



**Module A5 – Session 3**

# **Use of Geospatial Information Technology for Disaster Risk Management**

Organized by,

**United Nations International Children's Emergency Fund (UNICEF), Indonesia**

**unicef**  | for every child

***Jakarta, Indonesia  
18 October 2019***



# HAZARD

A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.



# Scenario 1 Mega Earthquake near a City

Likely to result in huge devastation as the origin of the earthquake is very near the densely populated city



Click to Generate  
Earthquake



# Scenario 2 Mega Earthquake in a Desert

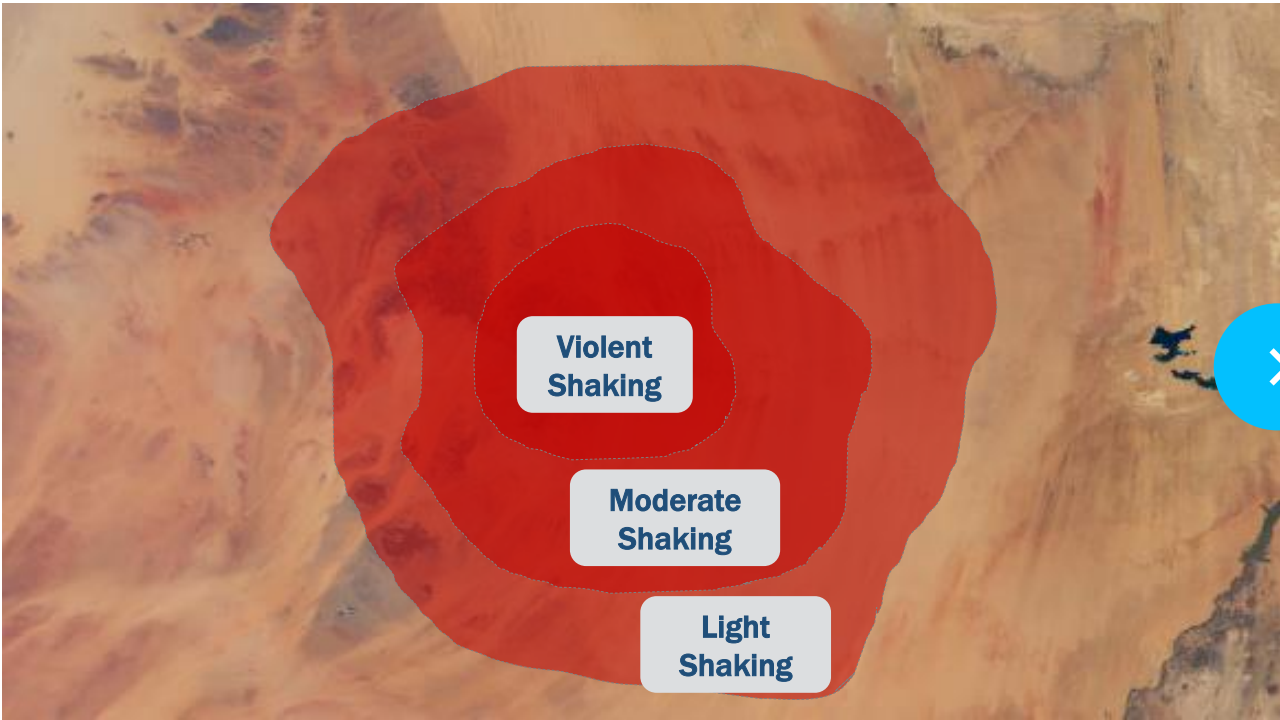
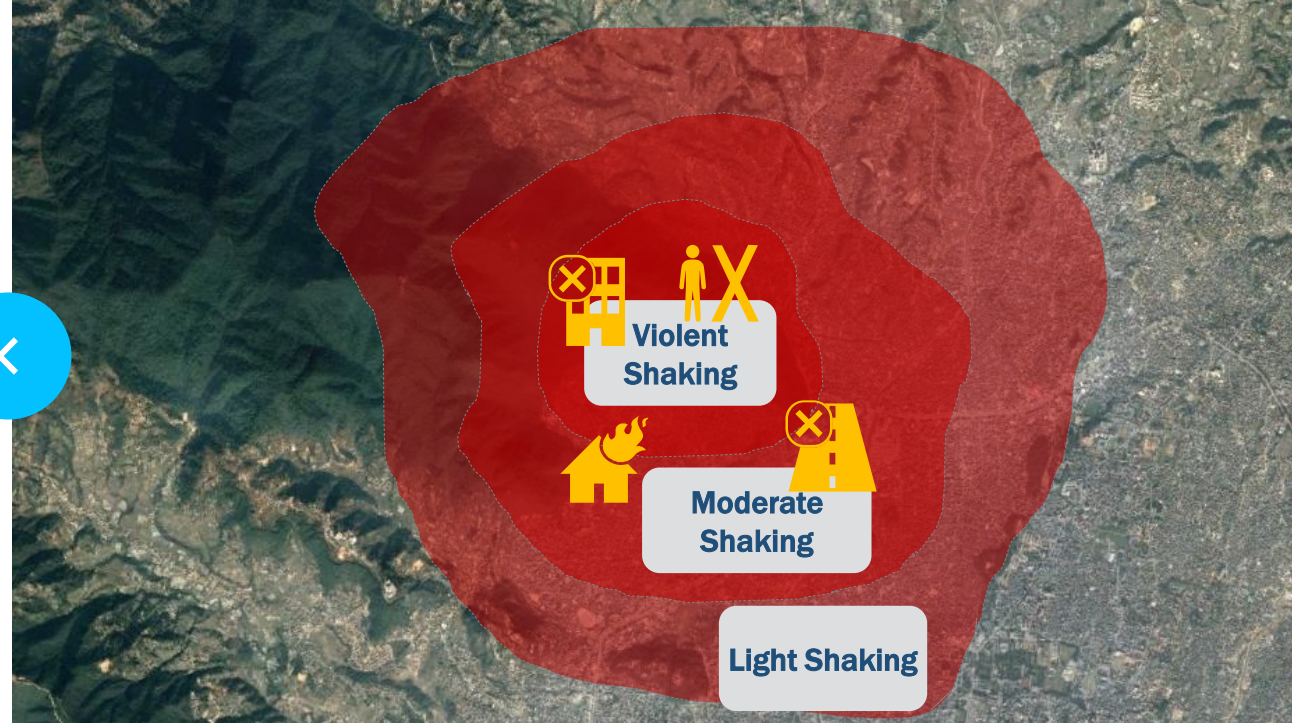
May not cause any considerable damage as no settlements are near the earthquake strong earthquake shaking areas.



Image Courtesy: USGS

# Scenario 1 Mega Earthquake near a City

Likely to result in huge devastation as the origin of the earthquake is very near the densely populated city



# Scenario 2 Mega Earthquake in a Desert

May not cause any considerable damage as no settlements are near the earthquake strong earthquake shaking areas.

Image Courtesy: USGS



# Vulnerability

The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

*Image Courtesy: UrbanPeek*



1

**Destroyed**

2

**Moderate Damage**

## **Hazard Same! Damage Different! Why??**

Both houses are subjected to same hazard, but one got destroyed, another experienced moderate damage.

- Gorkha Earthquake, 2015

*Image Courtesy: CBC*

# Exposure

The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.

*Image Courtesy: BBC Magazine*



# Same Type of Houses Suffer Different Damage Depending on its location

Different assets in the illustration experiences different flood water depth just due to their location. With higher water depth, houses will experience more content and structural damage

Animate  
Flood



# Same Type of Houses Suffer Different Damage Depending on its location

Different assets in the illustration experiences different flood water depth just due to their location. With higher water depth, houses will experience more content and structural damage



# Disaster Risk

The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.



# Disaster risk reduction

Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.



Reduce Vulnerability & Exposure

# Disaster risk reduction

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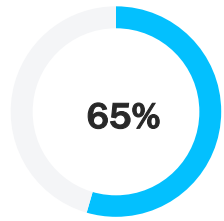
# UNDERSTANDING RISK



