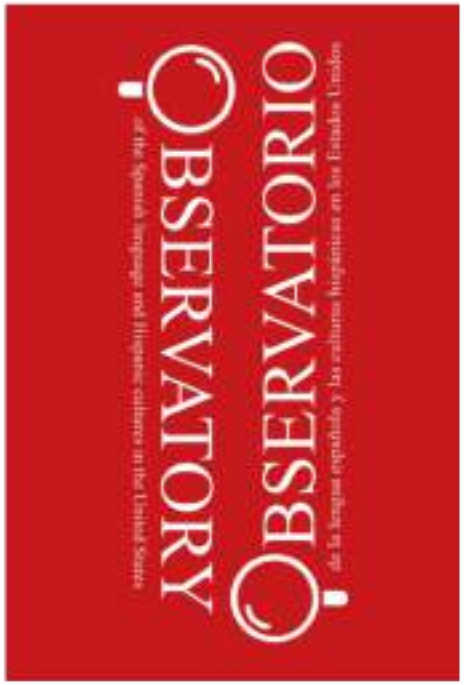
MATERIALES DEL OBSERVATORIO

OBSERVATORIO MATERIALS



Disaster Prevention

By Ramon Gilsanz, Dan Eschenasy, Gia Antonelli, Reed Miller, Veronica Cedillos, and Susan Bailey

Observatorio Instituto Cervantes at Harvard, Oct. 2023

Copyright Materials

Overview

Topics We Will Cover

- Overview
- Disasters and Civilization
- Modern-day Engineering Understanding
- Poverty As a Limitation of Response
- Defining the Problem
- Taking Action
- What Is GeoHazards International (GHI)
- Examples of Preventative Efforts

Overview

What is a Disaster

A **hazard** event can turn into a **disaster** when people live in **vulnerable** environments and don't have the **capacity** ("social vulnerability") to cope with the impact of the **hazard**.

Overview

How to Contribute

There are numerous ways **we** can **contribute** to disaster prevention.

Today we will outline how **you** can be the **next generation** to help **prevent disasters.**

Overview

Types of Hazards

- Earthquakes
- Fire
- Tornadoes
- Floods
- Tsunamis
- Hurricanes/Typhoons

Disasters and Civilization

Extinction of the Dinosaurs

- Asteroid struck earth 66 mill. yrs ago
- Dinosaurs extinct
- 75% of plant/animal species wiped out

The Washington Post, UT News, Natural History Museum

Disasters and Civilization

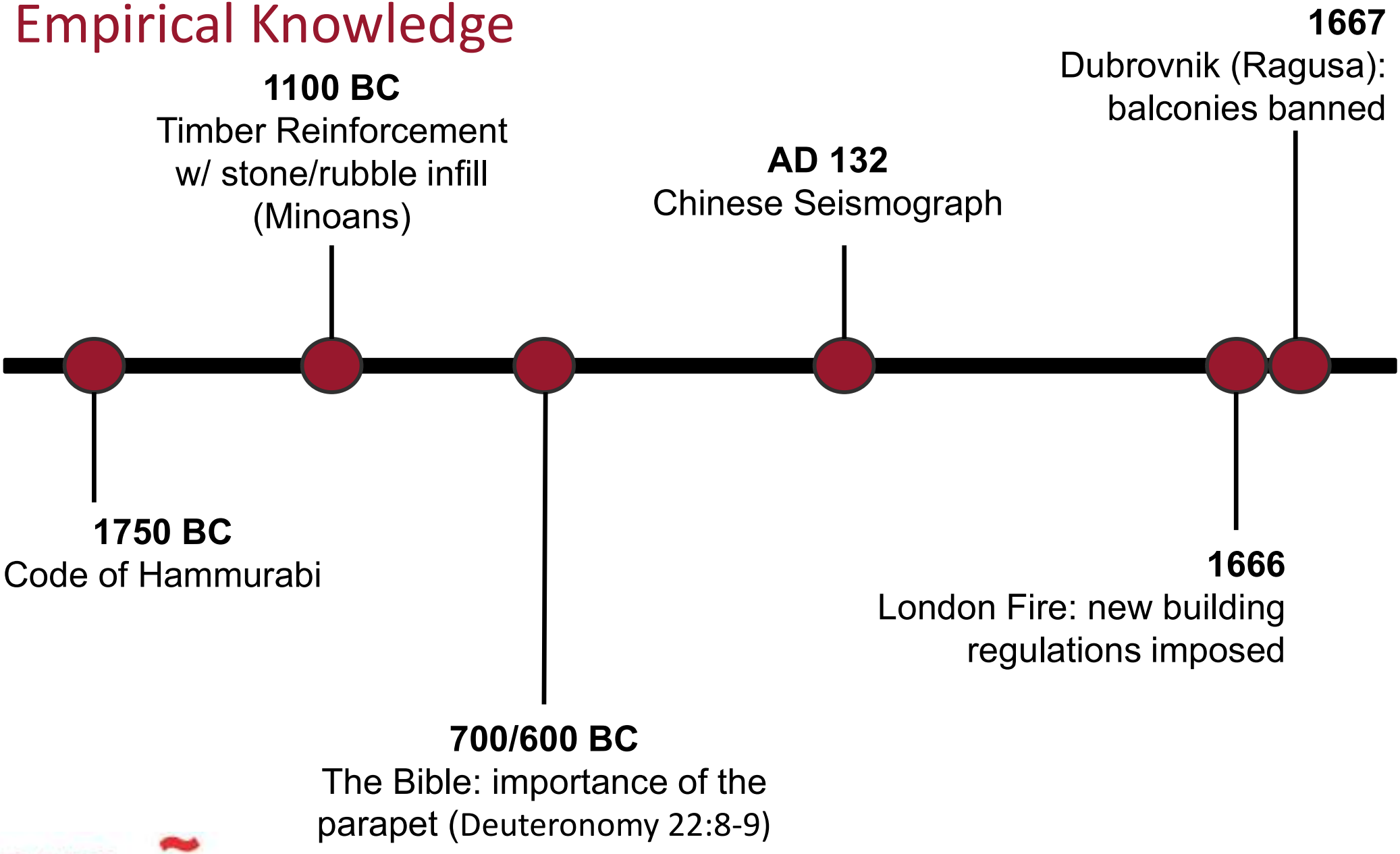
Fall of The Bronze Age Civilizations

- Many major Mediterranean civilizations began collapsing between 13th-12th centuries BC
- Minoans among one of many to collapse (fell 1500 BC)
- Contributing Factors:
  - Eruption of Thera Volcano
  - Climate Change

NASA, UNESCO, NPR, Time Magazine

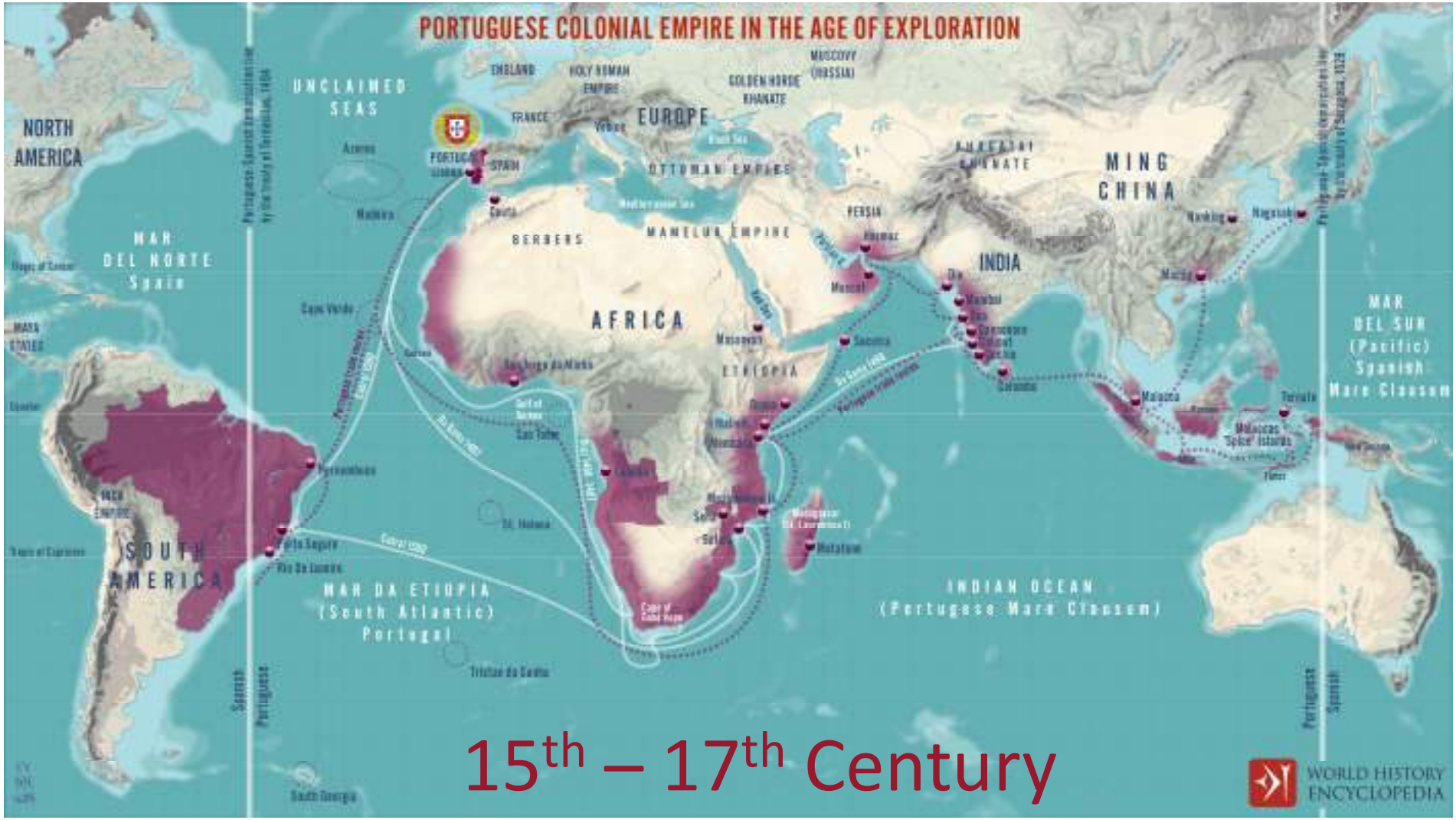
Disasters and Civilization

Empirical Knowledge



Disasters and Civilization

The Portuguese Empire



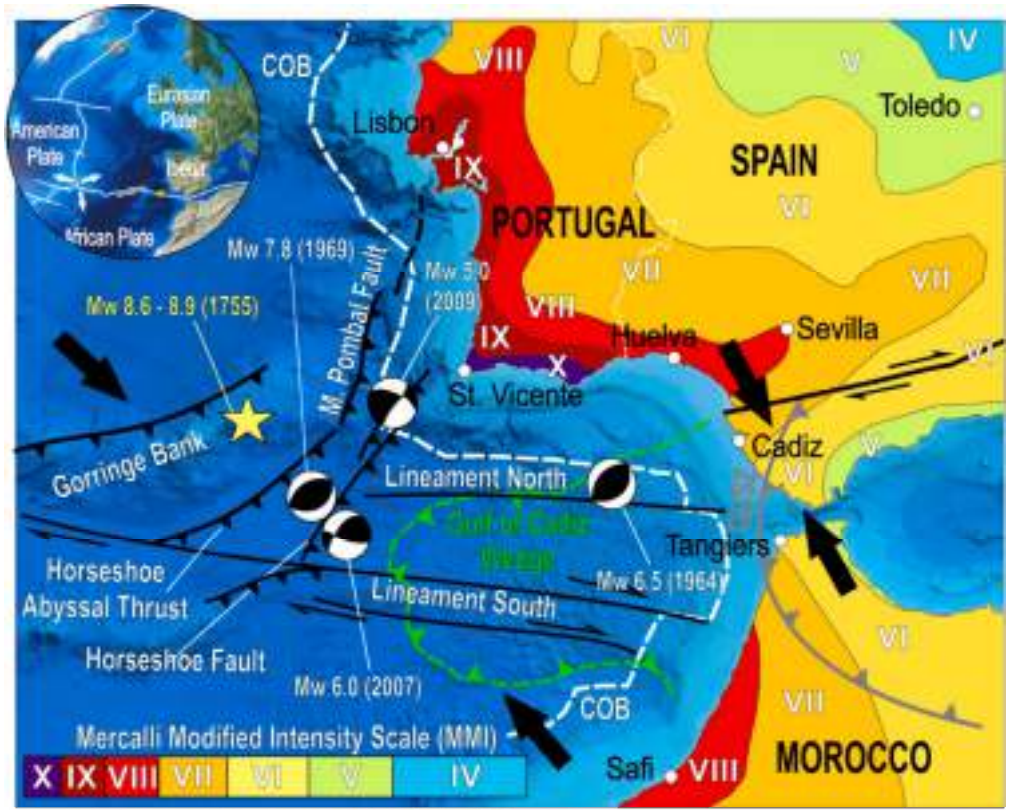
Disasters and Civilization

Dangers of Cities: 1755 Lisbon Earthquake

- Highly populated city
- 8.5M earthquake followed by a tsunami
- 40,000-50,000 deaths
- Damages estimated to be 32-48% of Portugal's GDP at the time

Disasters and Civilization

Dangers of Cities: 1755 Lisbon Earthquake



In Spain:

- 1,275 dead
- **84%** of victims due to people being hit by collapsed buildings/detached construction elements

Disasters and Civilization

Enlightenment Philosophers' Search for Causation

Nature is so cruel… Look at this devastation in Lisbon!

Voltaire

Nature did not construct twenty thousand houses of six to seven stories there!

Rousseau

There must be a scientific cause to this earthquake, it is not divine intervention!

