodwater is seen cascading down a steep, rocky valley. The water's force is immense, creating a thick mist of spray and debris as it moves. In the foreground, a small cluster of buildings with dark roofs is partially submerged or surrounded by the flood. To the right, a dirt road winds through the valley, where several people are visible, some appearing to be in a state of panic or seeking refuge. The surrounding terrain is rugged and rocky, with sparse vegetation. The overall scene conveys a sense of overwhelming natural power and the vulnerability of human settlements in such environments.

<https://weather.com/en-IN/india/news/news/2021-02-07-glacier-burst-triggers-massive-flood-in-uttarakhand-150-labourers-feared>







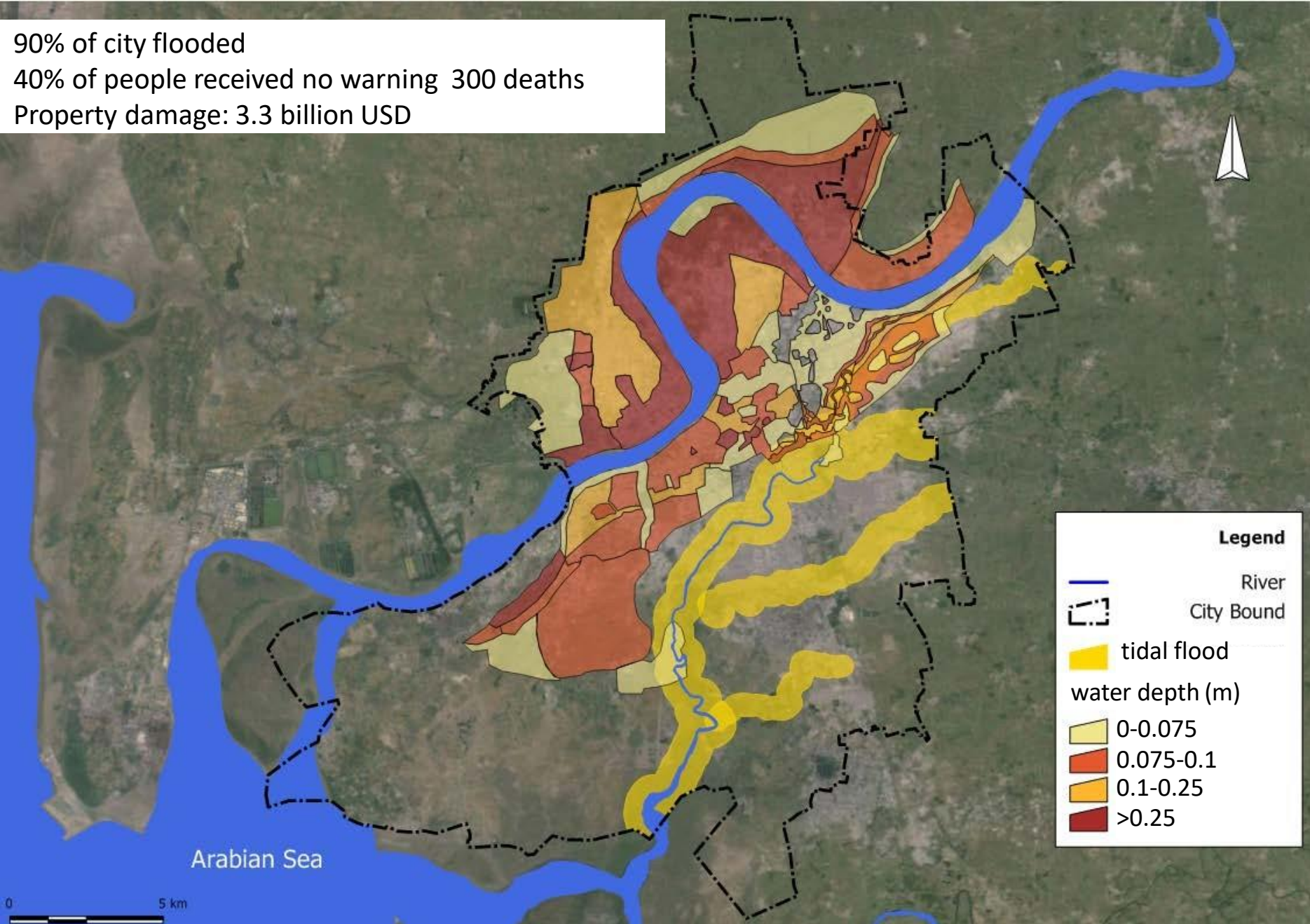
# FLOOD OCCURANCE IN INDIA






# IMPACTS OF FLOOD IN SURAT

90% of city flooded  
40% of people received no warning 300 deaths  
Property damage: 3.3 billion USD





What can be done about  
this?