# Understanding Disaster Risk






# Understanding Disaster Risk Geospatially





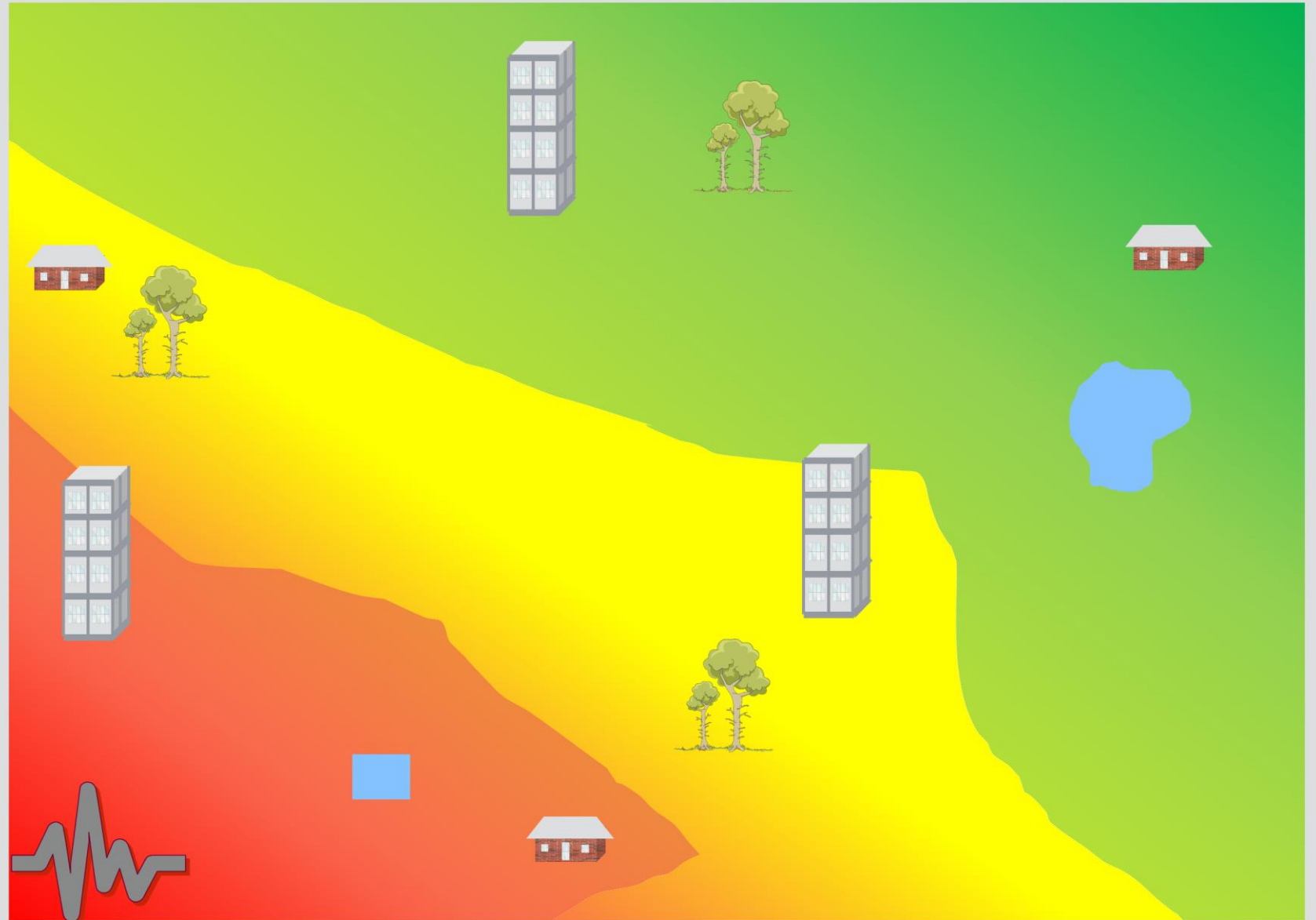
Risk Meter

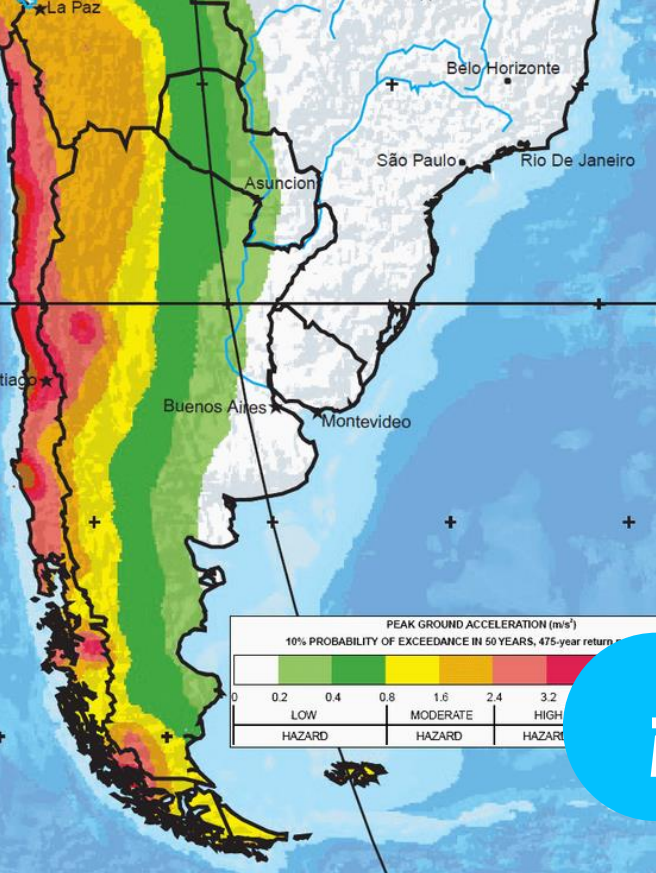
## Hazard Levels

	<b>Violent Shaking</b>	<b>IX</b>
	<b>Strong Shaking</b>	<b>VI</b>
	<b>Light Shaking</b>	<b>IV</b>

## Vulnerability

	<b>Concrete Building</b>	<b>Low Vulnerability</b>
	<b>Brick Building</b>	<b>High Vulnerability</b>





# Hazard Assessment

Hazard models estimate the probability of occurrence of a specific hazard, in a specific future time period, as well as its intensity. Natural hazard models replicate the physics of natural processes, including their propagation through the atmosphere (e.g. windstorm), the Earth's sub-surface (e.g. earthquake) and surface (e.g. flood), or a combination of all three. Hazard is estimated in terms of the occurrence, frequency and intensity of the event(s).

## ***Develop Historical Hazard Catalogue***

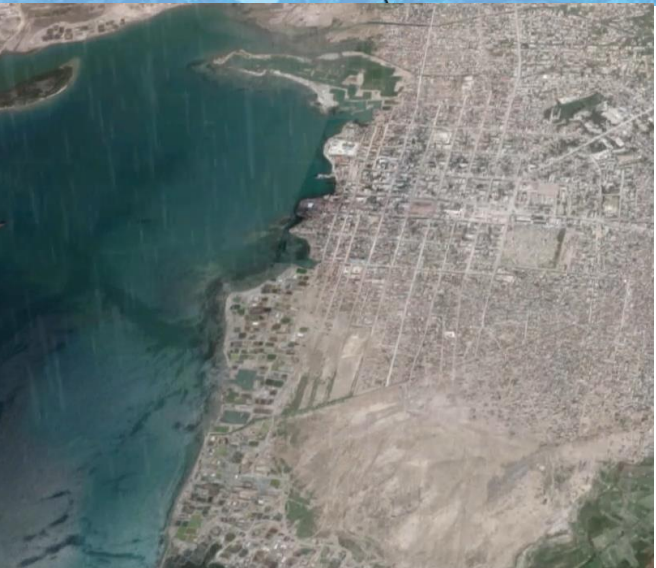
The most essential data define the date, geographical location and extent, and maximum intensity of historical events. A collection of the spatial, intensity, and temporal characteristics for events in an event set is termed a hazard catalogue.

## ***Develop Hazard Model***

Deduct physical mechanism of hazards from historical hazard knowledge and setup computer based simulation model.

## ***Define Probability of Events***

Estimate probability of a hazard level occurring at a location with a specific intensity

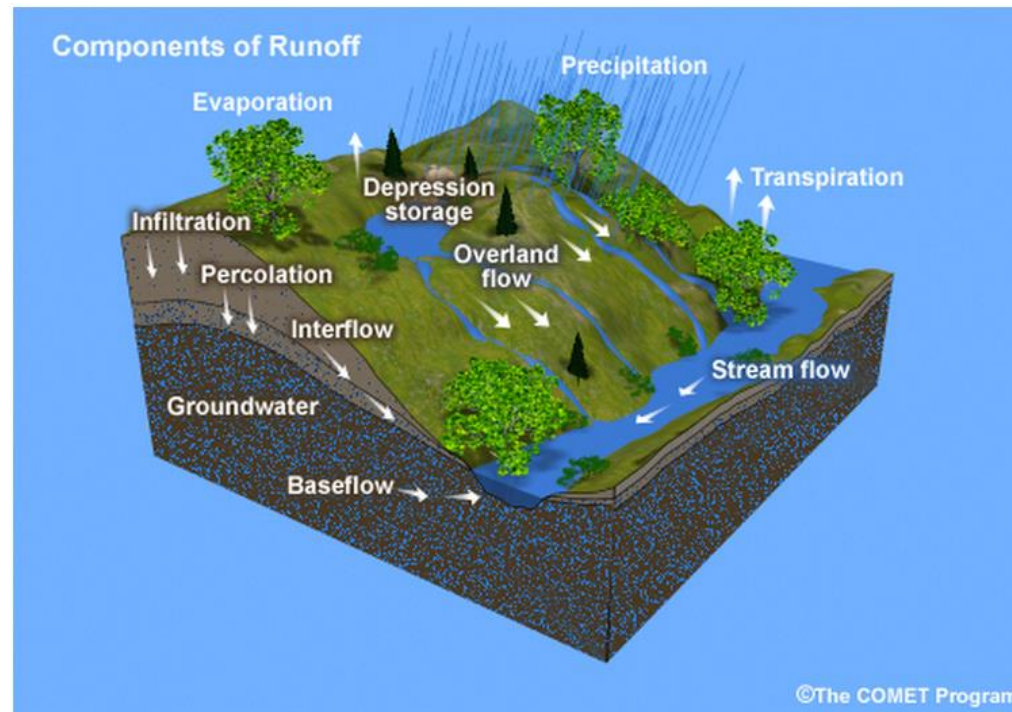


***“Effective disaster risk reduction requires the consideration of not just what has occurred but of what could occur. Most disasters that could happen have not yet happened” - UNISDR, 2013.***

# Example: Flood Hazard Modeling

Depends on how water moves over/through landscape:

- ❑ Terrain
- ❑ Characteristics of land/environment/soil



# Challenge1: Hydrologic Modeling

78	72	69	71	58	49
74	67	56	49	46	50
69	53	44	37	38	48
64	58	55	22	31	24
68	61	47	21	16	19
74	53	34	12	11	12

