The 2010 Haiti Earthquake: Lessons Learned, Challenges and Opportunities for a Resilient, Sustainable Haiti

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ISDR

L'UNION FAIT LA FORCE
RÉPUBLIQUE D'HAÏTI

One billion people in developing countries are vulnerable to disasters because they live in congested and poorly built houses without emergency services…… Fewer people die from cyclones, floods and earthquakes in countries with planned housing, infrastructure and emergency teams, but lack of financial capacity in developing countries, worsens the impact of disasters.
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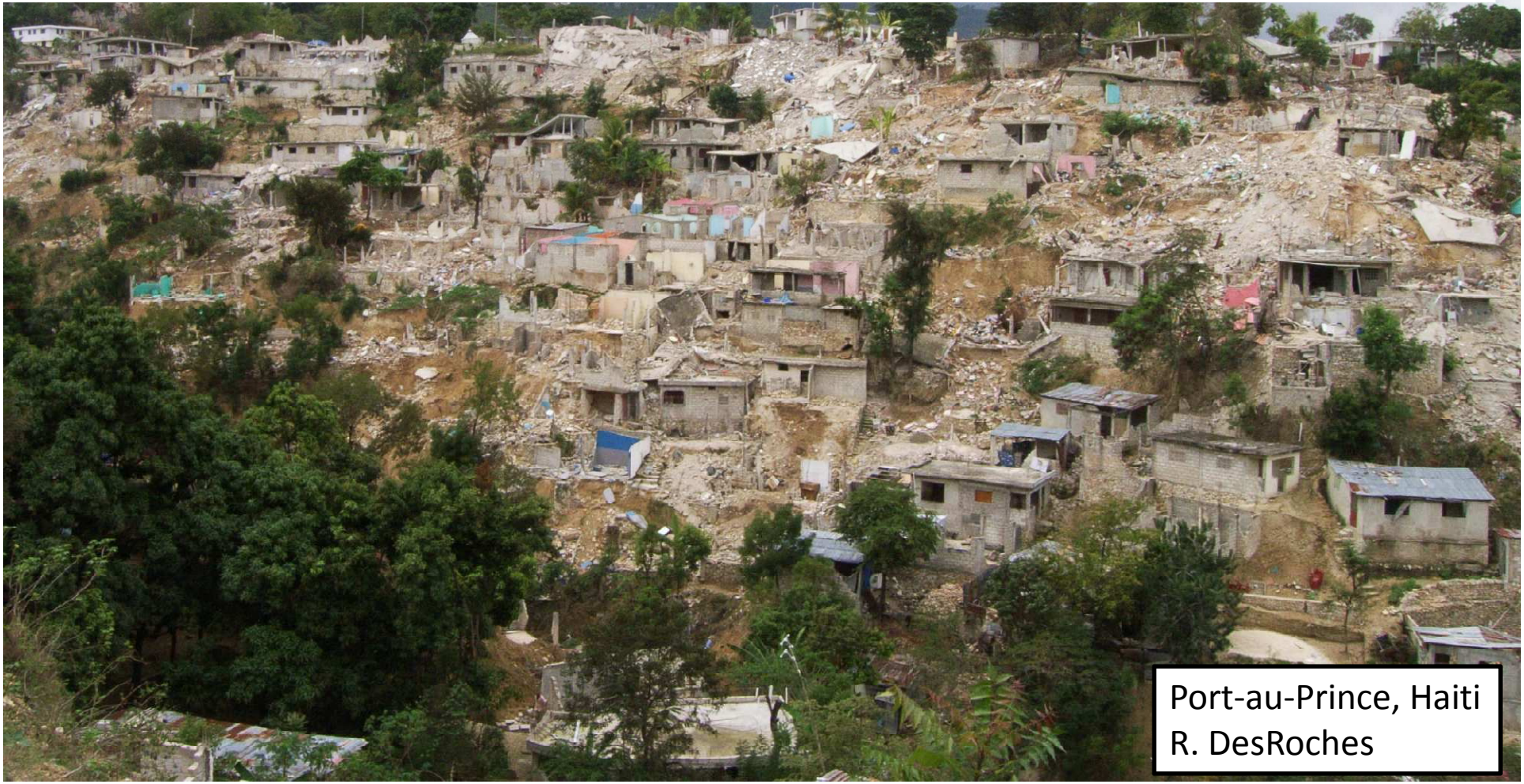
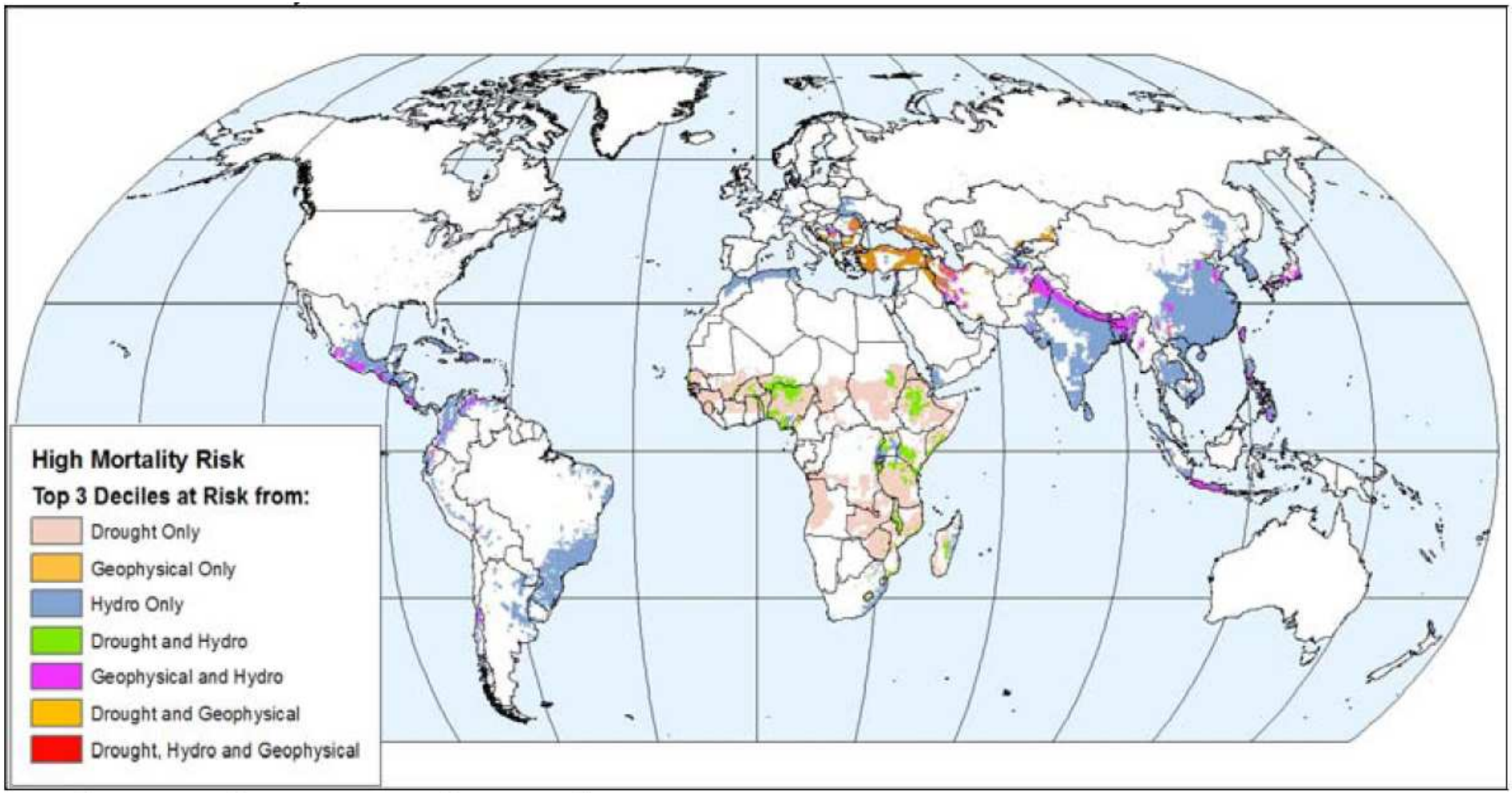