Kant

Disasters and Civilization

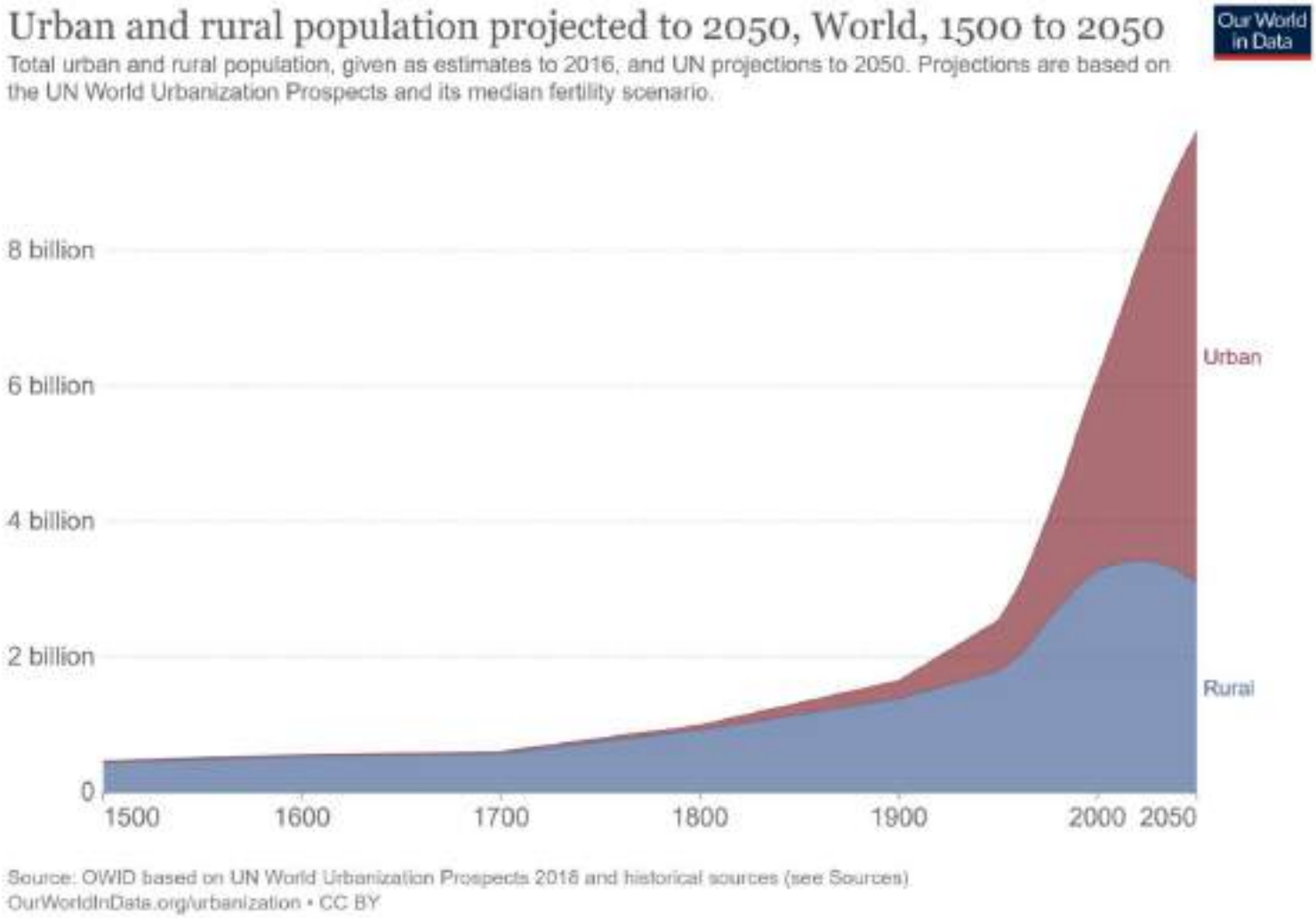
Voltaire: Hazards Are Unavoidable

Munich RE NatCatSERVICE

Disasters and Civilization

Rousseau: Cities Expose People to Hazards

Cities have shown to be more dangerous, but urbanization is only increasing.



Disasters and Civilization

Rousseau: Cities Expose People to Hazards

A Positive

Cities are generally more **strictly regulated by codes** whose enforcement can be afforded by owners, contractors, and designers with private money

A Negative

In places with limited financial and technical resources, ensuring adequate funding and **quality control is a big challenge**

Disasters and Civilization

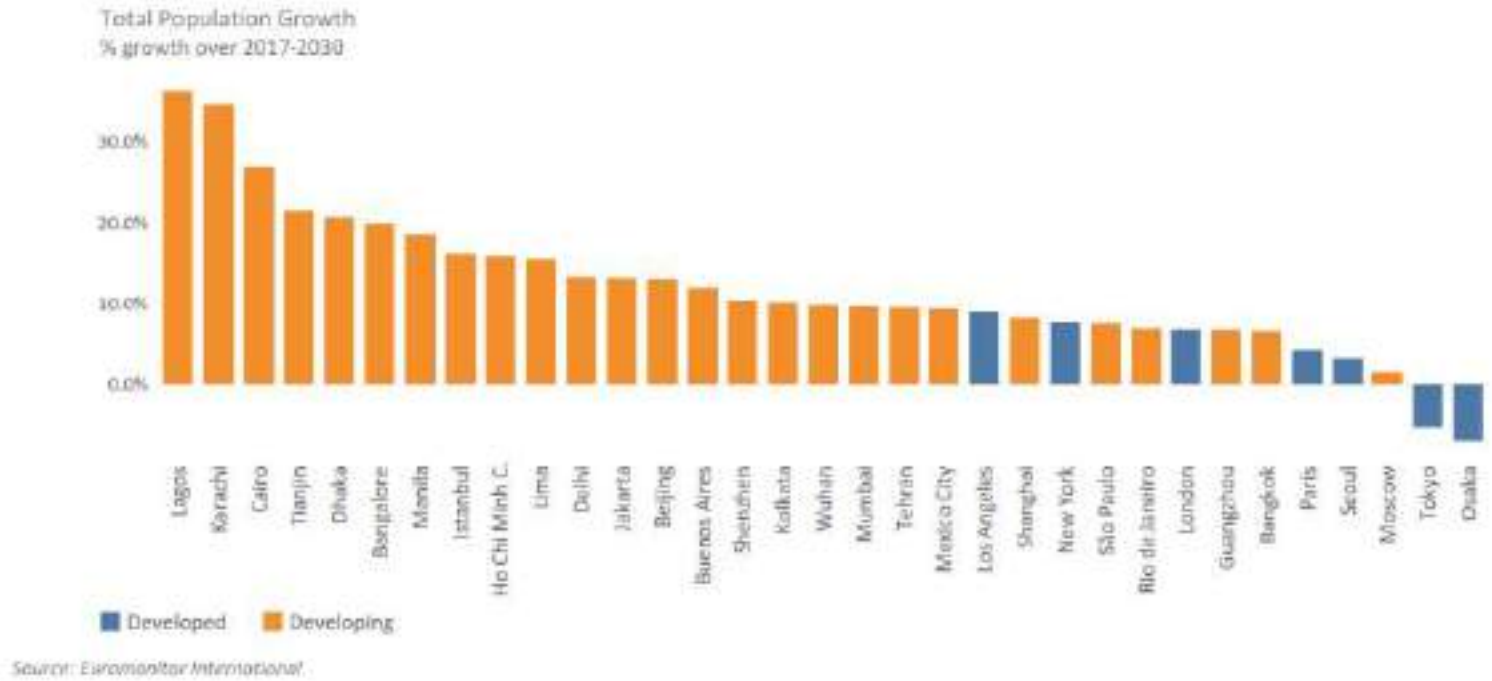
Rousseau: Cities Expose People to Hazards

Nepal: Fast Growing

Disasters and Civilization

Rousseau: Cities Expose People to Hazards

"As the world **urbanizes**, **risk** is being **concentrated** in densely **populated** areas, many of which are **not designed to withstand** their current levels of **hazard** exposure" (UN Disaster Risk Reduction)



Megacity: a city housing 10+ million inhabitants.

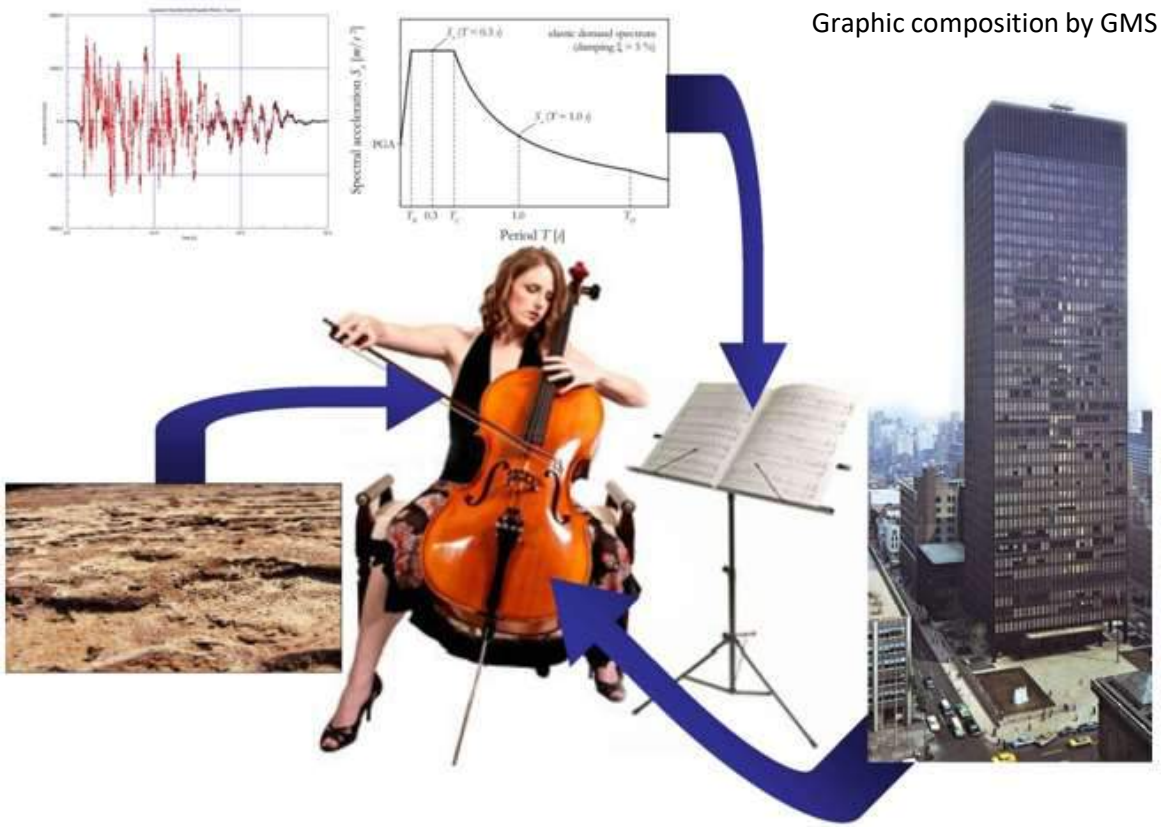
Modern-day Engineering Understanding

Kant: A Scientific Explanation-Where We Are Now

- Earthquake analysis
- Data acquisition
- Codes, American Society of Civil Engineers (ASCE) Standards
- High-end and low-end solutions

Modern-day Engineering Understanding

A Musical Analogy



Graphic composition by GMS

- Earthquake ↔ Music
- Soil ↔ Musician
- Seismic Spectrum ↔ Score
- Building ↔ Instrument
- Bldg. Response ↔ Melody
- Occupants ↔ Audience
- Social Context ↔ Concert Hall

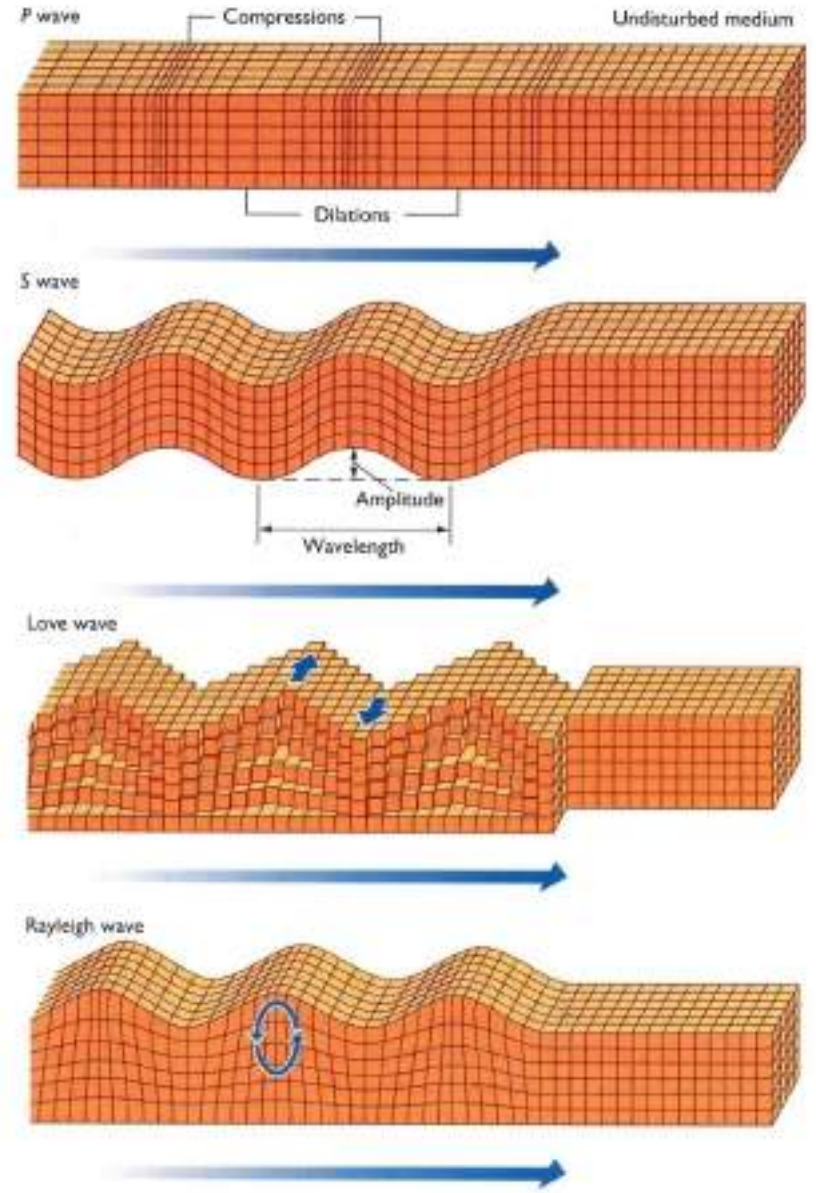
Modern-day Engineering Understanding

Data Acquisition

Warning Signs: **warning** systems detect nondestructive primary waves (**P waves**), before destructive secondary waves (**S waves**). The delay between the arrival of P and S waves controls the **amount of advance warning** given