Elevation surface

## Flow direction

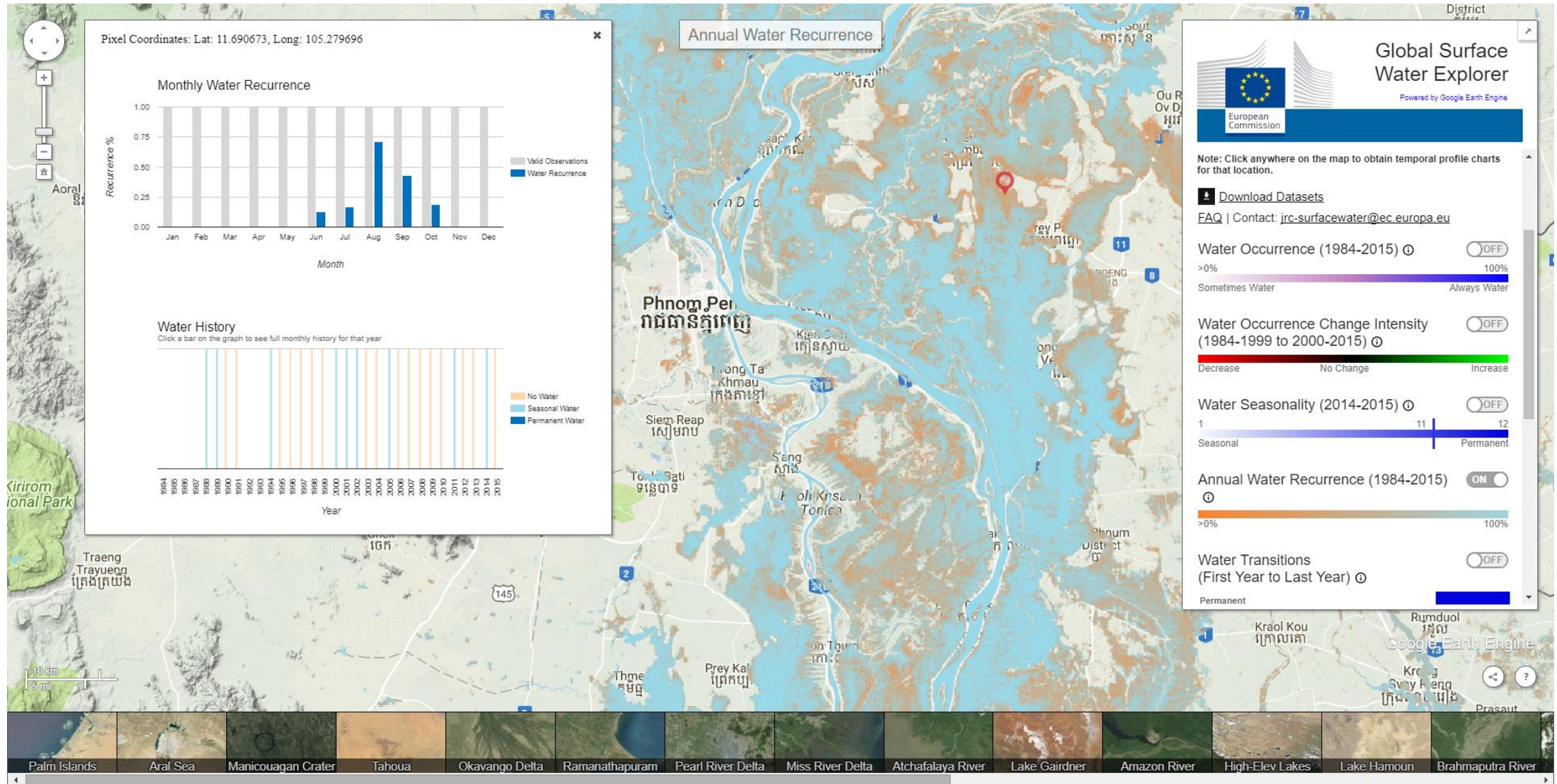
Direction from each cell to its steepest downslope neighbor

## The Flow Accumulation

Accumulated weight of all cells flowing into each downslope cell in the output raster. If no weight raster is provided, a weight of 1 is applied to each cell, and the value of cells in the output raster is the number of cells that flow into each cell.

1. How a raindrop will flow on this surface elevation?

# Example: Historical Flooding Trend from Earth Observation



**Examples of Rapid Structure Assessment for Buildings**

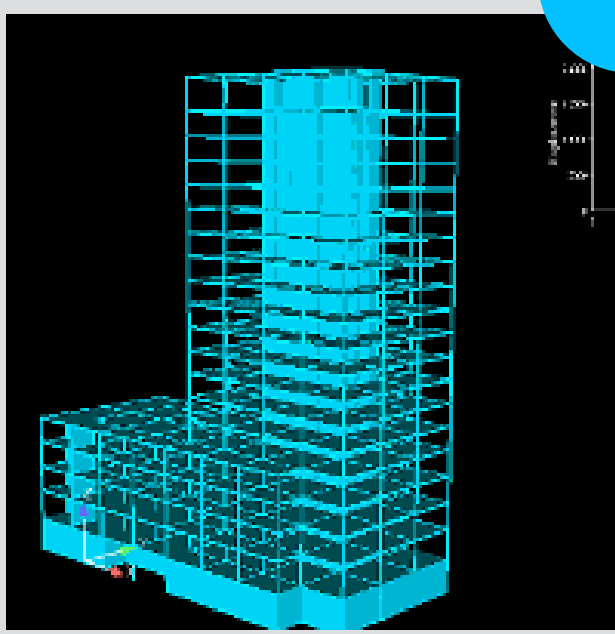
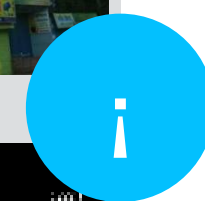
The FEMA 154 Manual (2002), Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, is a quick catalog for rapid visual screening of buildings for potential seismic hazards which has been used in the US and other countries. Other sites have been modified to suit the local conditions and codes of other countries like Canada, and India.

The HRS uses a methodology based on a "walk-through" of a building and a Data Collection Form, which the person conducting the survey completes relative to the observed conditions, based on visual observation of the building from the exterior, and if possible, the interior.

**The FEMA 154 Form\***      **The HRC-Canada Form\*\***

\*Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook (2002), FEMA 154, 2<sup>nd</sup> Edition, By Federal Emergency Management Agency (FEMA), Washington, D.C. 154 pp. <http://www.fema.gov/plan/preload/fema154.pdf>

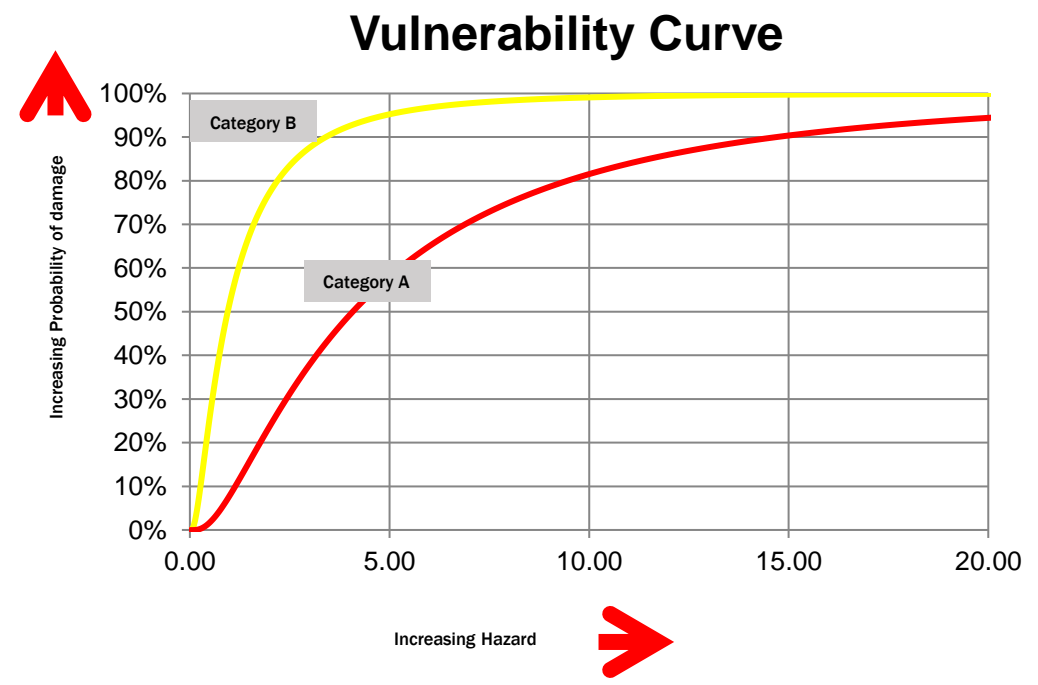
\*\*Manual for Screening of Buildings for Seismic Investigation (1992), National Research Council Canada, 46 pp. <http://www.nrc.ca/other/othermain.html?cat=seismic/othermain.html>



# Vulnerability Assessment

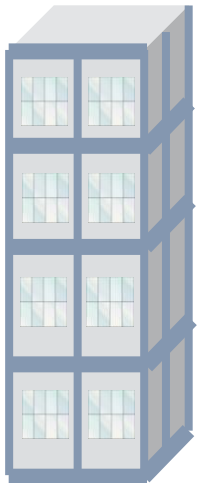
The methodology of developing the relationship between different intensity of hazard and probable damage is defined for different structural, social, economic systems.

- Group Building Construction Styles
- Historical Damage Database
- Computer Based Simulation
- Expert opinion



# Understanding Vulnerability Curves

Vulnerability Curves are developed by defining relationships between a measurement parameter of the hazard (e.g. water depth in case of flooding or the spectral acceleration in the case of earthquakes) to the likely damage of the particular building class.