Port-au-Prince, Haiti
R. DesRoches

Global Risks to Natural Hazards



Center for Hazard and Risk Research, 2005

Questioning the Disaster

- Why do the number of casualties in Haiti far exceed the “norm”.
- What are the conditions that led to the disaster in Haiti?
- Where are the future disasters likely to occur?
- What can/should the international community do to reduce the impact of future hazards in Haiti and other countries?

Overview of Haiti

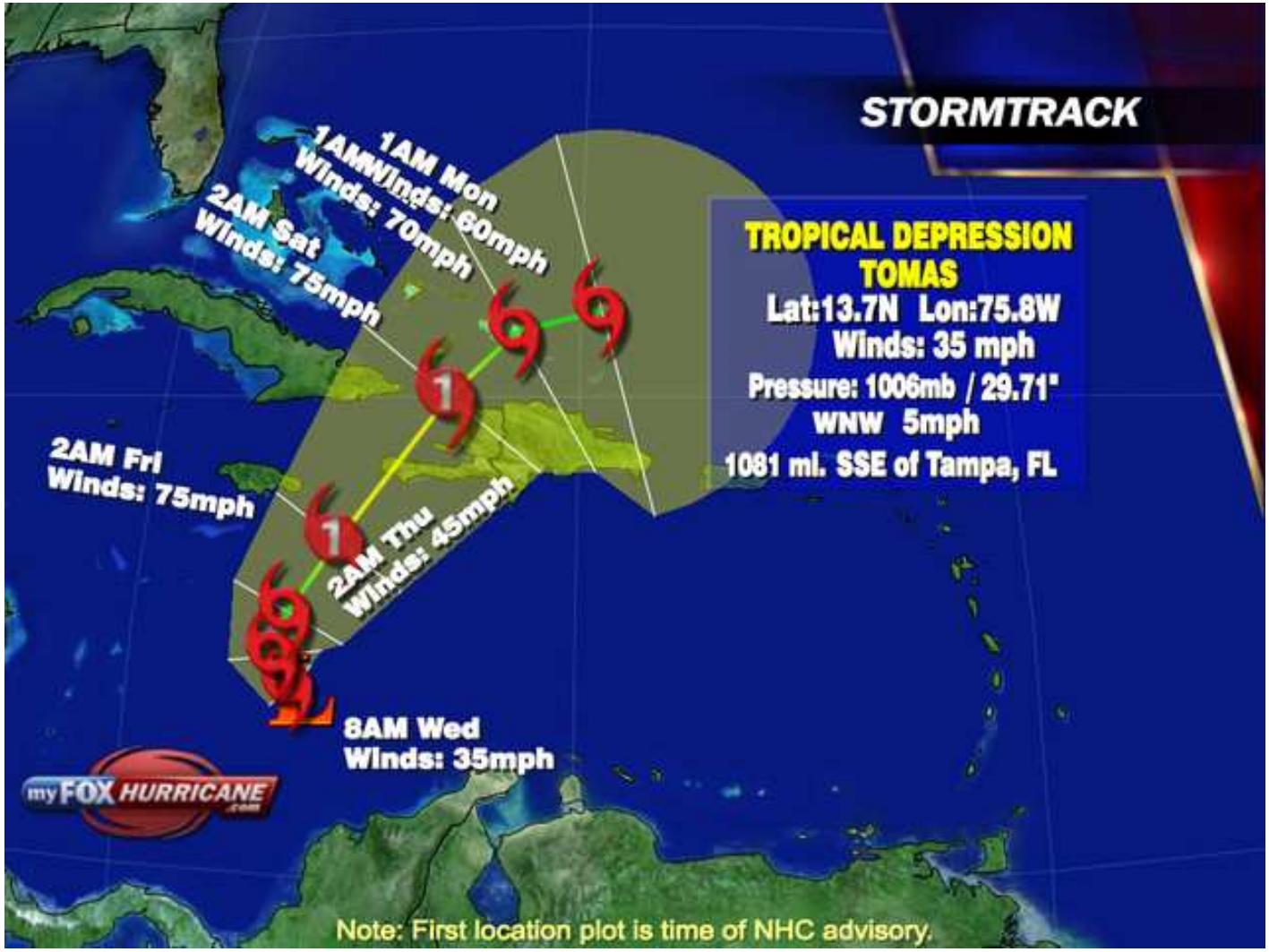
- 10,000 Square miles
- 1st Free Black Nation, 2nd Independent Country in West.
- Population of 10 million
  - PaP approx 3-4 million
- Poorest country in Western Hemisphere
  - $9 Billion GDP, $790 per year
- Illiteracy rate of 50-70%
- 50% of population less than 18 years old

Context – an ongoing crisis (1)

Haiti has one of highest exposure to hazards in the world

- 96% of the population is exposed to 1 or more hazards
- Two active seismic fault lines
- Highest index of vulnerability to cyclones of the island states in the region
- One the three most vulnerable countries to climate change impacts