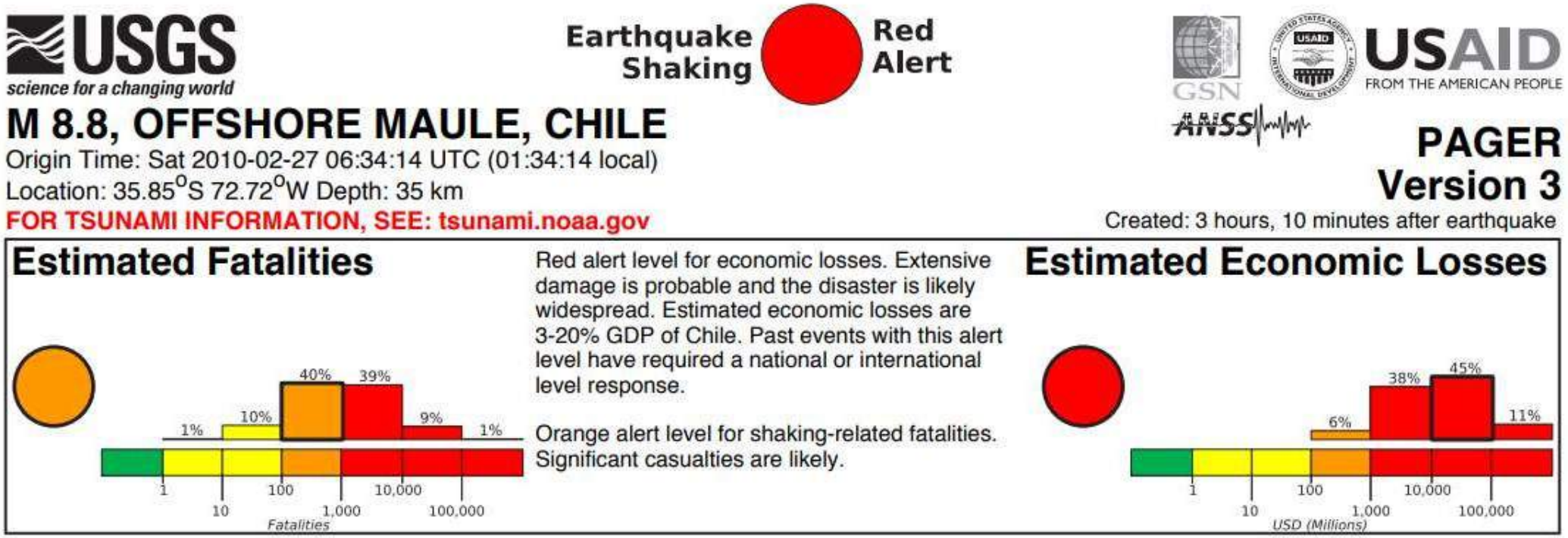
Detection: Systems can quickly **detect** where an earthquake has happened at any place in the world and **its impact** (pager)

Assessment: Post-earthquake systems **verify** what building **response** is **necessary**



Modern-day Engineering Understanding

Data Acquisition: Detection



USGS: United States Geological Survey

Modern-day Engineering Understanding

Codes and Standards

- ASCE 7: Structures must be **designed** to resist loads and wind, tsunami, tornado and earthquake forces

- ASCE 7: Buildings should be **classified** based on importance/risk factor imposed to public

- ASCE 7: Design requirements for **seismically isolated** building structures

ASCE 7: Standards for Minimum Design Loads for Buildings/Structures

Modern-day Engineering Understanding

Codes and Standards

- ASCE 41: Procedure for **evaluating** existing buildings for earthquake related risk

- ASCE 24: **Guidelines** on flood-resistant design

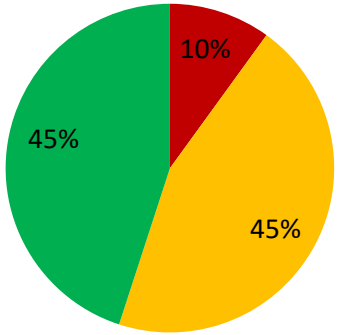
ASCE 41: Standards for Seismic Evaluation/Retrofit of Buildings

ASCE 24: Standard for Flood Resistant Design and Construction

Modern-day Engineering Understanding

Building Damage

US – Design Approach



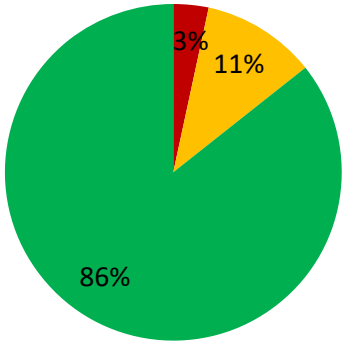
Chris Poland ASCE 31/41

MCE

- Collapse
- Unusable
- Usable

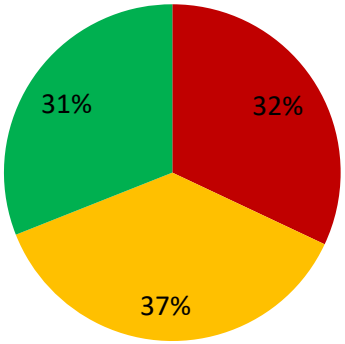
Post Disaster Statistics

Maule, Chile 2010 (M8.8)



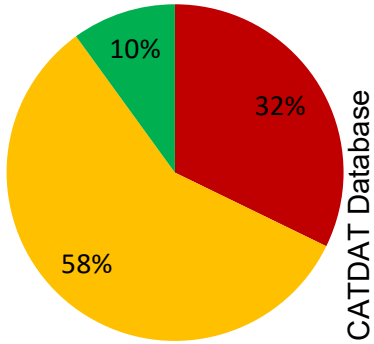
Colegio de Ingenieros de Chile

Pedernales, Ecuador 2016 (M 7.8)



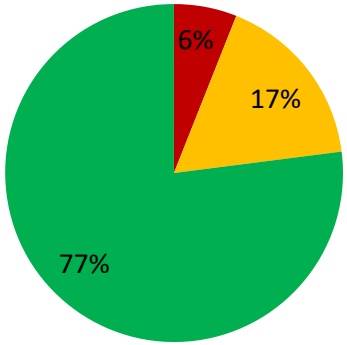
Xavier Vera-Grunauer

Port au Prince, Haiti 2010 (M 7.0)



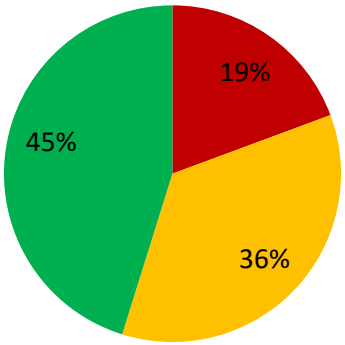
CATDAT Database

Northridge, US 1994 (M 6.7)



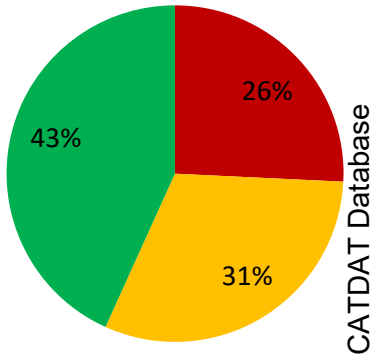
CATDAT Database

Cephalonia, Greece 2015 (M 6.5)



GEER/EERI/ATC Reconnaissance

Christchurch, NZ 2011 (M 6.3)

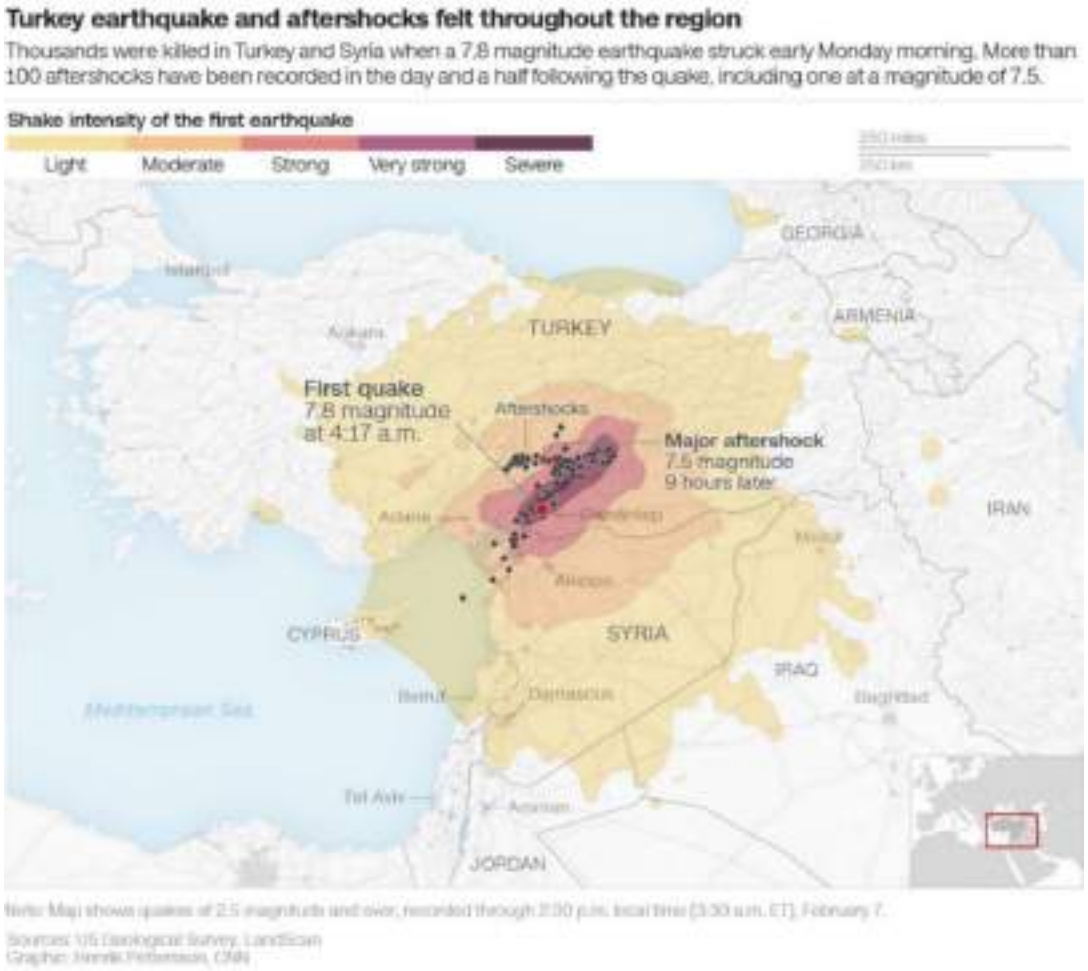


CATDAT Database

Comparative analysis prepared by GMS

Modern-day Engineering Understanding

Dangers of Unenforced Building Codes: Turkey 2023 Earthquake



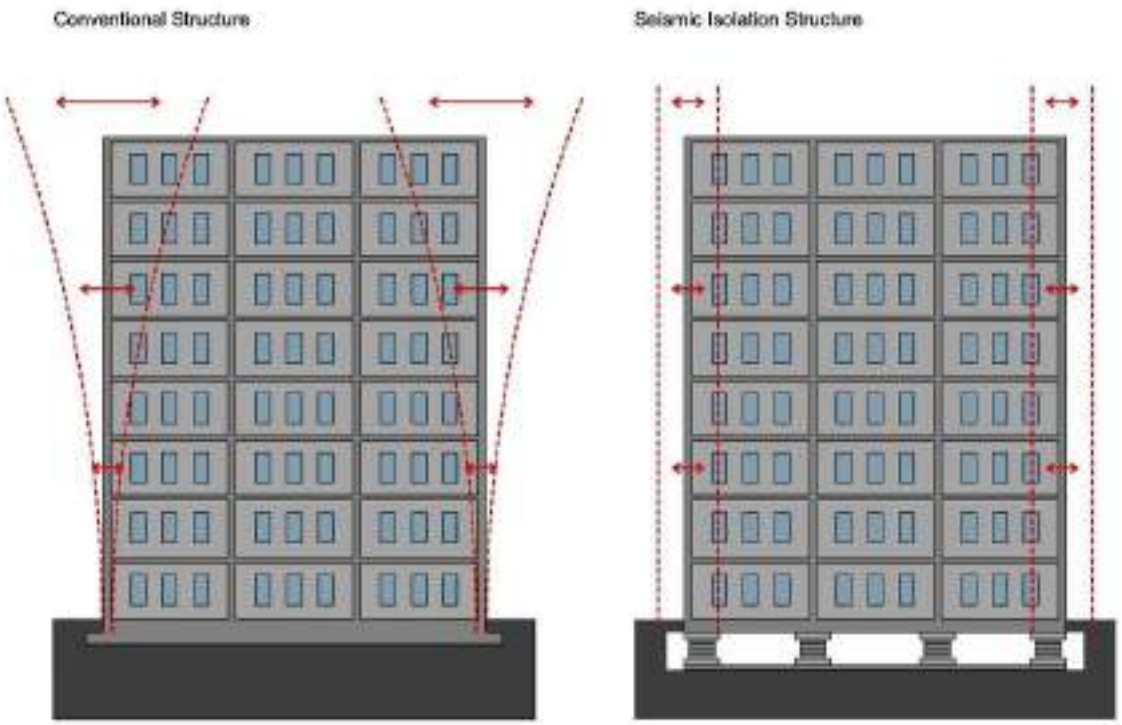
GDP per capita=$13,990 (Dec. 2022)

- 45,000+ killed
- Millions homeless
- Immediate damages=$34 billion
- Total cost=$84.1 billion
- Corruption → **unenforced building codes**