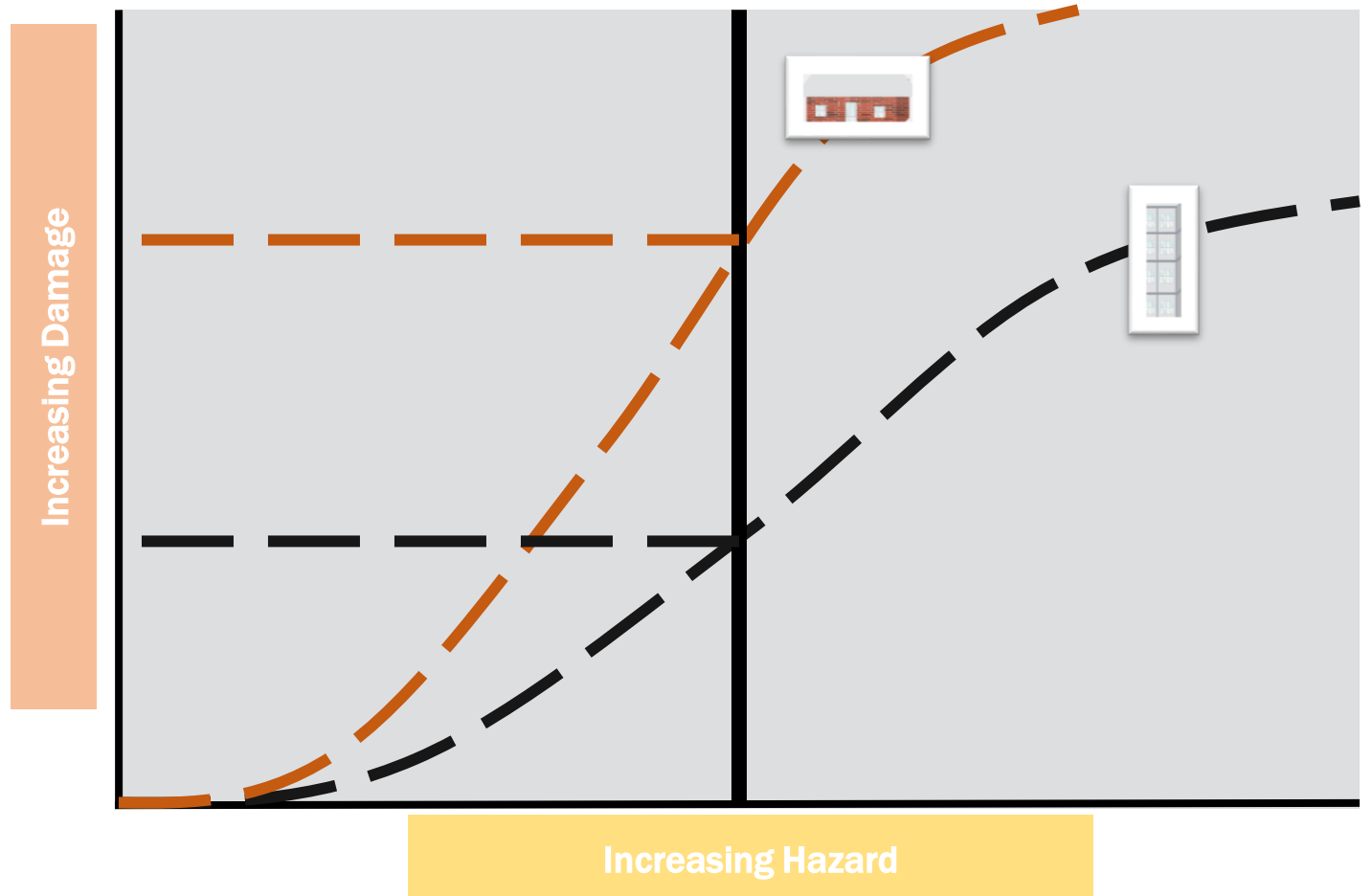
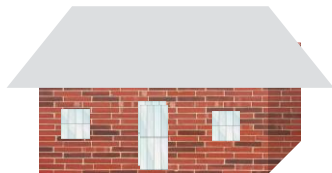
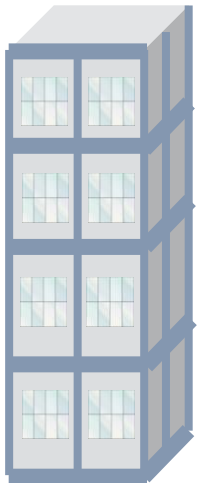
Vulnerability Curve

Increasing Damage

Increasing Hazard

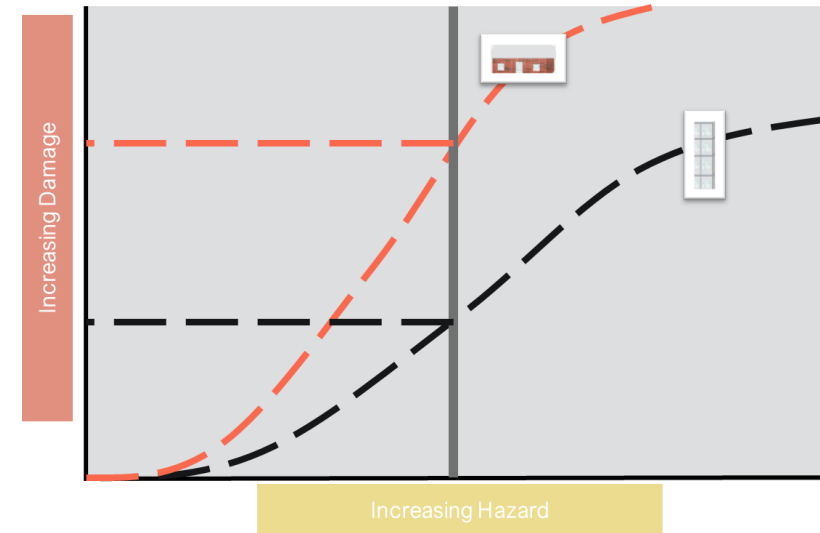
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## Challenge 2 : Flood Vulnerability Assessment from Historical Damage Records

SURVEY ID	BUILDING TYPE	BUILDING OCCUPANY	FLOOD DEPTH (CM)	DAMAGE RATIO
1	BRICK	RESIDENTIAL	138	0.4
2	ADOBE	RESIDENTIAL	129	0.8
3	BRICK	RESIDENTIAL	52	0.1
4	ADOBE	RESIDENTIAL	104	0.6
5	BRICK	RESIDENTIAL	9	0
6	ADOBE	COMMERCIAL	105	0.7
7	BRICK	HOSPITAL	17	0
8	ADOBE	RESIDENTIAL	142	0.9
9	BRICK	INDUSTRIAL	81	0.2
10	BRICK	GOVERNMENT	15	0
11	ADOBE	RESIDENTIAL	99	0.6
12	BRICK	RESIDENTIAL	109	0.3
13	BRICK	RESIDENTIAL	43	0.1
14	BRICK	RESIDENTIAL	125	0.4
15	ADOBE	RESIDENTIAL	127	0.8
16	BRICK	HOSPITAL	6	0
17	BRICK	RESIDENTIAL	5	0
18	ADOBE	SCHOOL	123	0.8
19	BRICK	RESIDENTIAL	45	0.1
20	ADOBE	GOVERNMENT	55	0.3



### 1. Prepare the Vulnerability Curve



# Exposure Assessment

Process of creating a geospatial dataset of people, property, systems. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest.