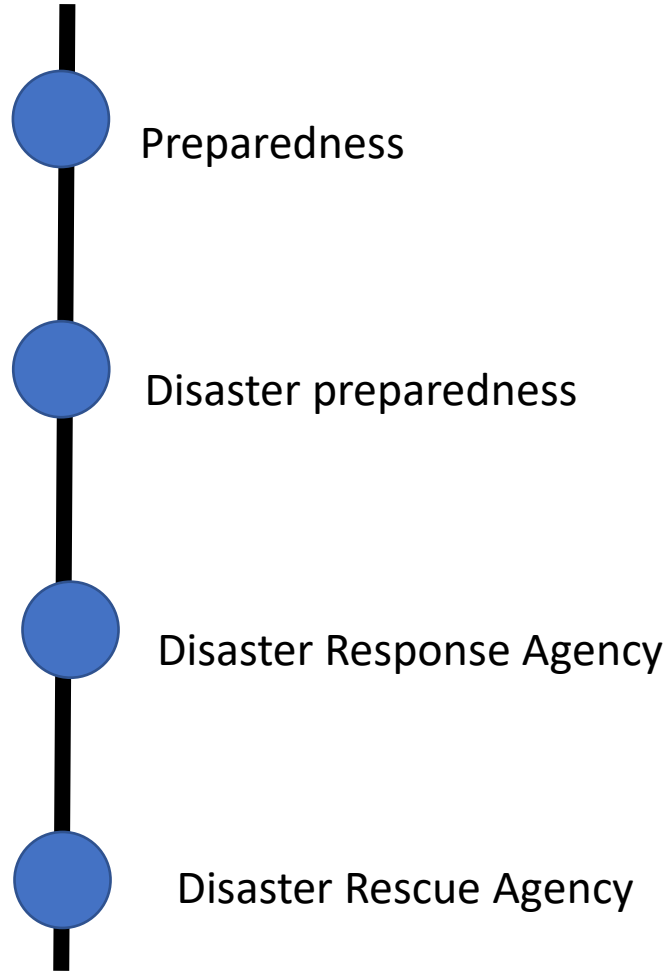


# Available time for planning for flooding

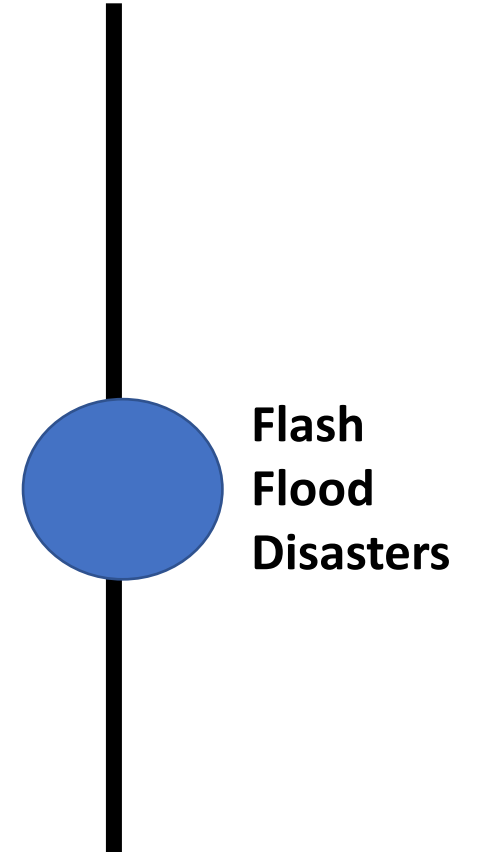
20 years



1 Year time



10 to 30 minutes



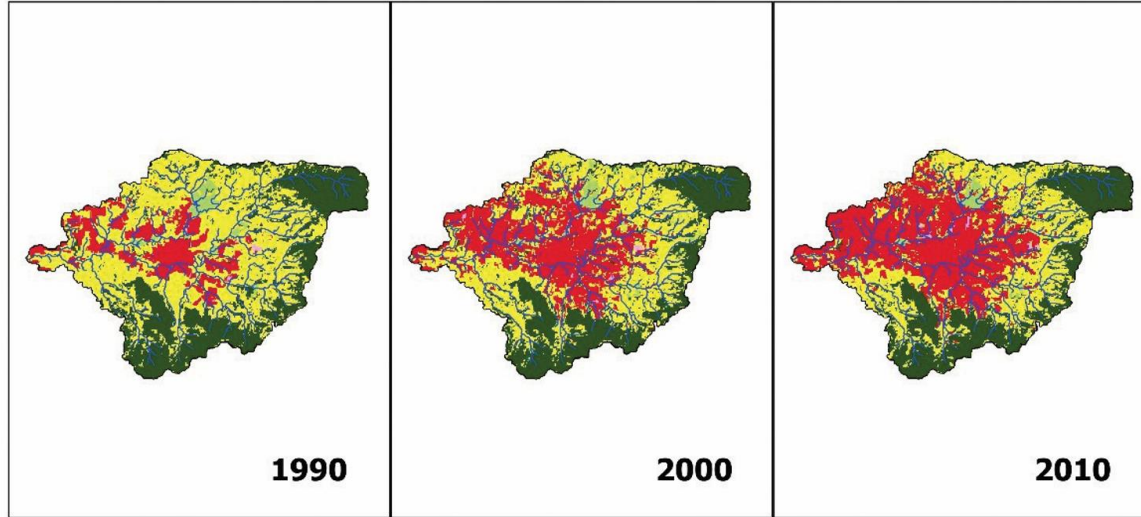




1991: KVUDPP

2002: KV 2020

2015: KV Masterplan (2020-035)



Before 2001:  
Average 1-day rainfall 80mm

After 2001:  
Average 1-day rainfall  
100mm

**Legend**

- |                  |   |  |   |
|------------------|---|--|---|
| Land Use Classes | <span style="color: green;">■</span> Shrubland      | <span style="color: yellow;">■</span> Agriculture Land | <span style="color: blue;">■</span> Water Bodies  |