USGS, CNN, The Washington Post

Modern-day Engineering Understanding

Building Successes: Turkey Post-Earthquake



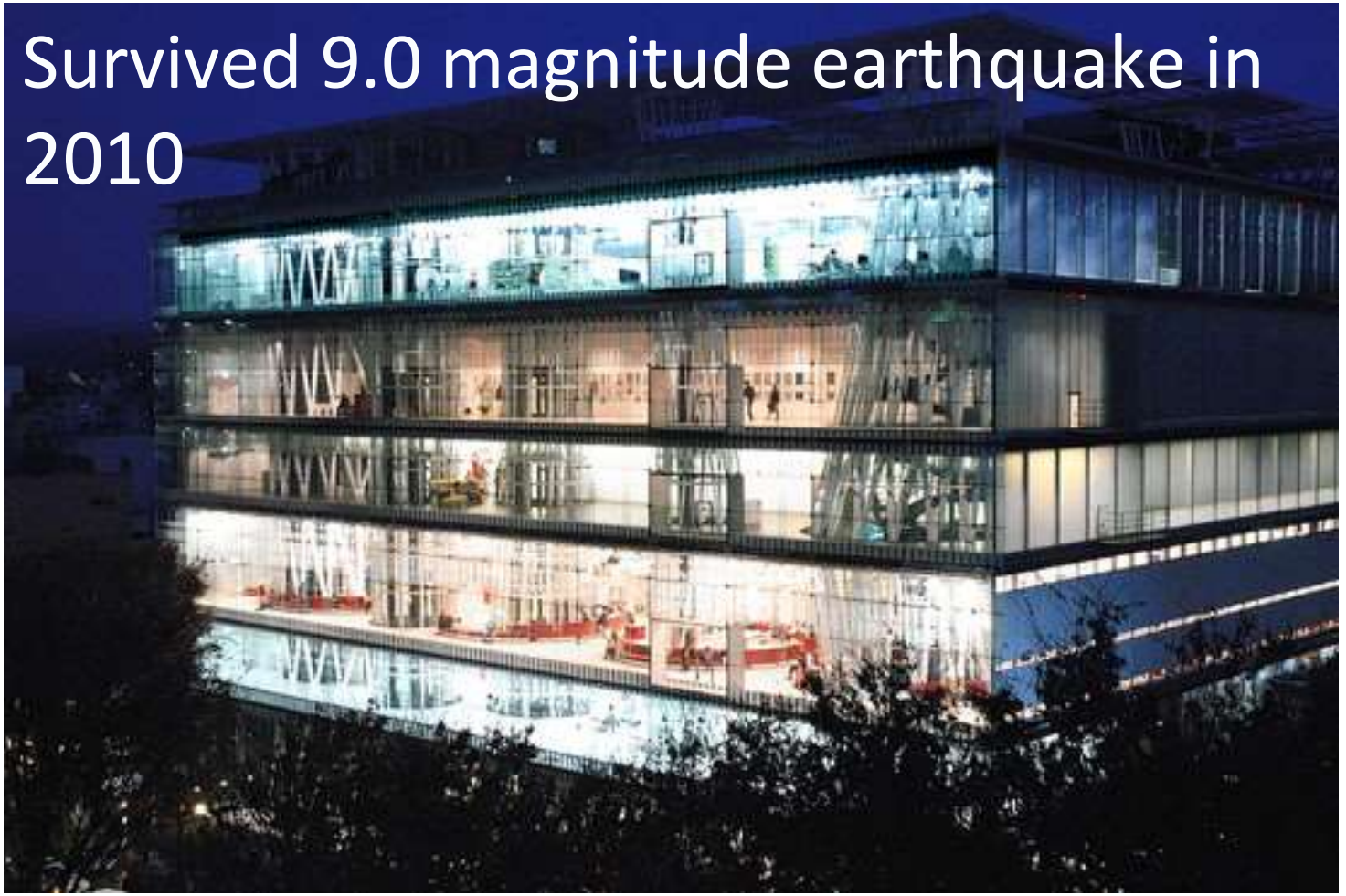
<u>Adana City Hospital:</u>

- One of few left standing after 2023 earthquake
- Advanced seismic isolation system → 75% reduction in shaking compared to neighboring structures
- Built in accordance with newer building codes

Modern-day Engineering Understanding

Building Successes: Japan Mediatheque Building

Japan: Mediatheque Building in Sendai



Building shook and swayed violently but did not collapse.

The Wall Street Journal

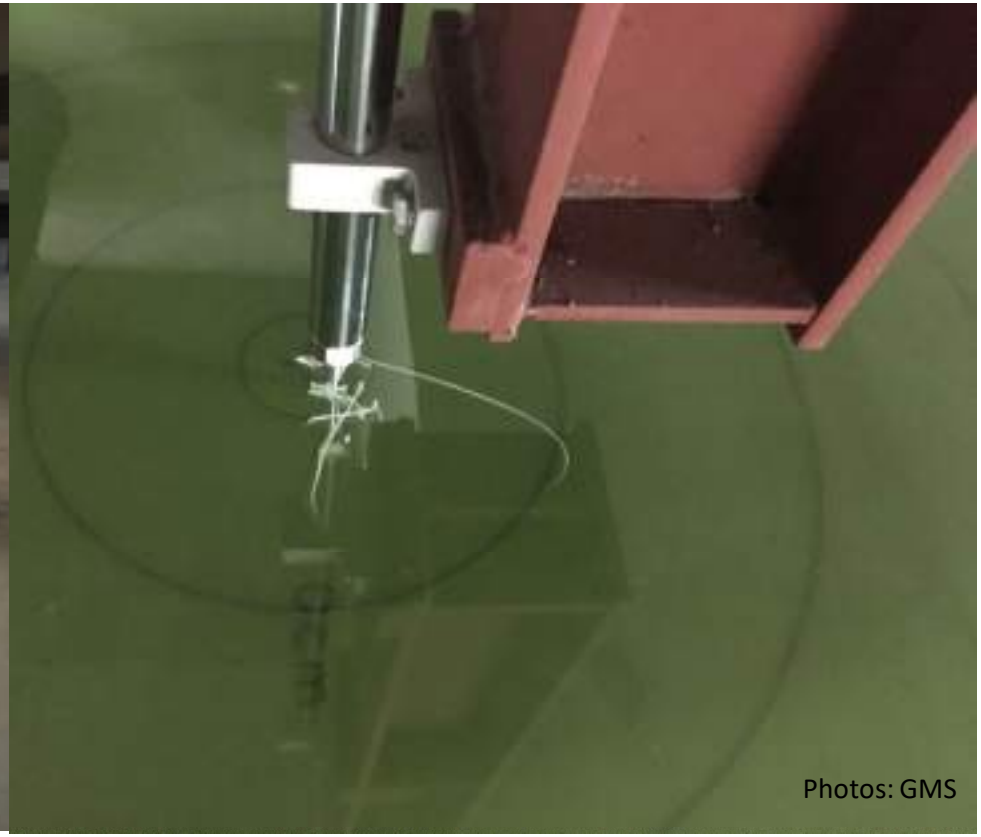
Modern-day Engineering Understanding

Building Successes: 2016 Taiwan Earthquake

Photo: GMS

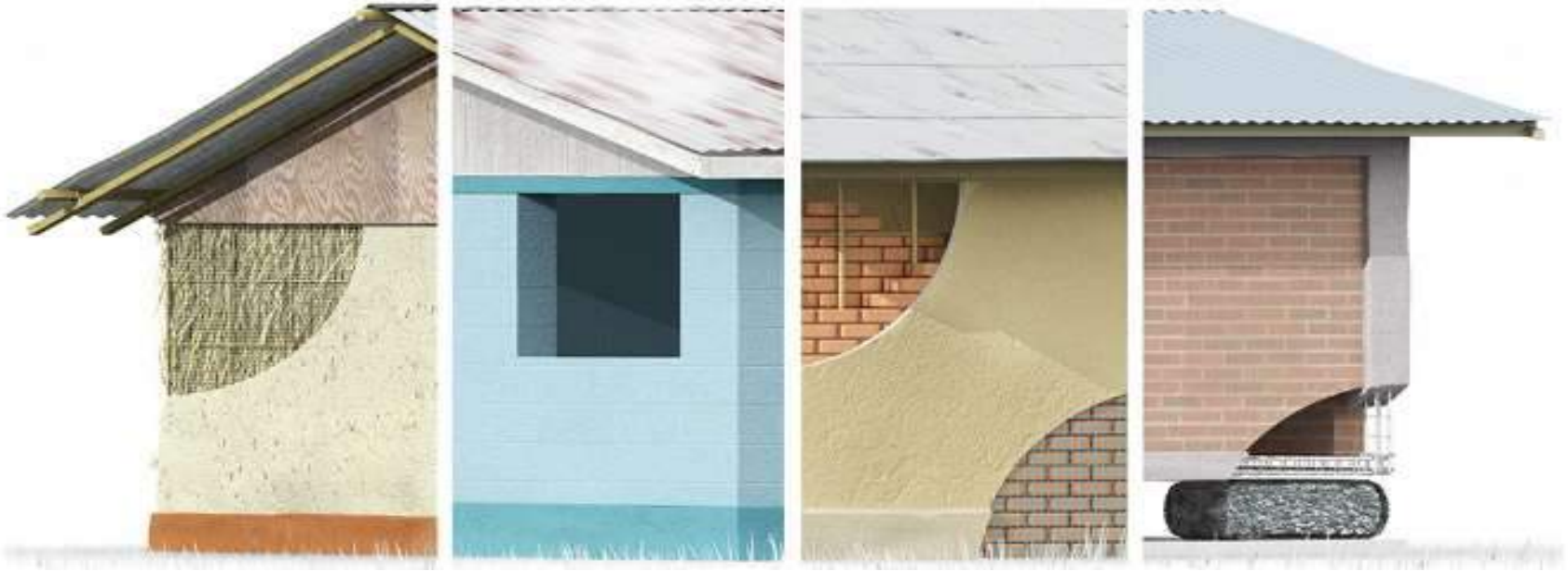
Modern-day Engineering Understanding

Building Successes: 2016 Taiwan Earthquake Design Approach



Modern-day Engineering Understanding

Solutions: Less Developed Areas



Pakistan

Light walls and gables

- Lightweight structures subject to smaller forces→less likely to fall
- In Pakistan quake resistant houses are built of straw

Haiti

Light roofs

- Metal roofs on wooden trusses are more resilient than concrete-less likely to collapse

Peru

Reinforced walls

- Reinforcing rods of eucalyptus or bamboo
- Peru-walls retrofitted with plastic mesh

Indonesia

Confined Masonry

- Brick walls framed and connected to roof by corner columns and crown beam of RC

Shock Absorbers

- Tires filled with stone/sand and fastened between floors and foundation

Gernot Minke, University Of Kassel; Elizabeth A. Hausler, Build Change; Anna Lang, University Of California, San Diego; Marcial Blondet And Álvaro Rubiños, Catholic University Of Peru; Pierre Paul Fouché, University At Buffalo; USGS