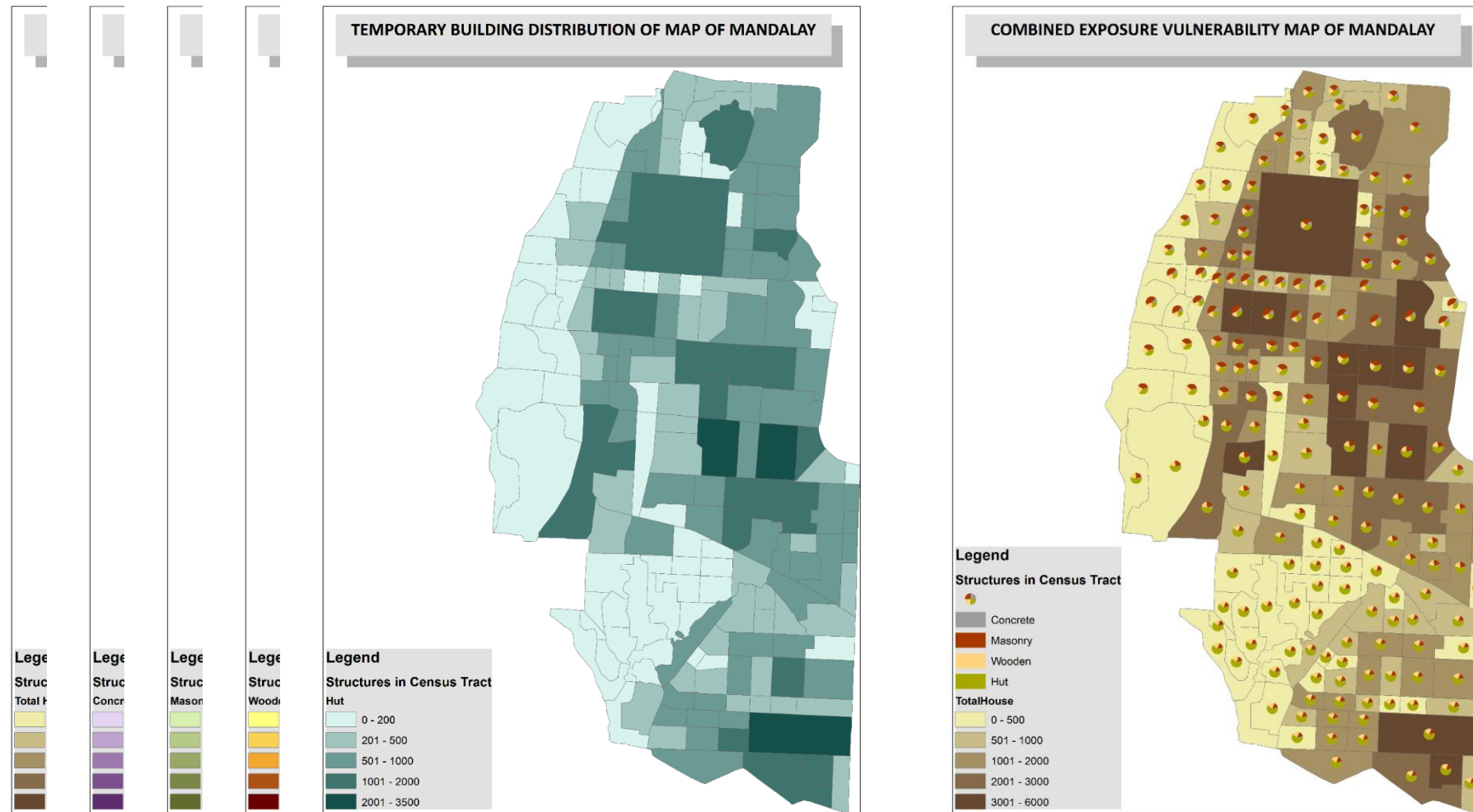
## Vulnerability Category

**Location**

**Cost**

**Human Exposure**

# Exposure Data Aggregated at Admin Block Level: From Housing Census

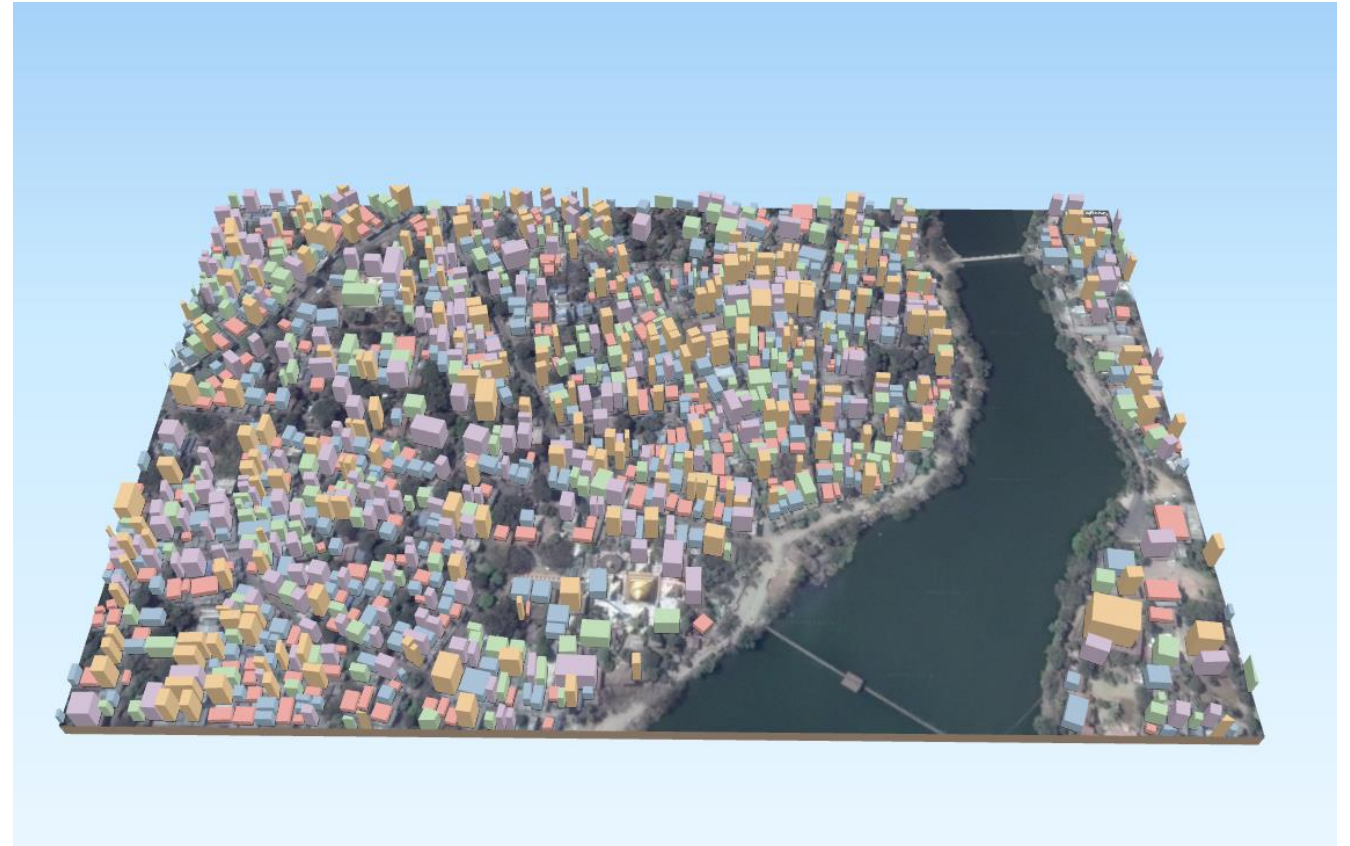


# Application of Remote Sensing and Earth observation for Exposure Data Development

Can be performed using a combination of Earth or Aerial observation and Field Survey.

## Typical Steps Include

1. Acquire High Resolution Satellite Image or UAV Survey
2. Digitization and extraction of elements at risk
3. Collection field data of attributes of each stock