|                  | <span style="color: lightgreen;">■</span> Grassland | <span style="color: pink;">■</span> Barren Land        | <span style="color: red;">■</span> Developed Area |
|                  | <span style="color: darkgreen;">■</span> Forest     |  |   |

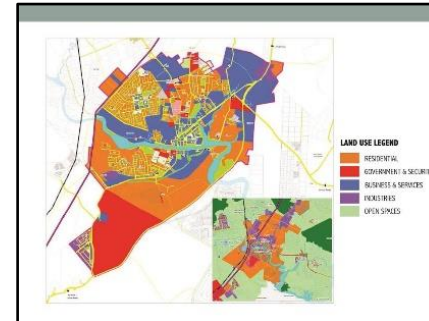
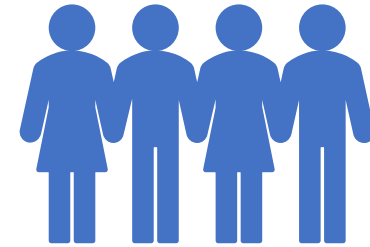


1990: 260mm (Average 1-day)



# Resilience at three levels

- Individual resilience
- Institutional resilience
- Regulatory resilience





# Individual Resilience



# Individual Resilience





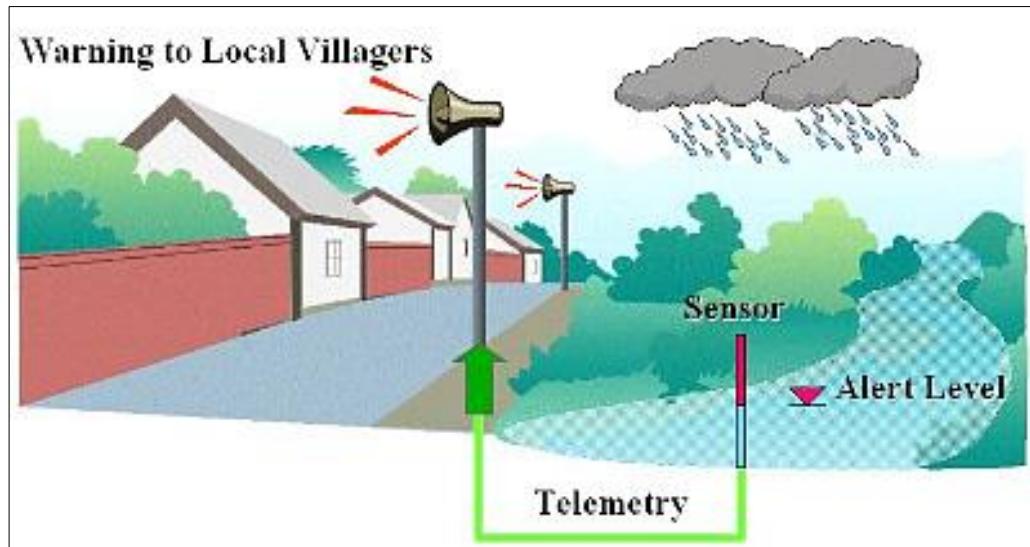
# Individual Resilience: Swimming and Boating