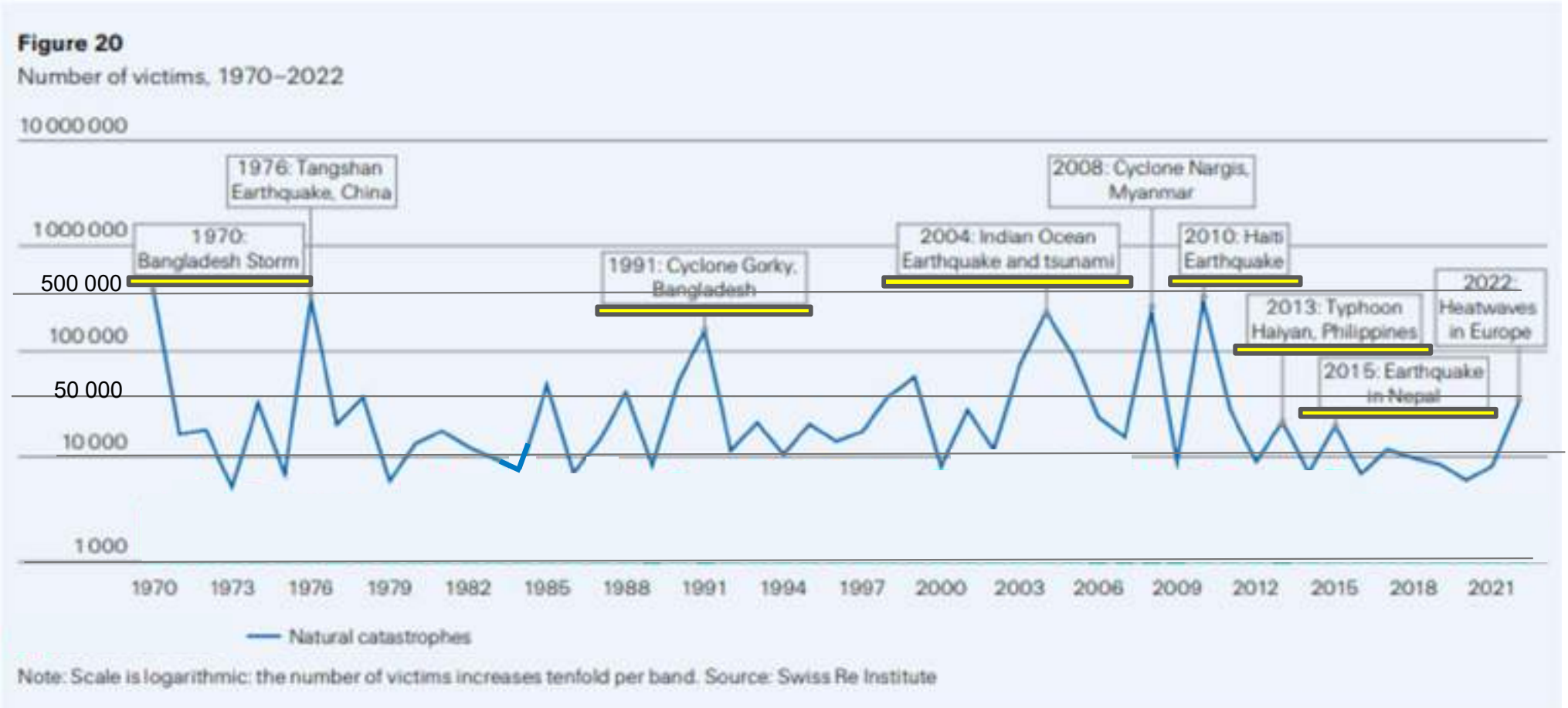
Modern-day Engineering Understanding

Building Successes: Less Developed Areas

Nepal: School buildings after 2015 M7.8 earthquake

Poverty As a Limitation of Response

Natural Catastrophes 1970-2022



Swiss Re Institute, World Bank

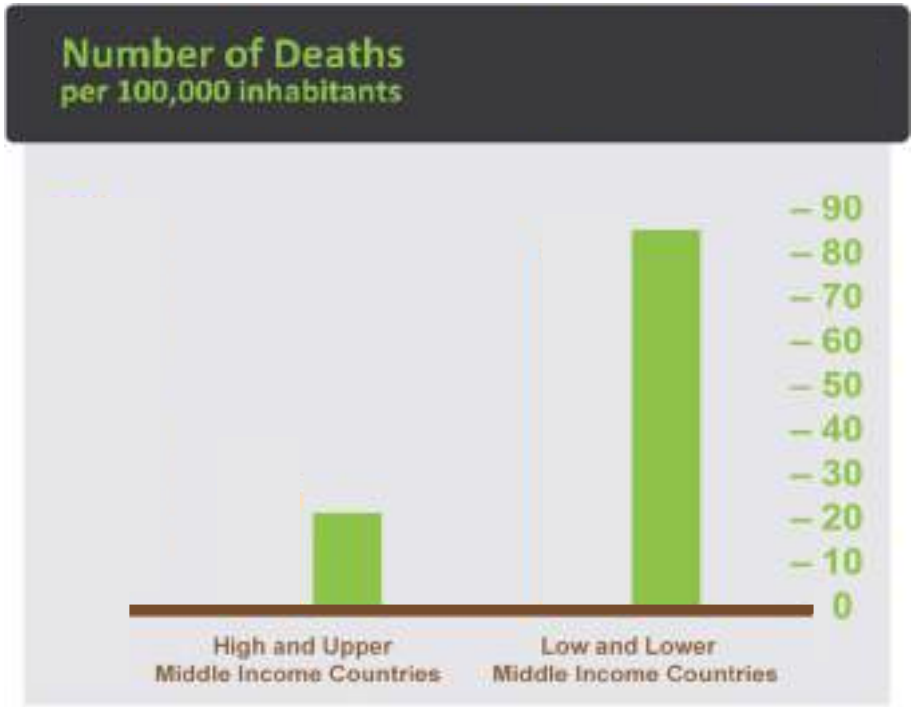
Poverty As a Limitation of Response

UN DRR (UN Disaster Risk Reduction)

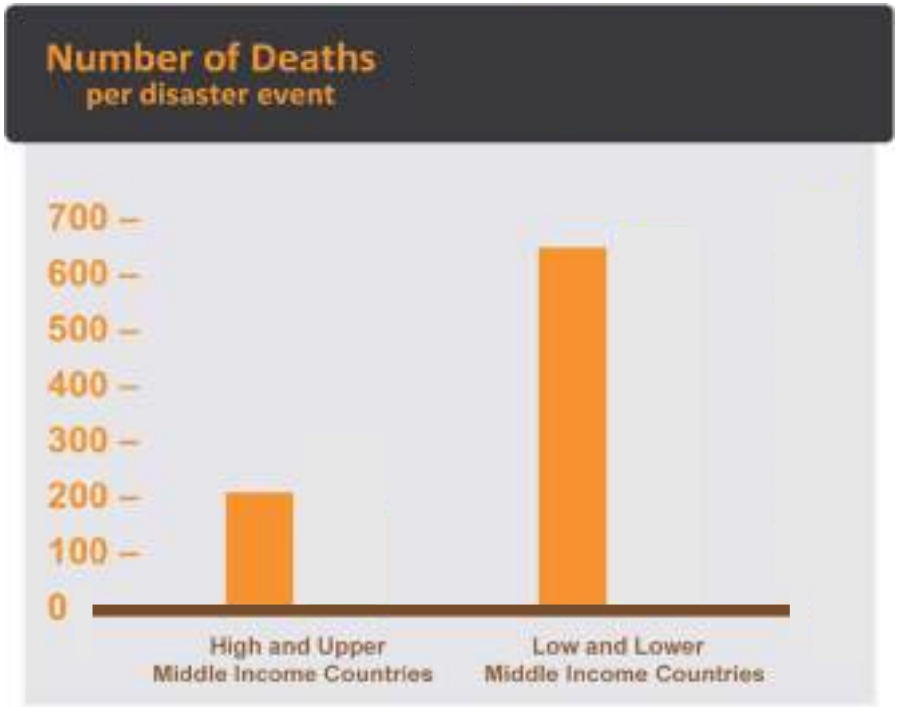
"Disasters impact the economies of **LDCs** [less developed countries] around **10 times worse** than the economies of the **richest countries**, as a share of their GDP."

Poverty As a Limitation of Response

Fatalities Based on Income Level



1996-2015
Data taken from the United Nations Office For Disaster Risk Reduction (UNISDR)



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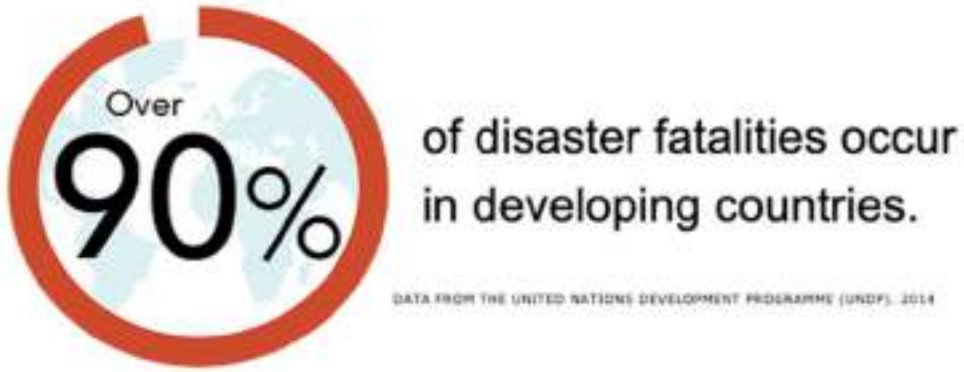


Poverty As a Limitation of Response

Haiti-Chile Earthquakes: Lethality Comparison

Haitian Earthquake
7.0 magnitude (2010)

11% “strongly shaken” died

Chilean Earthquake
8.8 magnitude (2010)

0.1% “strongly shaken” died

Poverty As a Limitation of Response

Haiti-Chile Earthquakes: Lethality Comparison

Haiti

GDP per capita= $1,205 (2022)

Size of city= 9.8 mill. people (2010)

Did not focus on the proper threat:

- Concrete/cinder block structures instead of wood structures
- Masonry holds up better in storms but not in earthquakes

Chile

GDP per capita= $12,768 (2022)

Size of city= 17 mill. people (2010)

Poverty As a Limitation of Response

Armenia-California Earthquakes: Lethality Comparison

Armenian Earthquake
6.8 magnitude (1988)

Loma Prieta, California Earthquake
6.9 magnitude (1989)

63 deaths

Poverty As a Limitation of Response

26 million people pushed into **poverty each year** because of natural disasters

- Poor people lose more share of their assets and wealth
- Education and future derailed
- Loss of access to jobs and opportunities

Poverty As a Limitation of Response

The Poor Are Disproportionally Affected In Wealthy Countries Too

Americans of low socioeconomic status (SES) have been found to be less prepared than other Americans for disasters…

Superstorm Sandy:

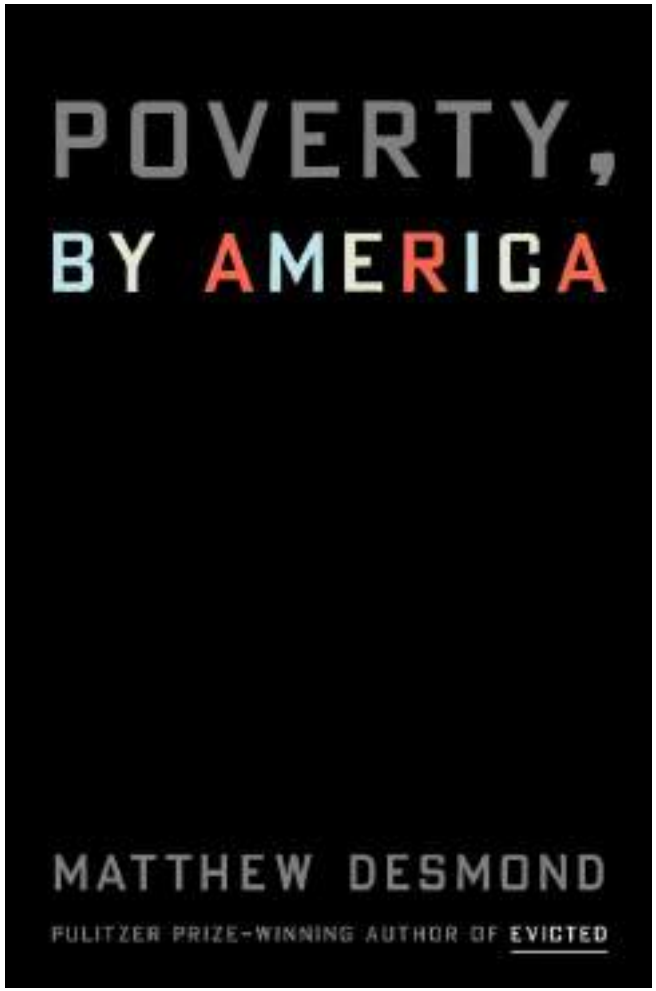
1 in 3 flooded census tracts had a **poverty rate of ≥20%** in NYC

In **flooded** tracts, **18.7%** of the population was below the poverty line. In **non-flooded** tracts **only 14.7%** was below the poverty live.

SAMHSA (Substance Abuse and Mental Health Services Administration)

Poverty As a Limitation of Response

Addressing The Root of The Problem



Outlines how wealthy Americans consciously and subconsciously keep poor people poor

Poverty by America, WAMC

Defining The Problem

How Should We Use The Limited Resources We Have

- What is risk
- What is risk's metrification
- What is risk's public perception
- When to act to mitigate risk
- How do we quantify risk

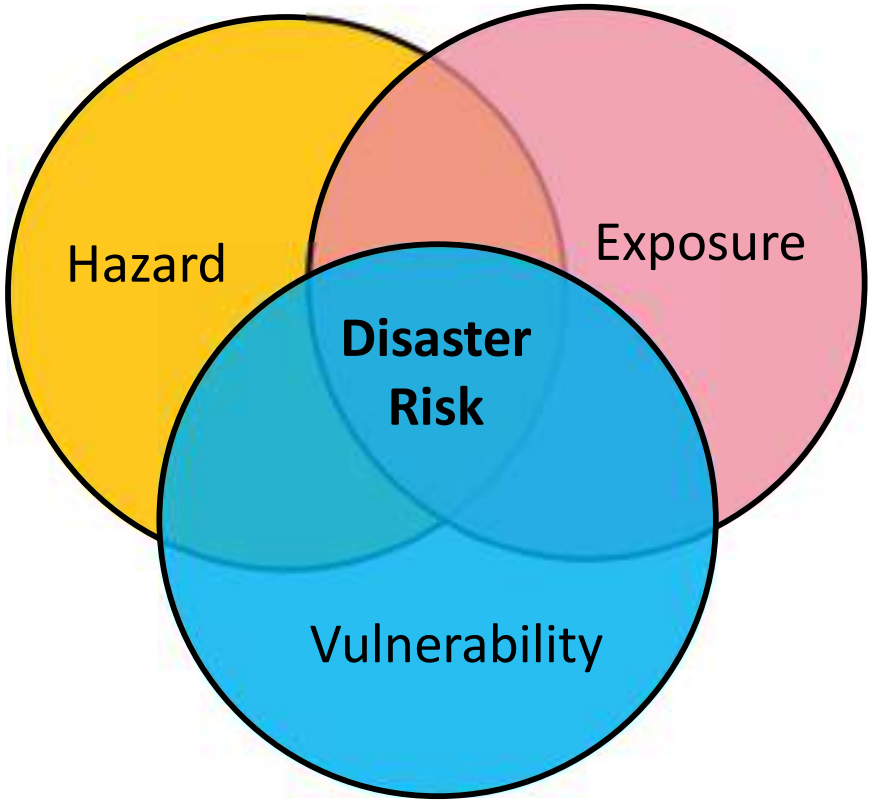
Defining The Problem

Some Definitions

Hazard: a physical event that can potentially trigger a disaster (e.g. earthquakes, floods, etc.)

Exposure: refers to what is exposed to the hazard (e.g., the **built environment & people**).