High Resolution  
Satellite Image

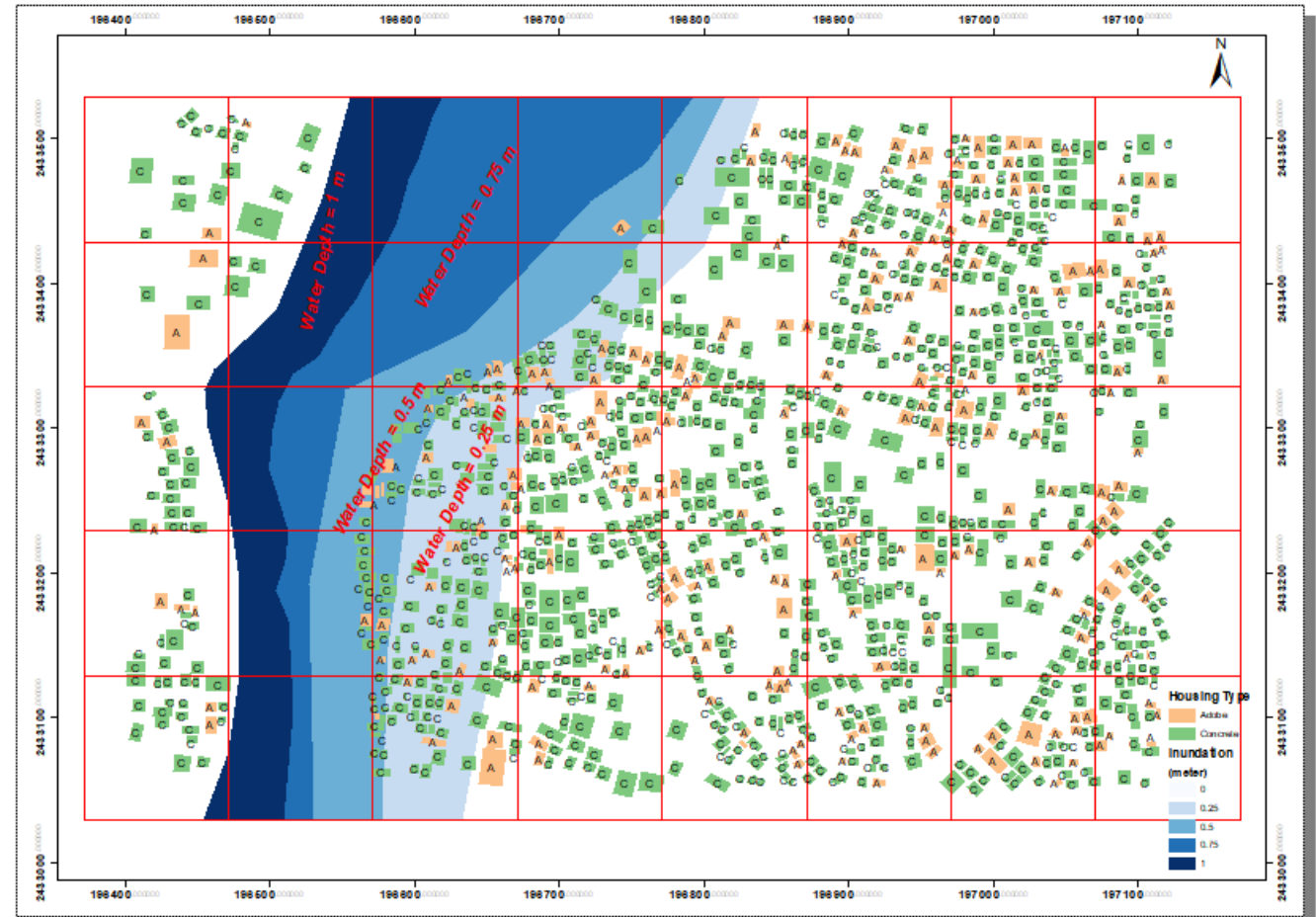
Feature  
Extraction

Field Attribute  
Collection

Final Exposure  
Data in 3D

## Challenge 3 : Exposure Assessment from geospatial data

1. Prepare Exposure Estimates for Each Flood Depth.
2. Can you calculate probable damage?



**REDUCING RISK**



# GI for Mitigation

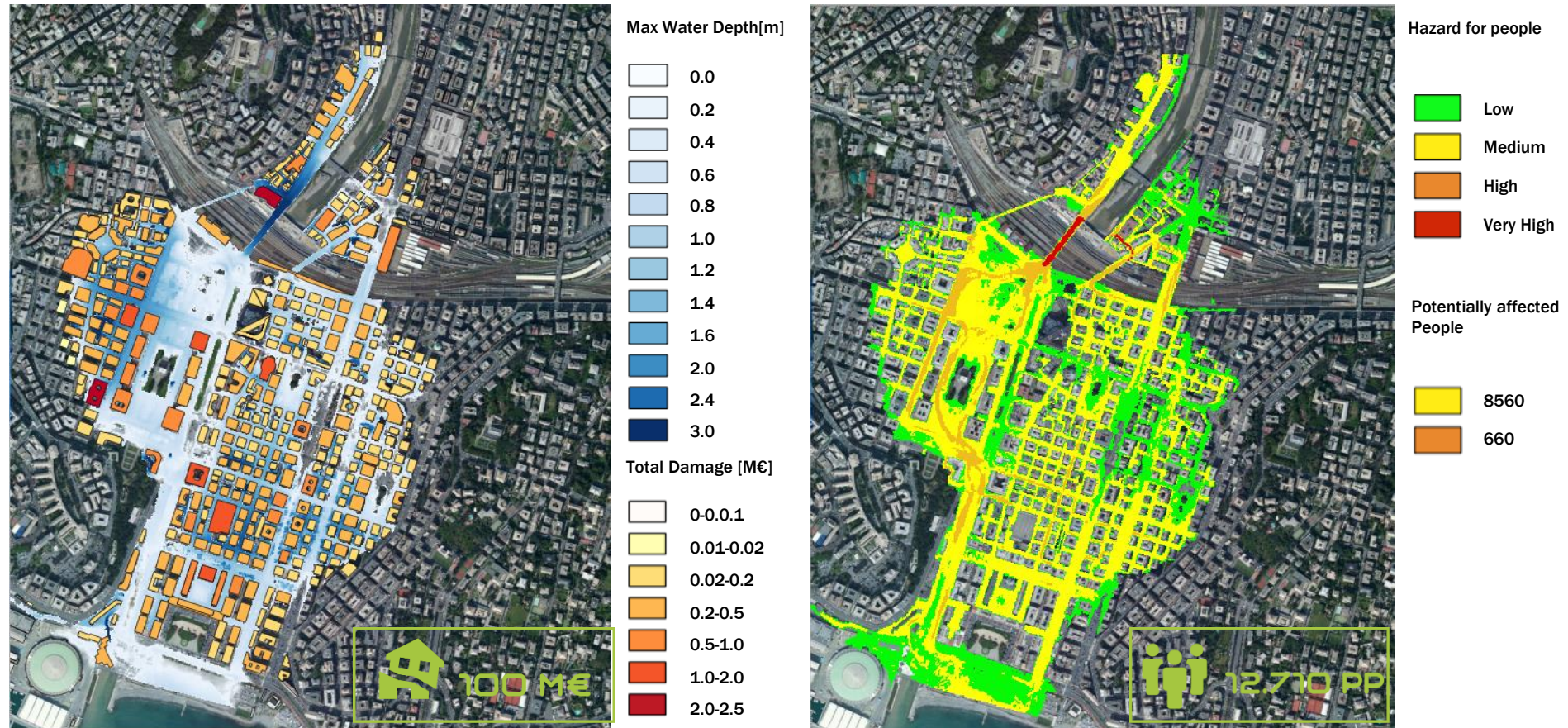
The lessening or minimizing of the adverse impacts of a hazardous event.

Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public awareness.

All mitigation measures can be justified by geospatial cost benefit analysis for optimal solution.

# Cost Benefit Analysis for Mitigation: Application of Geospatial Risk Maps

## Current Risk



Courtesy: CIMA Foundation

# Cost Benefit Analysis for Mitigation: Application of Geospatial Risk Maps

## Reduced Risk: After Building Diversion Channel



Courtesy: CIMA Foundation

# Cost Benefit Analysis for Mitigation: Application of Geospatial Risk Maps

## Reduced Risk: After Building Diversion Channel



Google earth  
image Landsat

Courtesy: CIMA Foundation

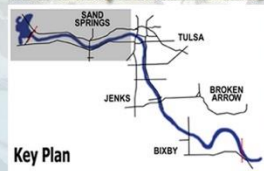
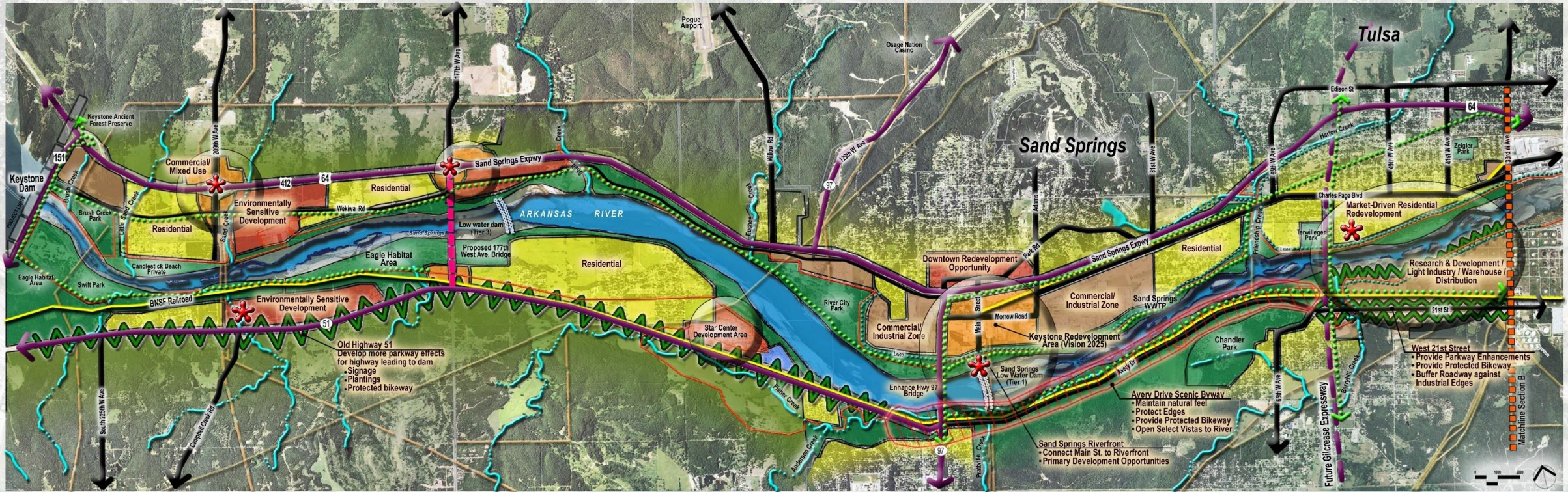
# Cost Benefit Analysis for Mitigation: Application of Geospatial Risk Maps

## Investment Breakeven in 50 Years and Human Suffering Lessened by 32,000 Affected People

MEASURES	ECONOMIC INVESTMENT (M€)	ANNUAL AVERAGE LOSS <sup>1</sup> (M€/YR)	SAVINGS (M€/YR)	INVESTMENT BREAKEVEN	AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE
<b>NO MEASURES</b>	0 M€	6.5 M€/YR	-	-	4 EVENTS X 11'000 PEOPLE
<b>DIVERSION CHANNEL + NEW CULVERT</b>	251 M€	1 M€/YR	5.5 M€/YR	ABOUT 50 YRS	4 EVENTS X 3'000 PEOPLE

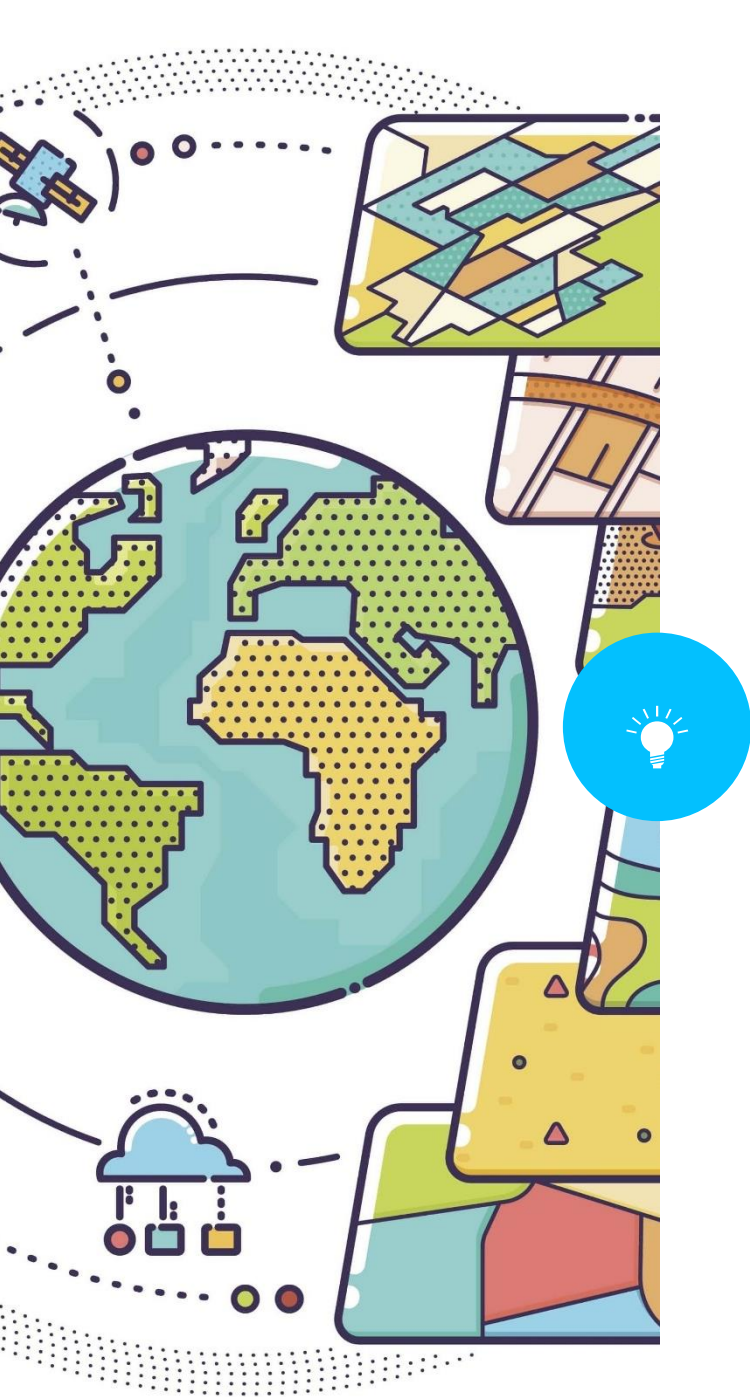
Courtesy: CIMA Foundation

# Hazard Sensitive Landuse Zoning



**LEGEND**

COMMERCIAL USES	OPEN SPACE	PROPOSED LOW WATER DAM (TIER 1 & TIER 2)	GREEN BUFFER ZONE
MIXED-USE ZONES	EDUCATIONAL / INSTITUTIONAL	LONG TERM LOW WATER DAM (TIER 3)	CREEK
INDUSTRIAL USES	GATEWAY OPPORTUNITY	HIGHWAY	1986 FLOOD LINE
RESIDENTIAL ZONES	SPECIAL DEVELOPMENT ZONE	THOROUGHFARE	LEVEE
AGRICULTURAL USES	DEVELOPMENT AREA OF INTEREST	RAIL LINE	HIKE/BIKE TRAIL
		POWER EASEMENT	PIPELINE CORRIDOR