# Institutional Resilience



# Institutional resilience



# Institutional resilience





# Institutional resilience



**Humanity, Not Everyone Has It!**





# Institutional resilience





# Institutional resilience

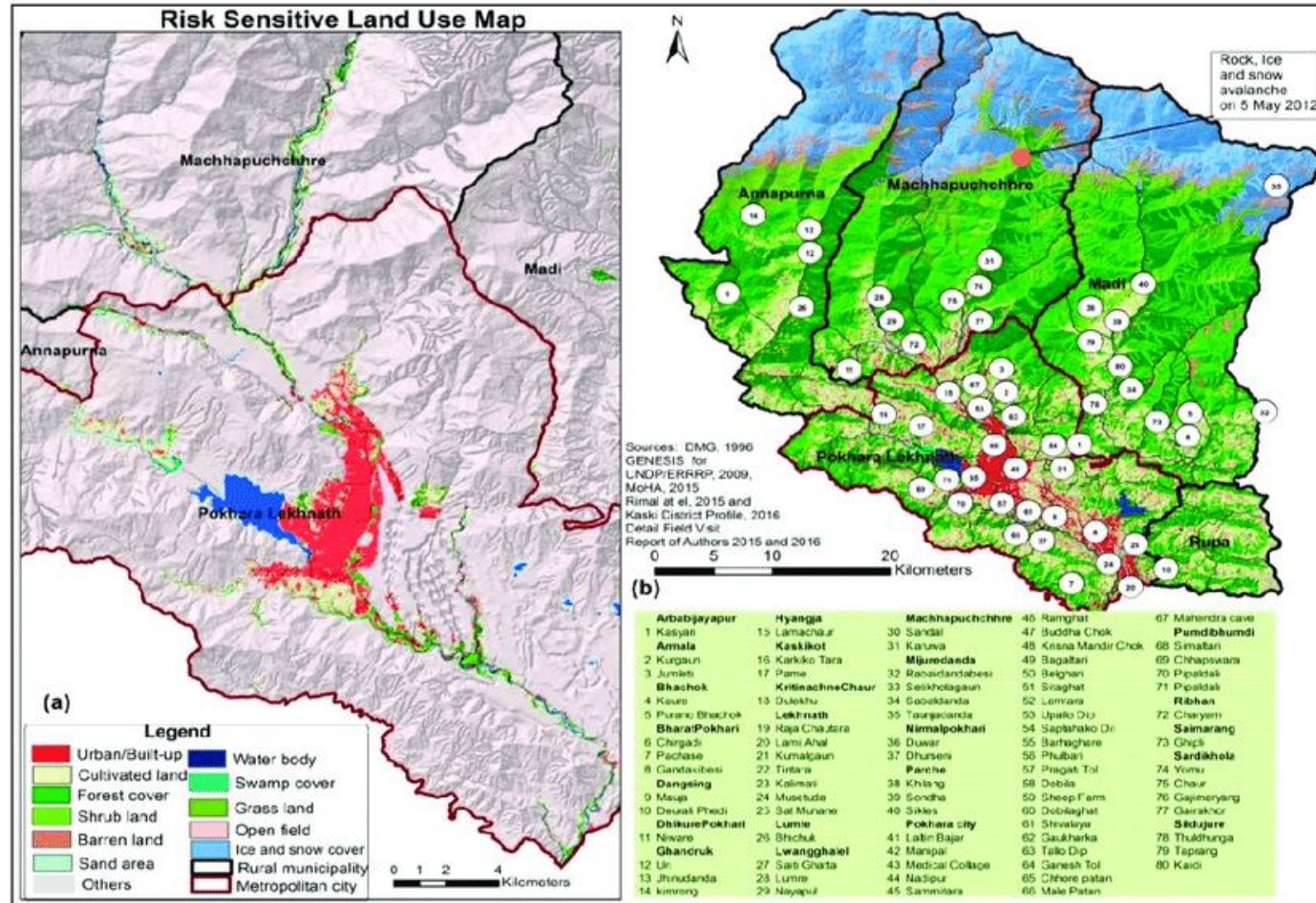
## Local Level Residential Consultation and Preparation



# Regulatory Resilience



# Regulatory Resilience: Zoning vulnerabilities







# Regulatory Resilience: Building Bylaws





# Regulatory Resilience: Pond Protection

# Conclusions

## **Nature and causes**

- Flash flood emerges suddenly
- Leaves no time to prepare
- Outcome of past 20 year's planning failures
- Inaction and negligence

## **Actions that needs to be taken**

- Individual resilience
- Institutional resilience
- Regulatory resilience