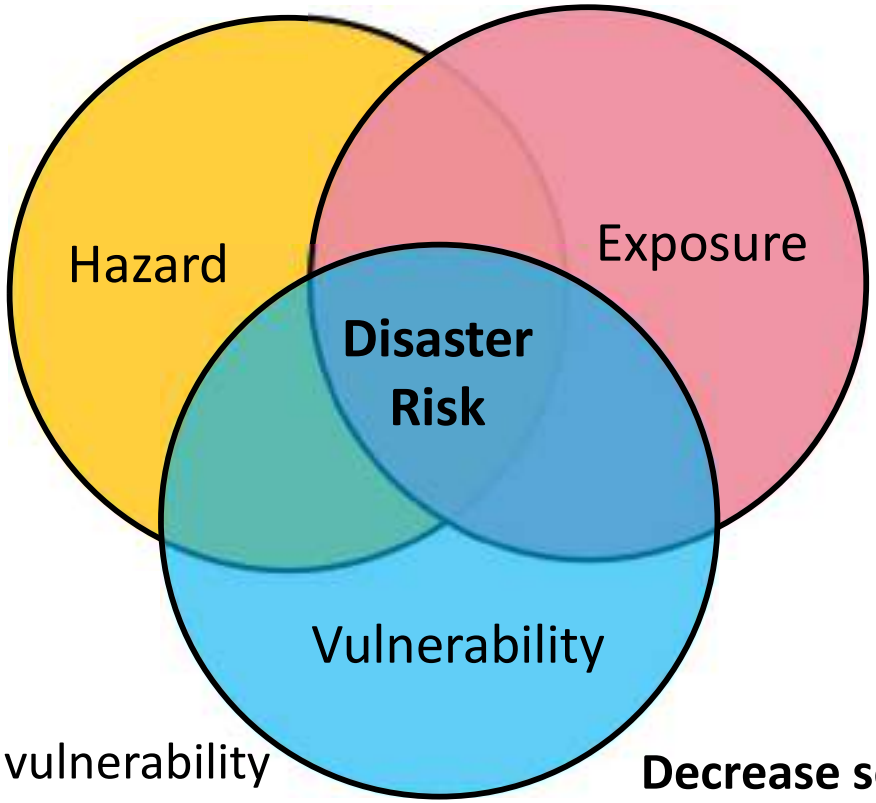
Vulnerability: depends on
(1) degree to which the **built environment** is **susceptible to damage**;
(2) **capacity of the society** to cope with the impact of the hazard



Defining The Problem

How Can We Reduce Disaster Risk

Reduce or prevent hazards
- Not possible for some hazards (e.g., earthquakes)
- Strategies exist for flooding/ landslides
- Minimize climate change



Reduce exposure
- Keep high-density development outside high hazard areas
- Put protective measures in high hazard areas

Decrease built environment vulnerability
- Implement/enforce building codes
- Require disaster-resilient design/construction
- Identify and strengthen vulnerable existing buildings

Decrease social vulnerability
- Raise awareness of local risk
- Promote preparedness/planning
- Offer disaster prevention training

Defining The Problem

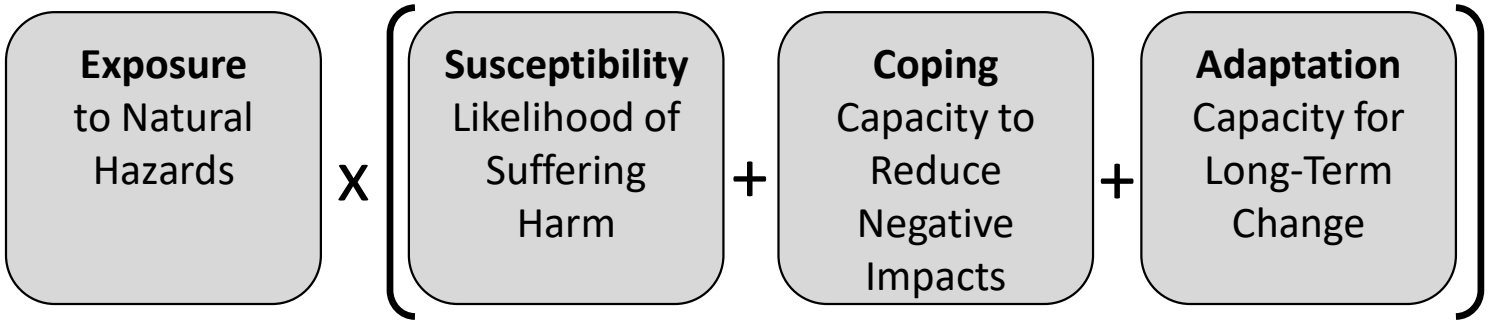
Vulnerability: World Risk Index

Risk = Hazard x Consequence Cost

Defining The Problem

Vulnerability: World Risk Index

Risk = Exposure x Vulnerability



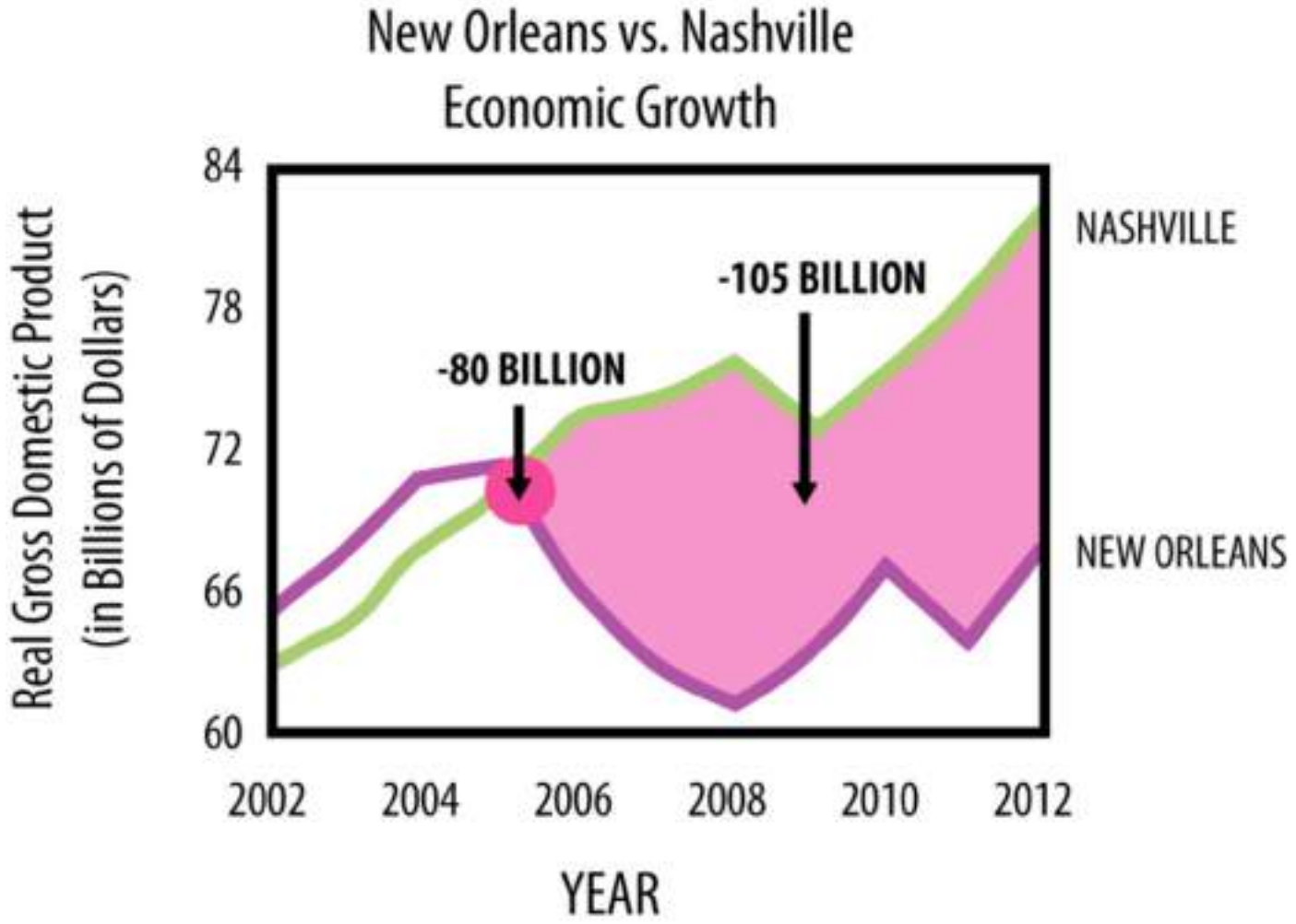
Measures a country's exposure, resiliency, response to an event, and preparedness for future events

Defining The Problem

The Consequences of Not Being Prepared

Similar sized cities

Similar economies and demographic



U.S. Bureau of Economic Analysis, Google Data

Defining The Problem

When Do People Act

- Before the disaster
- During or immediately after the disaster
- Post disaster

Defining The Problem

Benefit of Preventative Measures

EVERY $1 INVESTED

IN RISK REDUCTION & PREVENTION

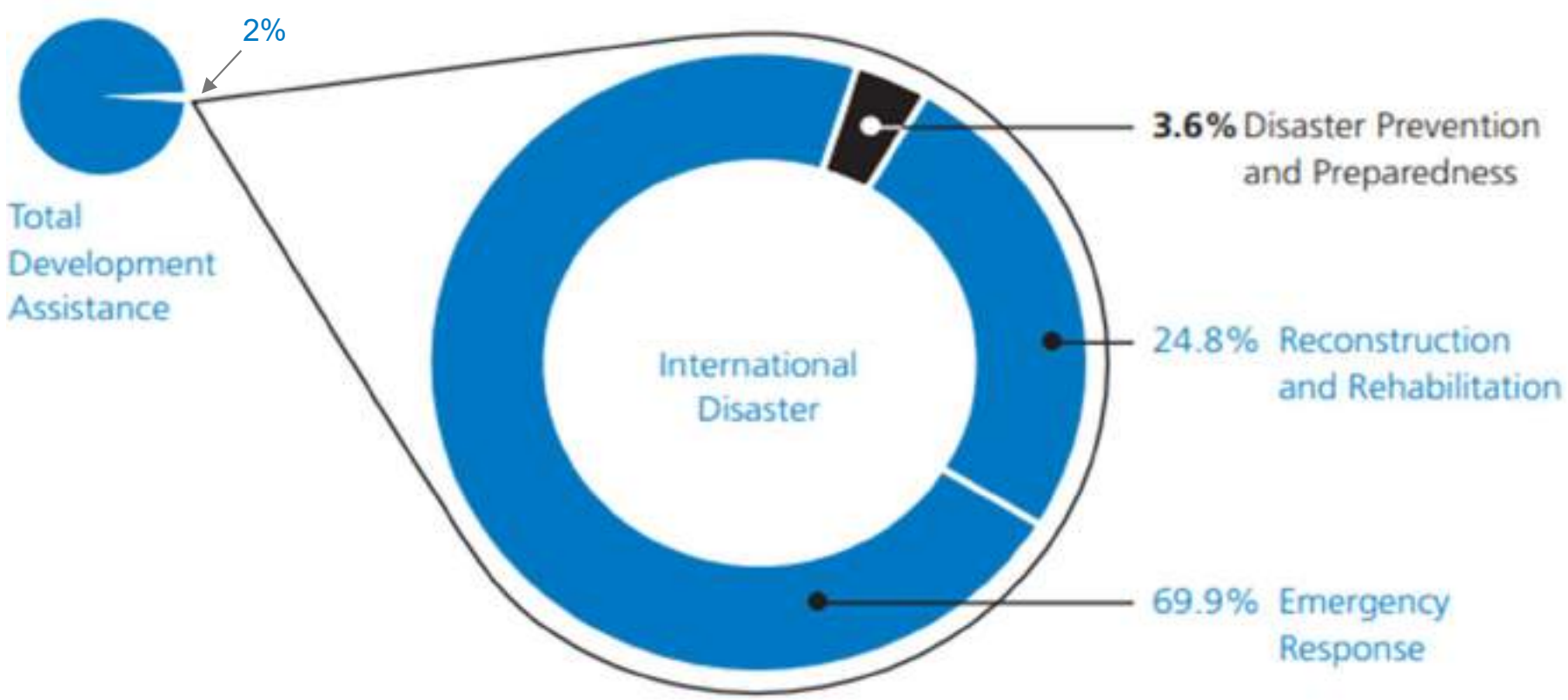
CAN SAVE UP TO $15

IN POST-DISASTER RECOVERY

– MAMI MIZUTORI, HEAD OF UN OFFICE FOR DISASTER RISK REDUCTION

Defining The Problem

U.S. Disaster Prevention Fund



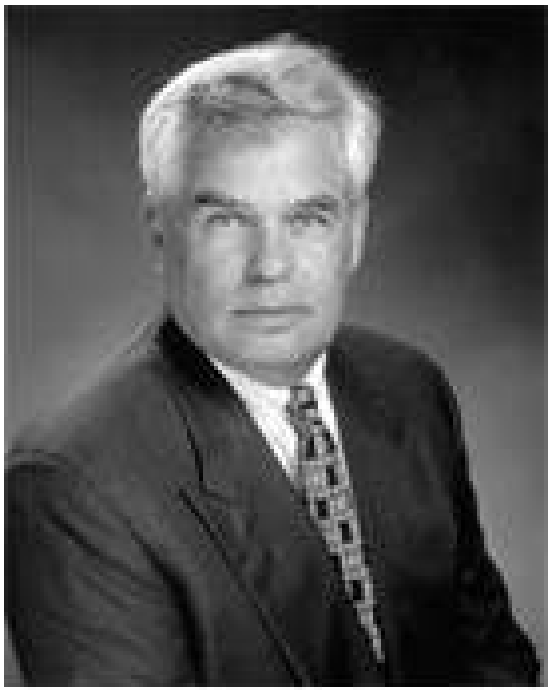
We should put our efforts into whatever provides the largest economic and humanitarian payoff

Taking Action

Catherine Bertini

- Executive director of UN World Food Program from 1992-2002
- For more info, go to: catherinebertini.com

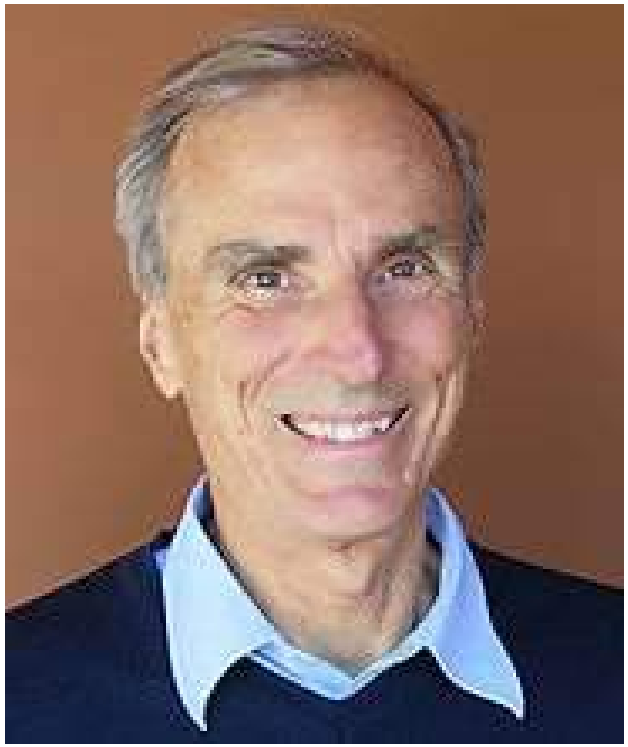
Taking Action



Chris Rojahn

- USGS (1973-1981)
- Executive director of American Technology Council (ATC) (1981-2015)
- Led 100+ projects on earthquake and natural hazard mitigation
- Contributed to codifying red, green, yellow earthquake safety tagging of buildings

Taking Action



Brian Tucker

- Worked to prevent losses from natural disasters in less developed countries
- Founded GHI in 1991
- Awarded Gorakha Dakshin Bahu Award by Nepalian King for his service to Nepal

Taking Action

Veronica Cedillos

- Current President of GHI (2019-Present)
- Directed projects on seismic and tsunami risk reduction in Armenia, Haiti, Indonesia, Kyrgyz Republic, Peru, and U.S., etc.