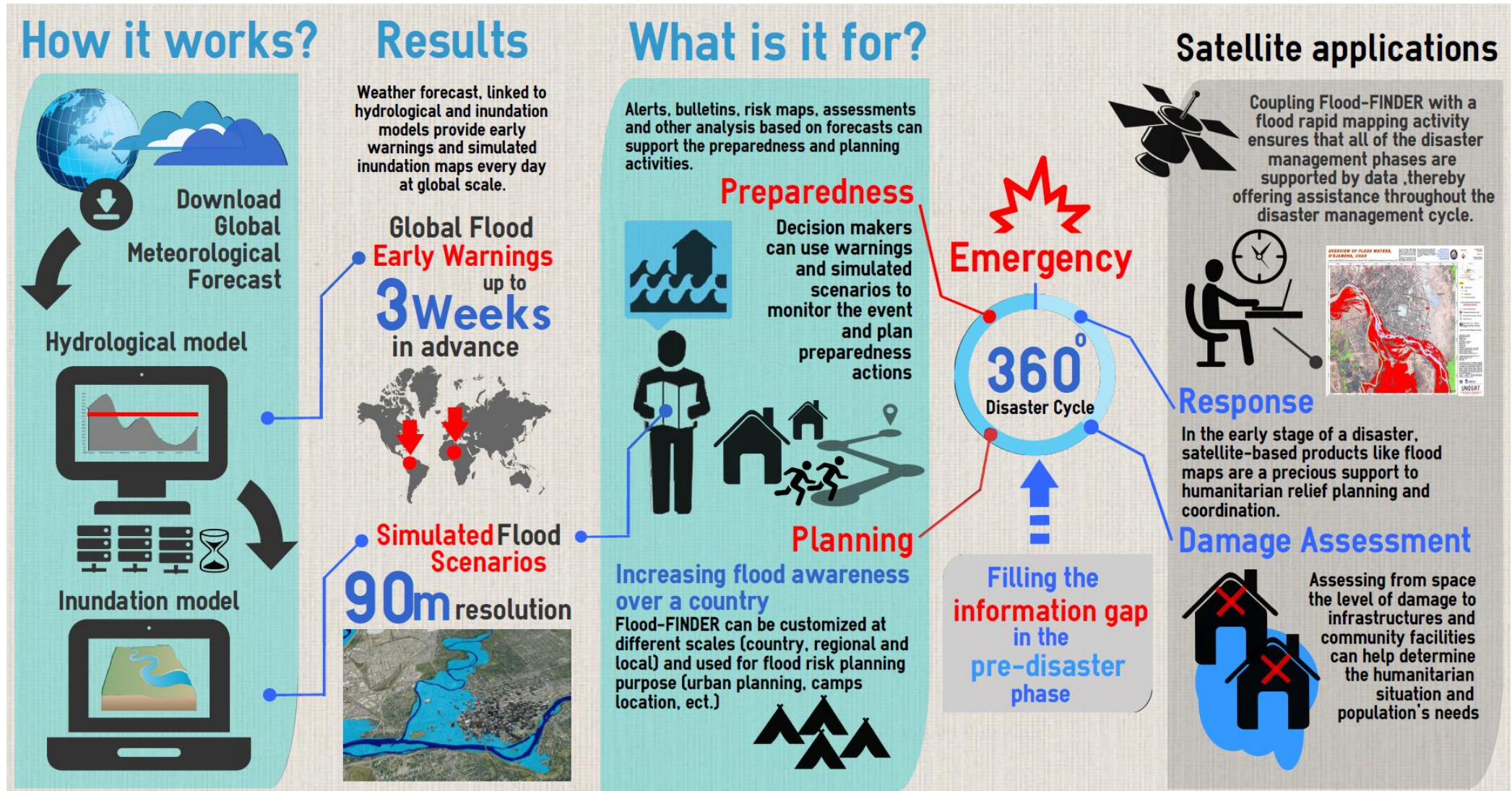
# GIT for Preparedness

The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters.

Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems, and includes such activities as contingency planning, the stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. All of these can be enhanced by the use of Geospatial information technology.

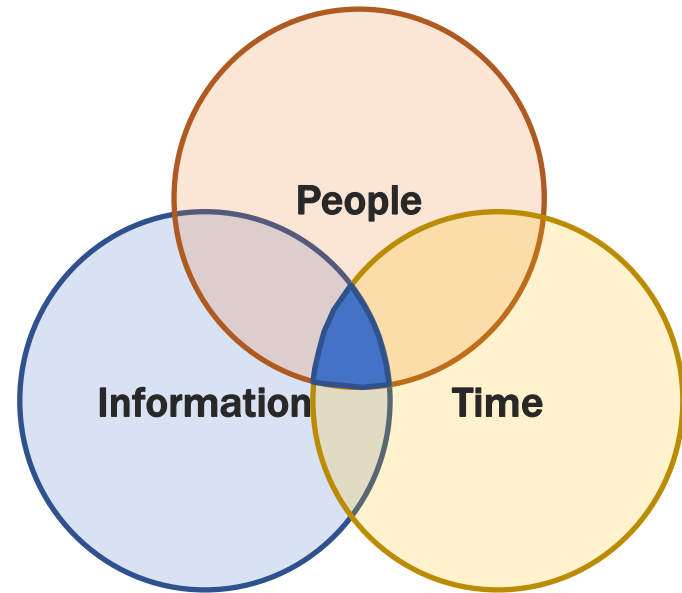
# Flood-FINDER:

A Forecast-based INtegrated flood Detection system for Emergency response and disaster Risk reduction





# GIT for Emergency Response



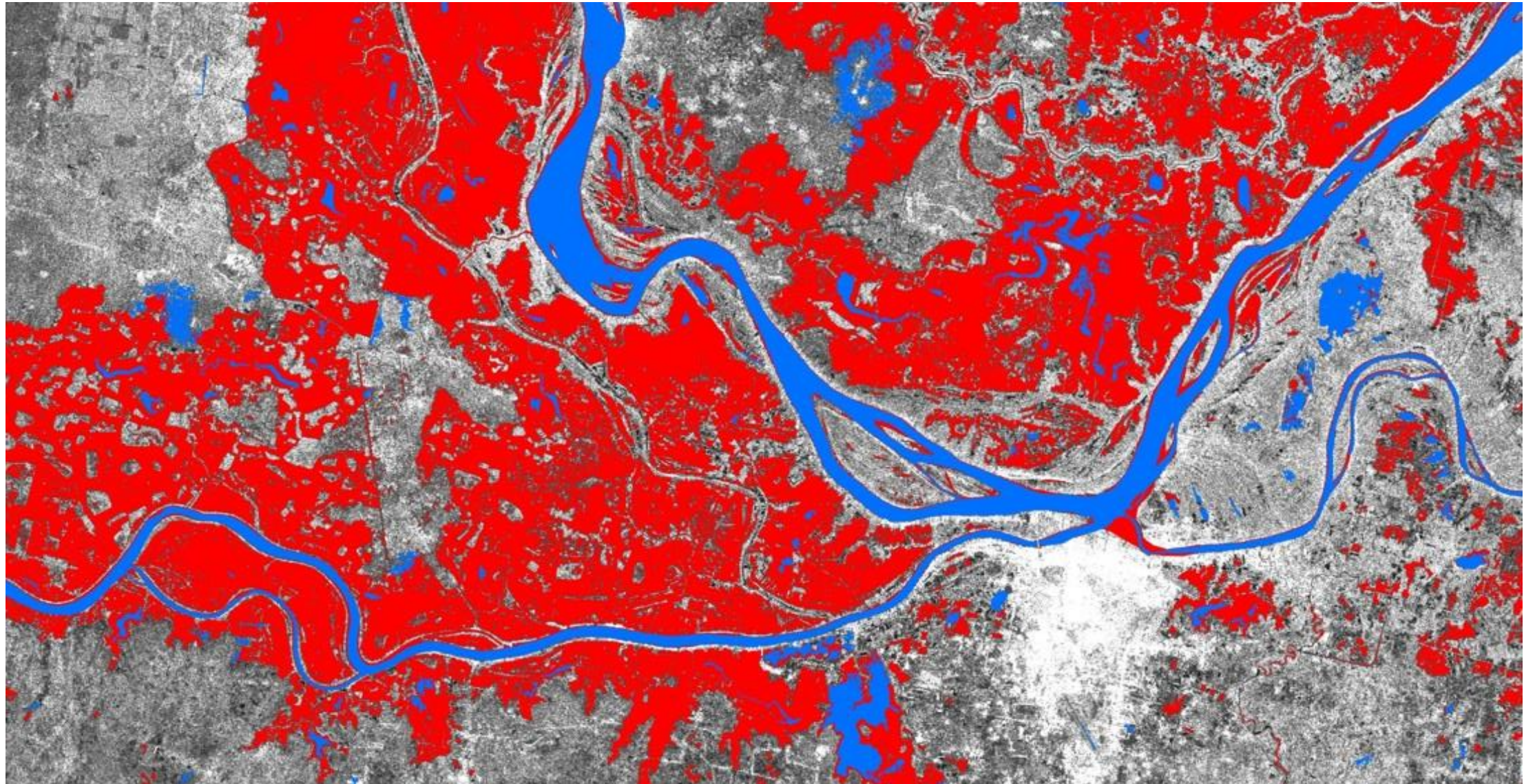
Information is the foundation on which decision-making for a coordinated and effective response is based.