Taking Action

GeoHazards International

Internal Revenue Service (IRS) Declaration:

Non-profit organization dedicated to ending preventable death and suffering caused by natural disasters in the world's most vulnerable communities.

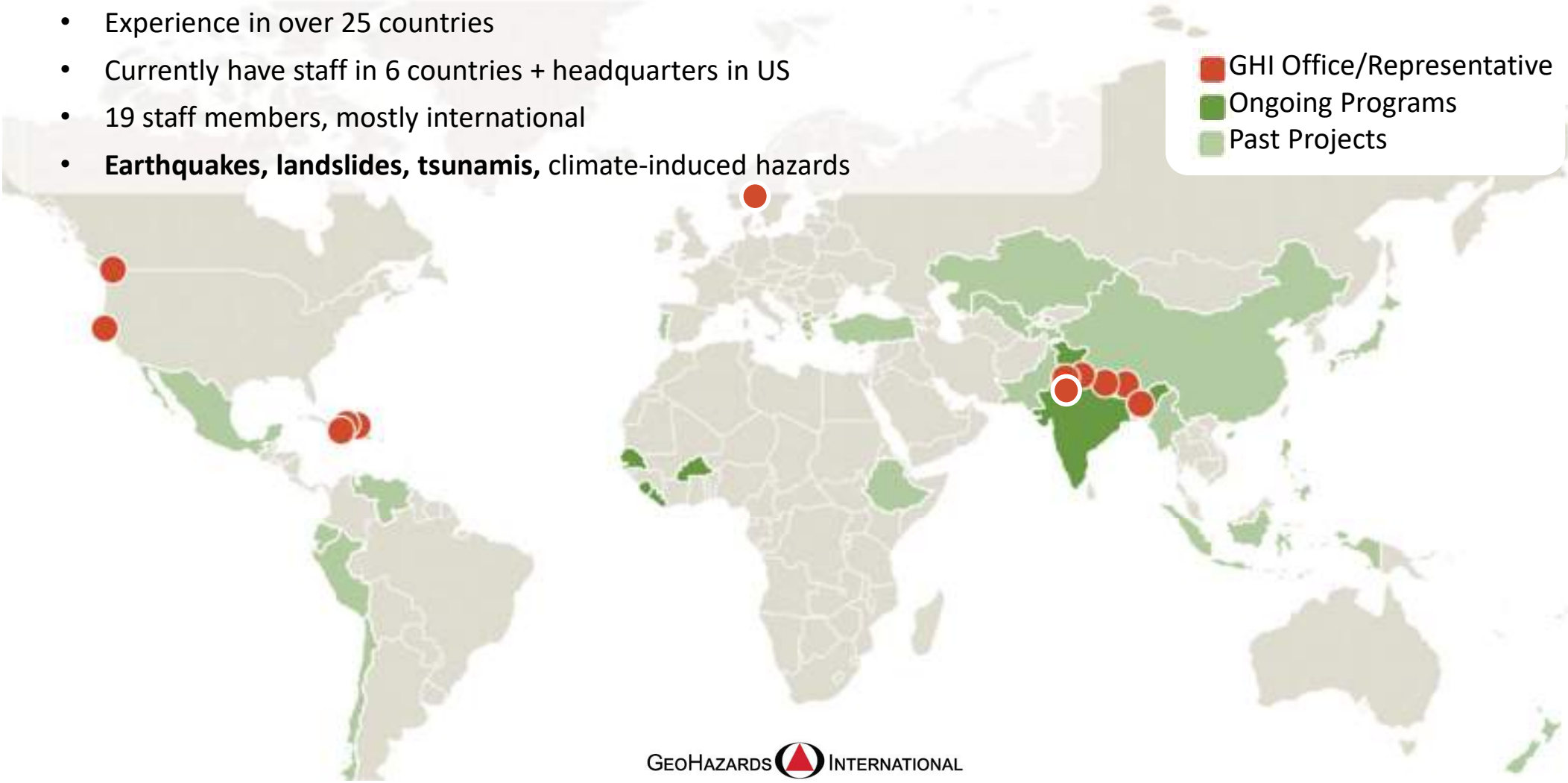
What Is GeoHazards International (GHI)

Focus Areas

What Is GHI

Areas of Work

- Experience in over 25 countries
- Currently have staff in 6 countries + headquarters in US
- 19 staff members, mostly international
- **Earthquakes, landslides, tsunamis,** climate-induced hazards



What Is GHI

Who Funds GHI

World Health Organization

USAID (US Agency for International Development)/ USGS

Corporations

Private/Family Foundations

Individual Donors

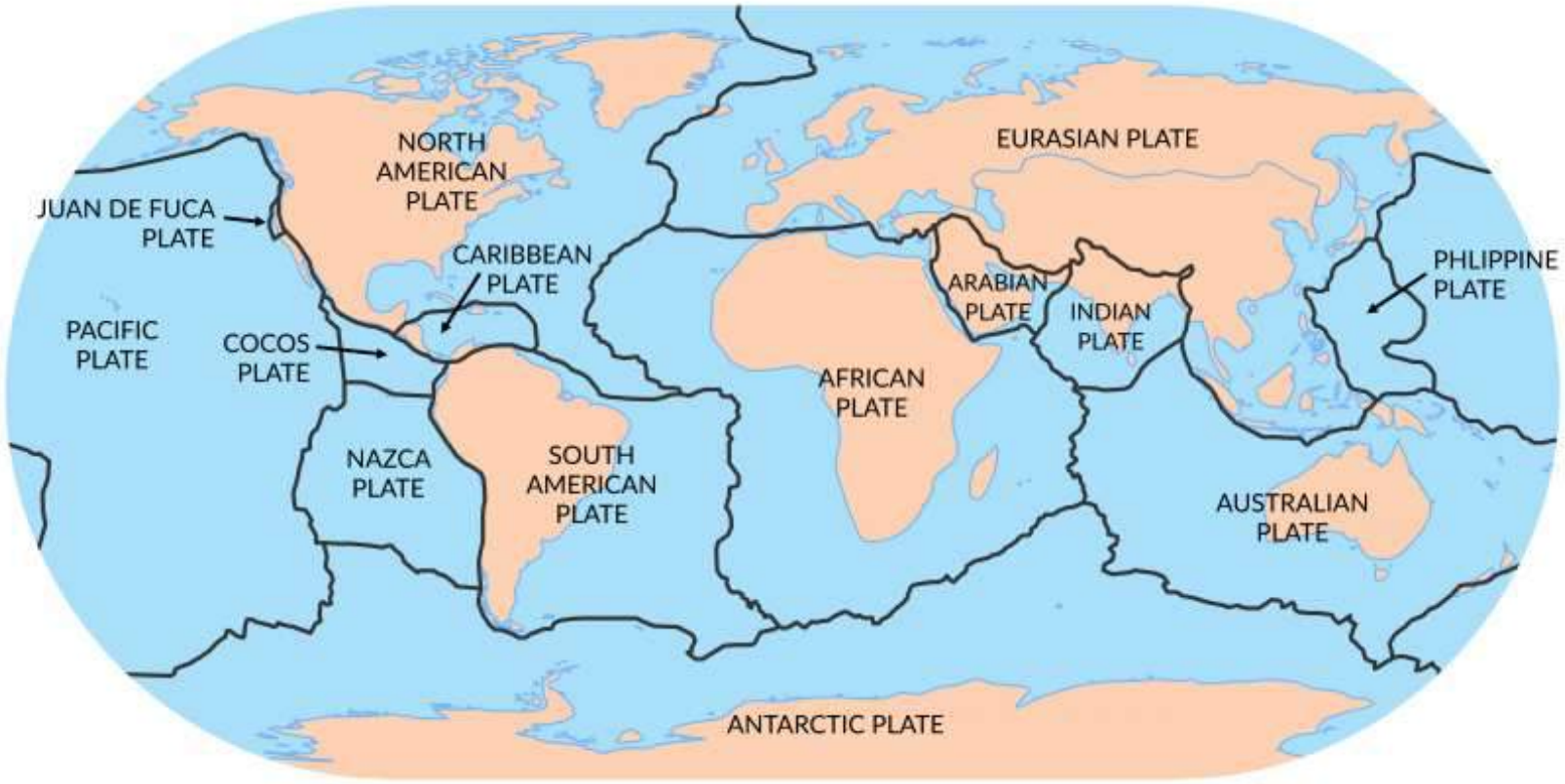
What Is GHI

Methods For Prevention

- Utilizing risk-informed planning
- Developing disaster-resistant design/construction
- Planning for post-event functionality of critical infrastructure
- Developing science-informed preparedness

Examples of Preventative Efforts

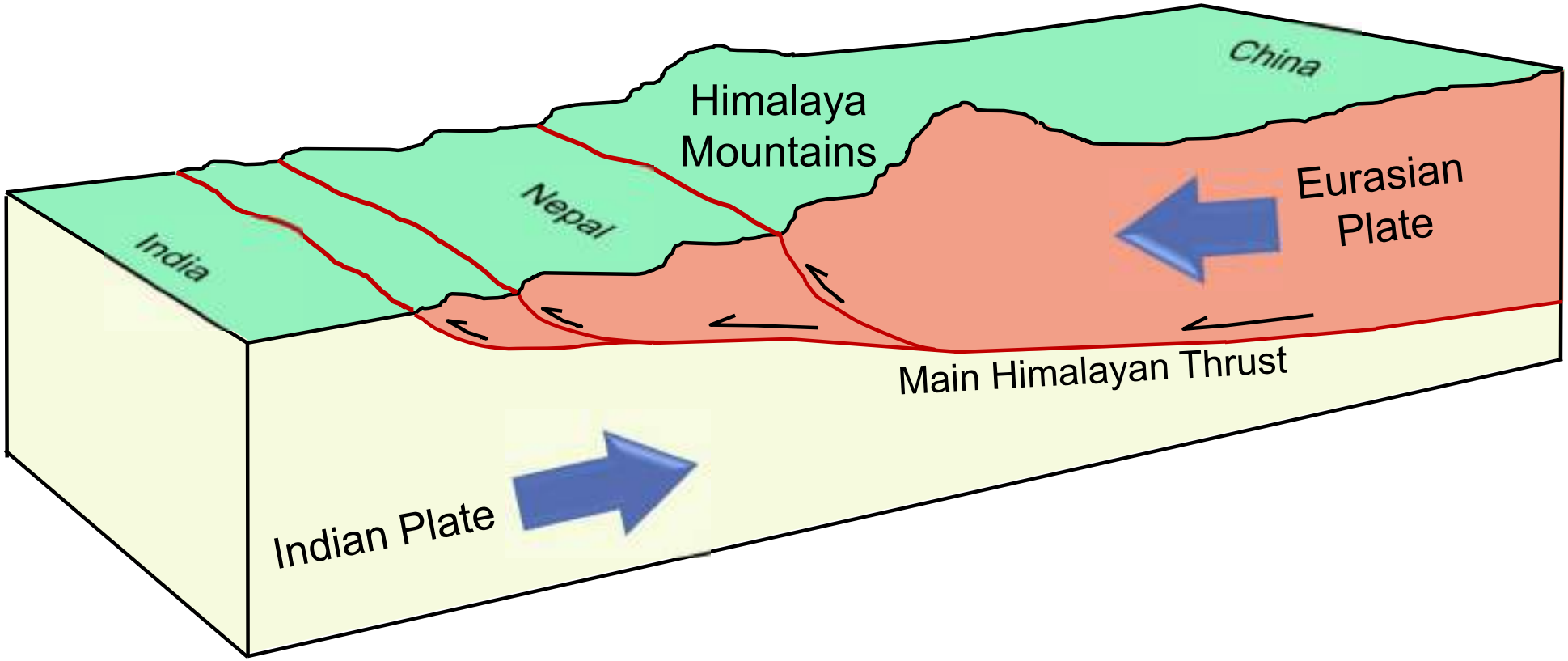
Earth's Tectonic Plates



Tectonic Plates: Large pieces of the earth's outermost layer/crust

Examples of Preventative Efforts

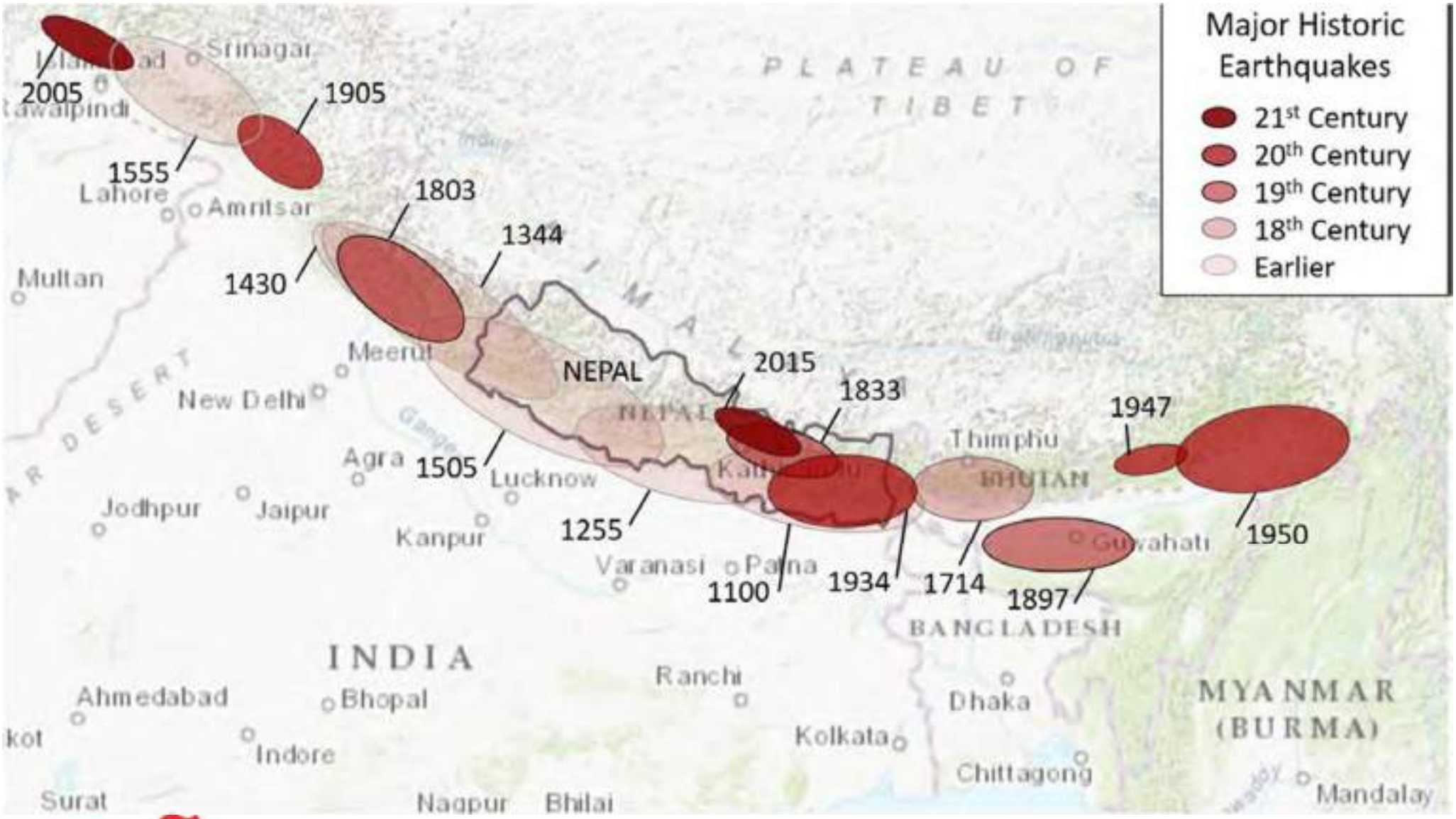
Indian and Eurasian Plate Boundary



Subduction Zone: where two plates collide, and one plate is thrust under the other

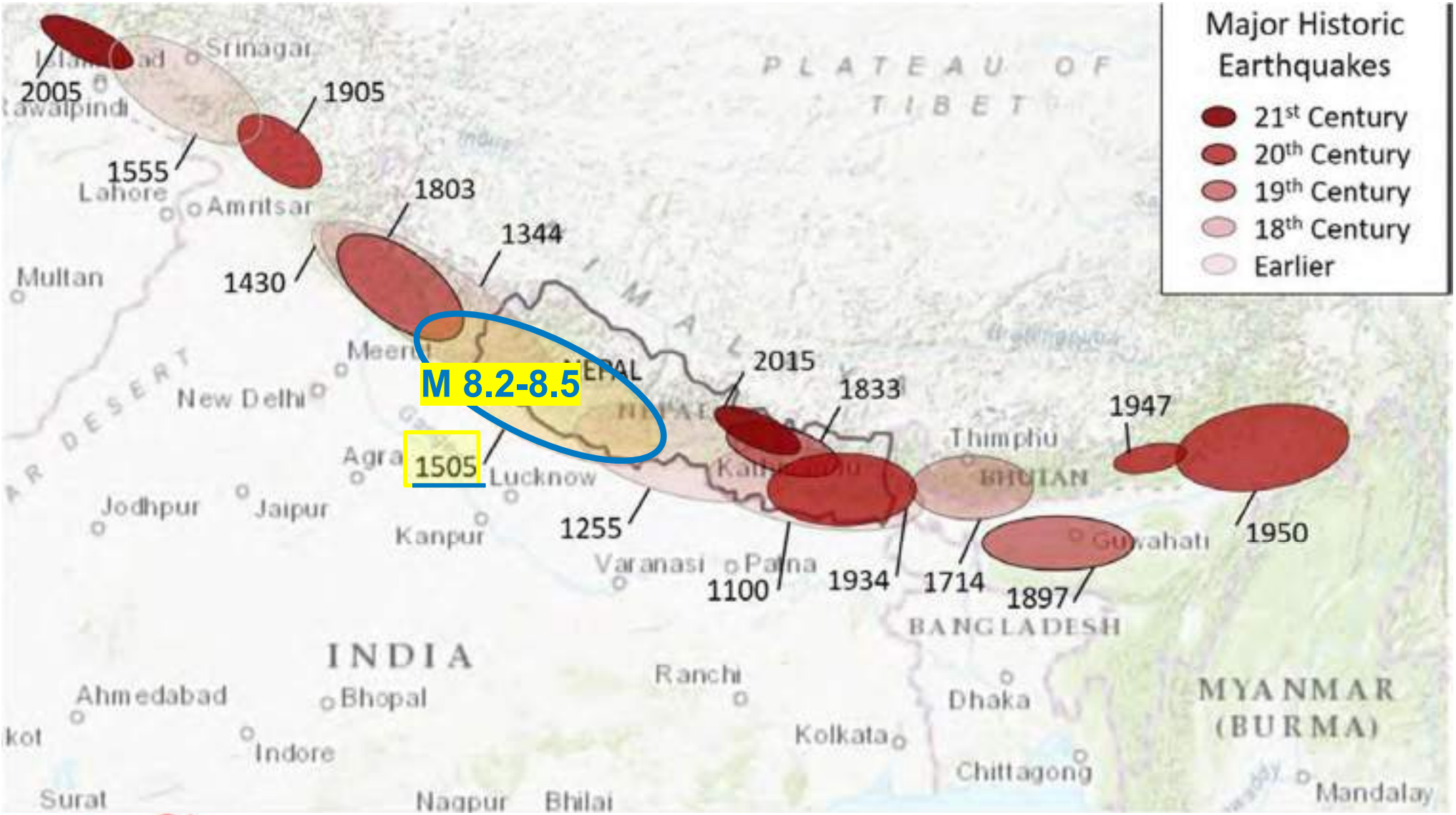
Examples of Preventative Efforts: GHI

Earthquake Tracking Along Boundary



Examples of Preventative Efforts: GHI

Predicting the Next Event



Examples of Preventative Efforts: GHI

School Retrofitting Program: Nepal (late 1990s)

- First school earthquake retrofit in Nepal
- Local masons trained, community participation
- Sparked hundreds of retrofits & new construction using similar methods

Examples of Preventative Efforts: GHI

School Retrofitting Program Successes

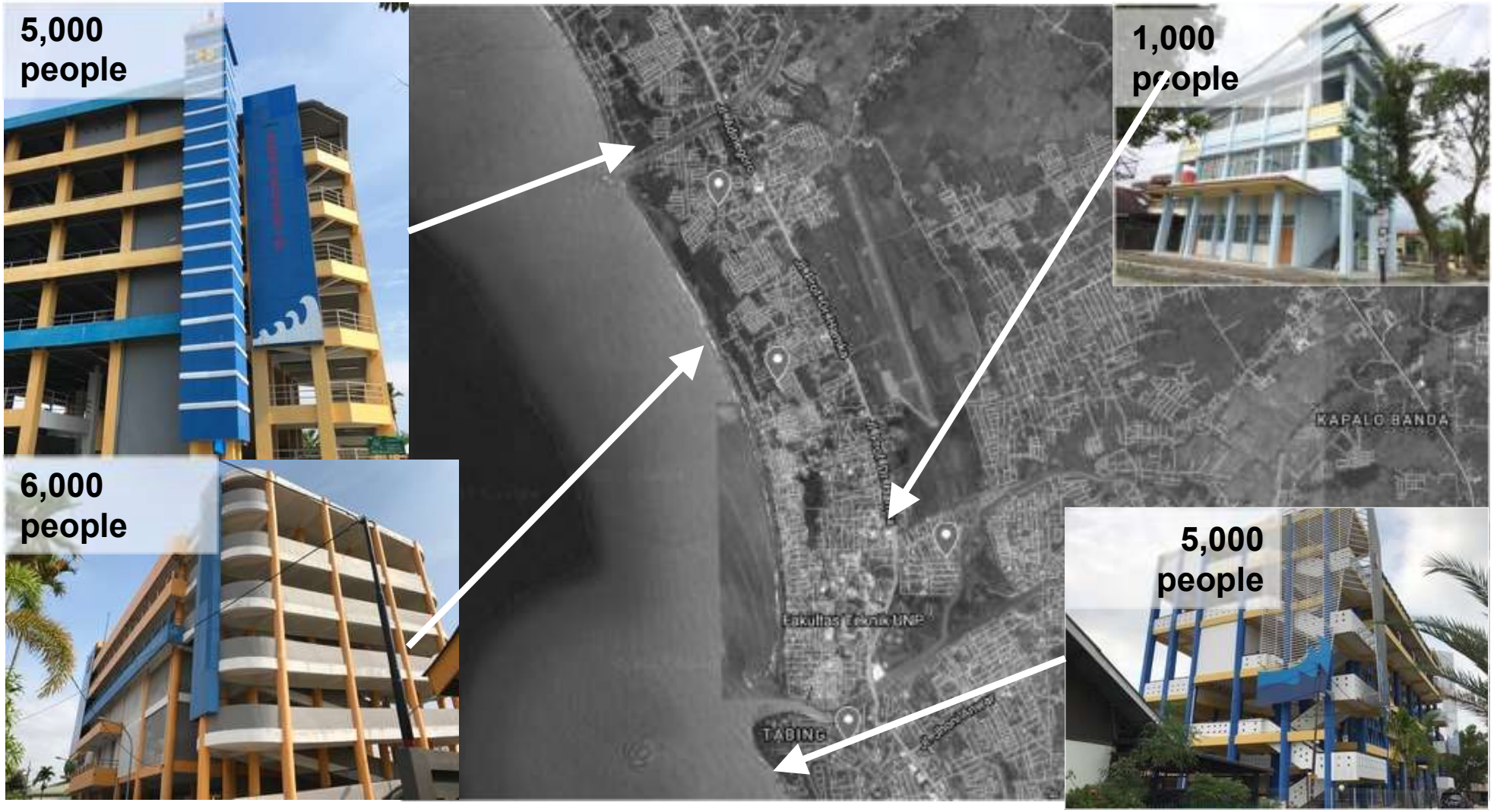
2015 M7.8 Earthquake in Nepal:

- 7,000+ schools destroyed

- Impact from program in the late 1990s -- ALL retrofitted schools were undamaged, some used as shelters

Examples of Preventative Efforts

Tsunamic Evacuation Buildings: Padang Indonesia



Examples of Preventative Efforts

Pedestrian Overpasses: Japan

Examples of Preventative Efforts: GHI

Tsunami Evacuation Raised Earth Parks (TEREPS)

Can become:

- Walking paths
- Public spaces
- Sports fields

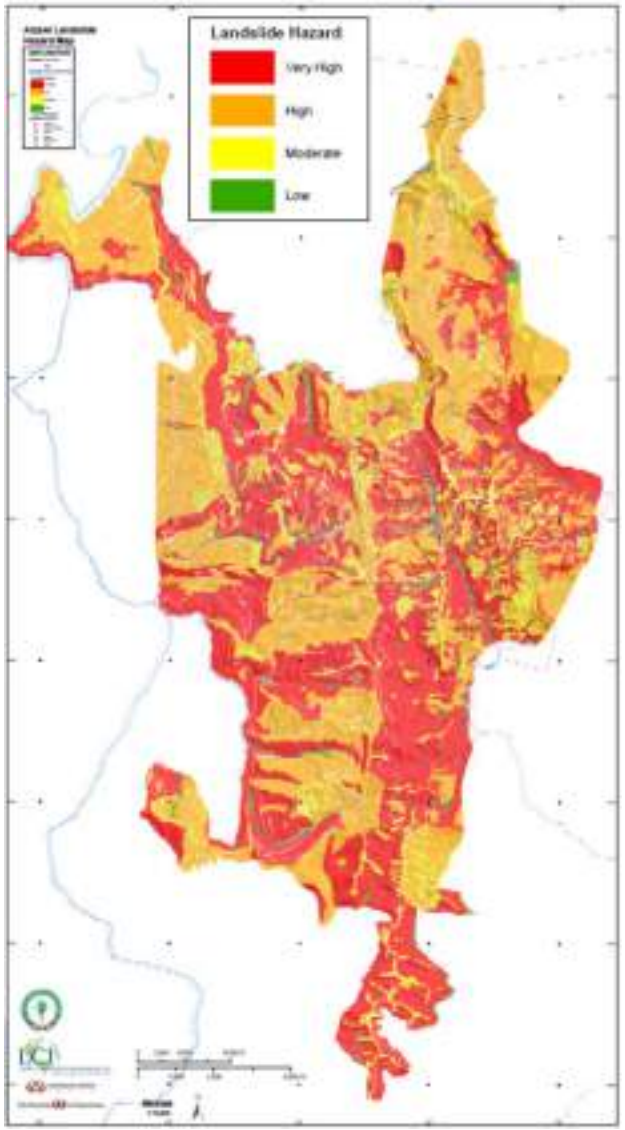
Combat flat terrain, dense population, lack of effective evacuation options

GHI, Swiss Re

Examples of Preventative Efforts: GHI

Aizawl, India: Landslide Risk Mitigation (2017)

- Area largely susceptible to landslides
- Developed landslide hazard map
- Trained locals in landslide risk



Conclusions

Key Takeaways

- Hazard events don't necessarily **need** to turn into disasters
- Shift the paradigm – **proactive** approach & disaster **resilience** at every table
- Treat this with **urgency** – staggering increase in risk, climate crisis & deepening inequities

Conclusions

We Have Seen What Others Have Done, Now It's In Your Hands…What Can **You** Do

- As future structural engineers & leaders, you can play a ***major role*** in promoting ***disaster-*** and ***climate-resilient*** buildings and infrastructure.
- ***Advocate*** for ***disaster resilience*** in your *industry*.
- Lean into ***other disciplines***, disaster resilience is not achieved in silos.
- Learn to ***communicate effectively*** to decision-makers, influential people, and within your broader community.
- ***Advocate* for *those that are most exposed*, and *most vulnerable*.**

For More Information…

Contact:

ramon.gilsanz@gmsllp.com

cedillos@geohaz.org

Contact GHI:

www.geohaz.com

geohaz.org

geohazards_international

@geosafety

geohazards-international

Credits

Ramon Gilsanz, PE, SE, F.SEI, F.ASCE - GMS

Dan Eschenasy, PE, F.SEI - GMS

Gia Antonelli - GMS

Reed Miller - GMS

Veronica Cedillos, President and CEO - GHI

Susan Bailey, Development Director - GHI

Thank You

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