## **Objective:**

To ensure that right information of the humanitarian emergency is provided to the right person at the right time in a usable form to facilitate situational understanding and decision-making.

Photo Courtesy: National Geographic

## Extraction of water extent from pre and post event satellite image



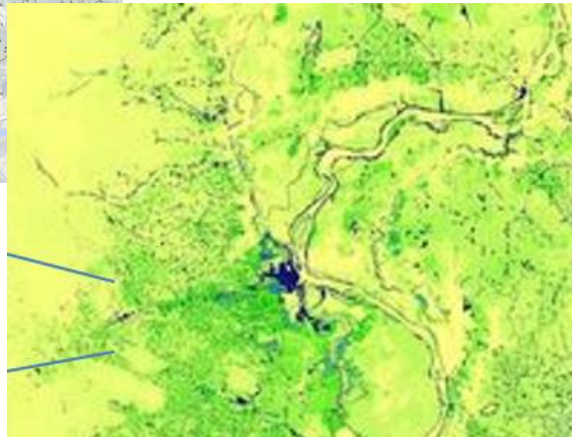
Before Flooding

After Flooding

Flood Extent

# Geo-spatial Methodology for exposure/impact and damage analysis

## Preliminary Exposure/Impact Analysis

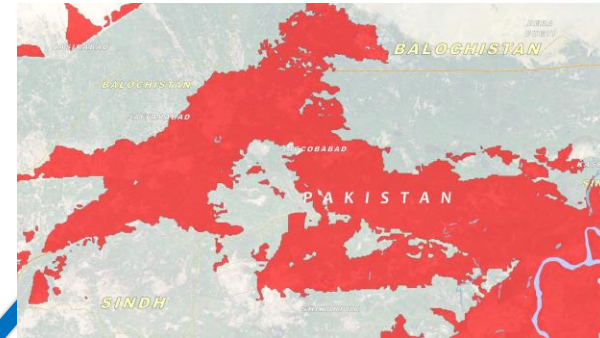


**Vector  
Baseline Data**

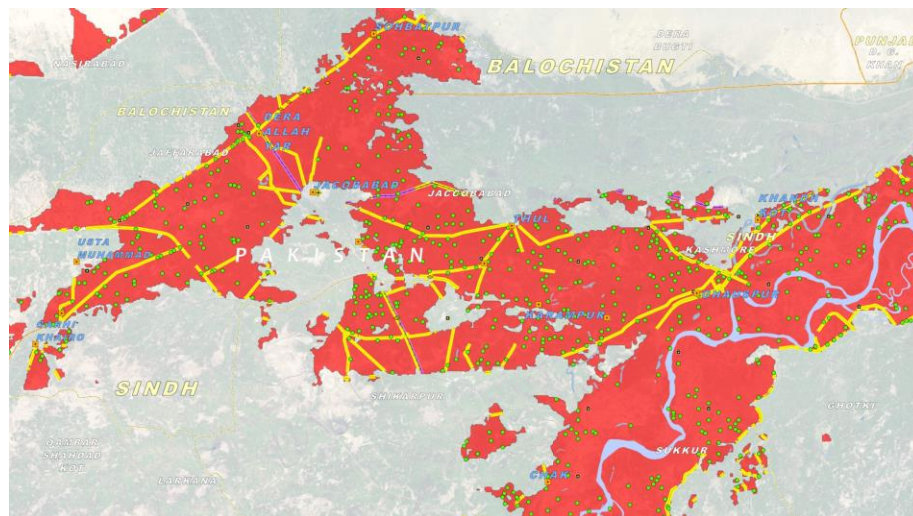
**Population  
distribution**

+

**Flood  
Water  
Extent**



**Combination of data allows for detailed and comprehensive preliminary exposure analysis**



**SUMMARY OF FLOOD-AFFECTED POPULATED PLACES AND INFRASTRUCTURE**

PROVINCE	BALOCHESTAN	KHYBER PAKHTUNKHWA	PUNJAB	SINDH	OTHERS	TOTAL
VILLAGE COUNT	174	808	4,037	2,463	10	<b>7,492</b>
TOWNS / CITIES	6	39	54	36	0	<b>135</b>
HEALTH FACILITIES	12	20	70	88	0	<b>190</b>
BRIDGES	11	183	139	95	1	<b>429</b>
ROADS (KM)	313	772	1,613	2,331	21	<b>5,051</b>
RAILWAYS (KM)	10	27	169	199	0	<b>406</b>

# Geo-spatial Methodology for exposure/impact and damage analysis

## Visual Interpretation of level of building damage from Pre and Post VHR Image



# **GIT for Building Back Better**

**Recovery planning**

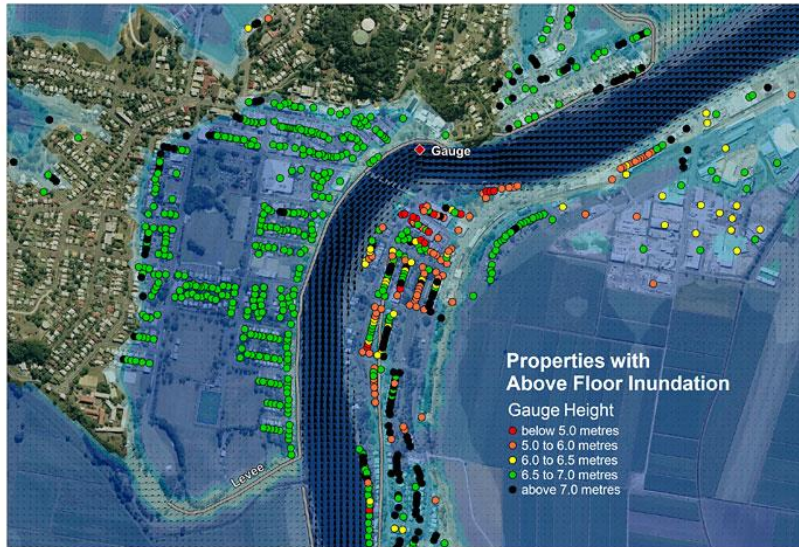
**Monitor recovery progress**

**Cost Estimation**

**Time & Resource allocation**



# GIT for Building Back Better



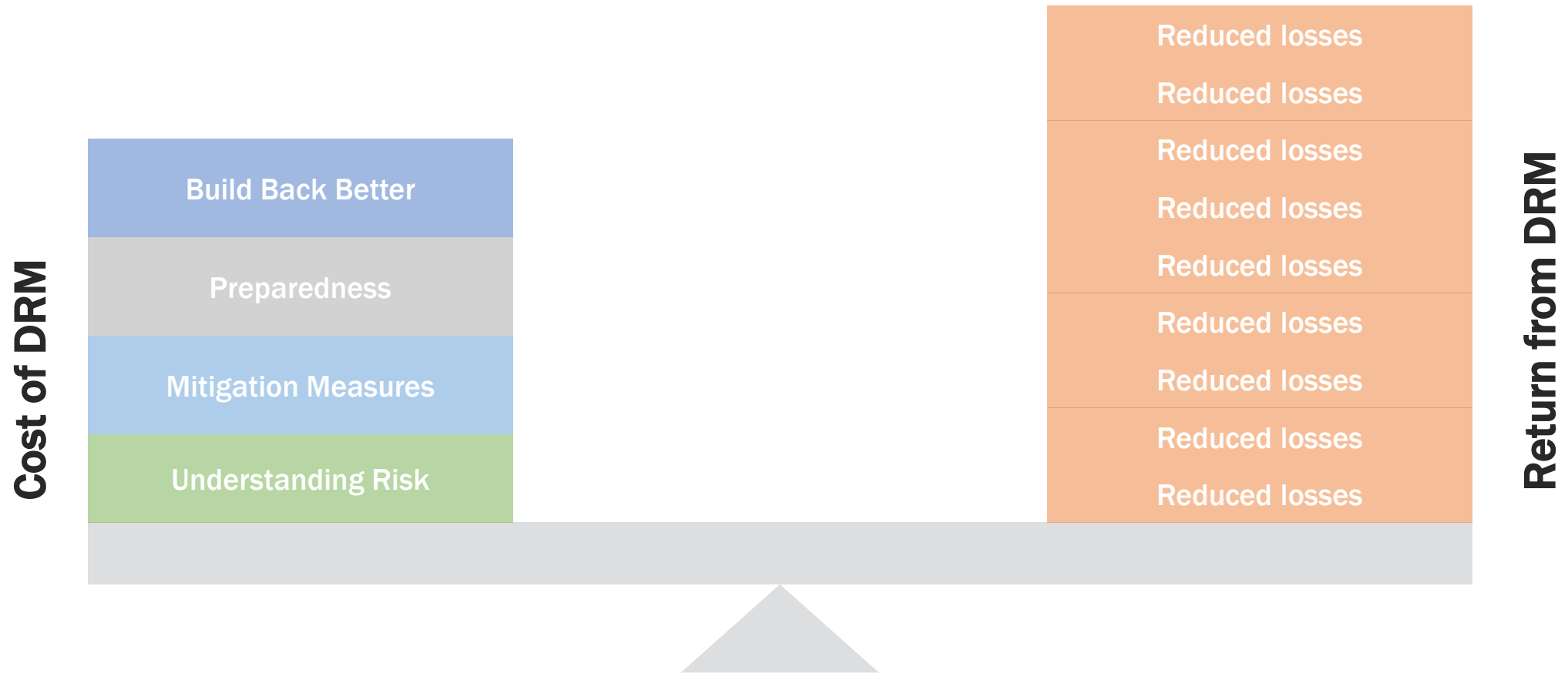
## Risk Aware Recovery Plans



## Remote Monitoring Recovery Progress

Courtesy: Office of the Queensland Chief Scientist, Google timelapse

# Return of Investment in Disaster Risk Management





# unitar

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