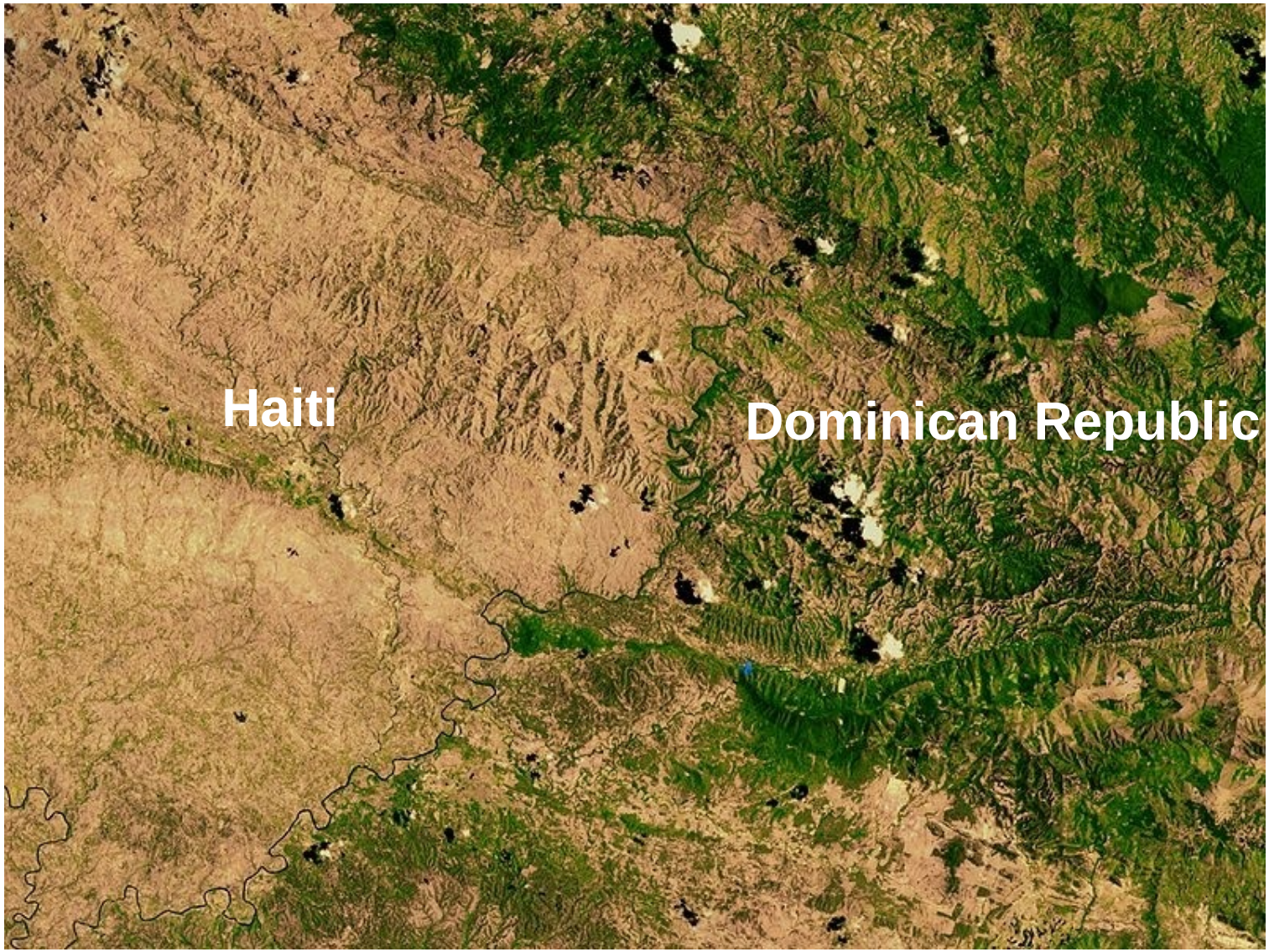
Hurricane Tomas



Context – an ongoing crisis (2)

- **Extreme vulnerability**
- High environmental degradation, housing and infrastructure in flood prone areas
- High level of poverty
  - Most people live on less than $2 per day
  - Largest income inequity in hemisphere
- Limited public infrastructure
  - Poor road network (less than 500 miles of paved road)
  - <10% access to clean water
  - <12.5% access to electricity
- Governance challenges
  - Weak government
  - 92% of services provided by NGOs
- Limited technical capability
- Chronic financial deficit
  - Only country to have long term decline of GDP

Environmental Degradation in Haiti



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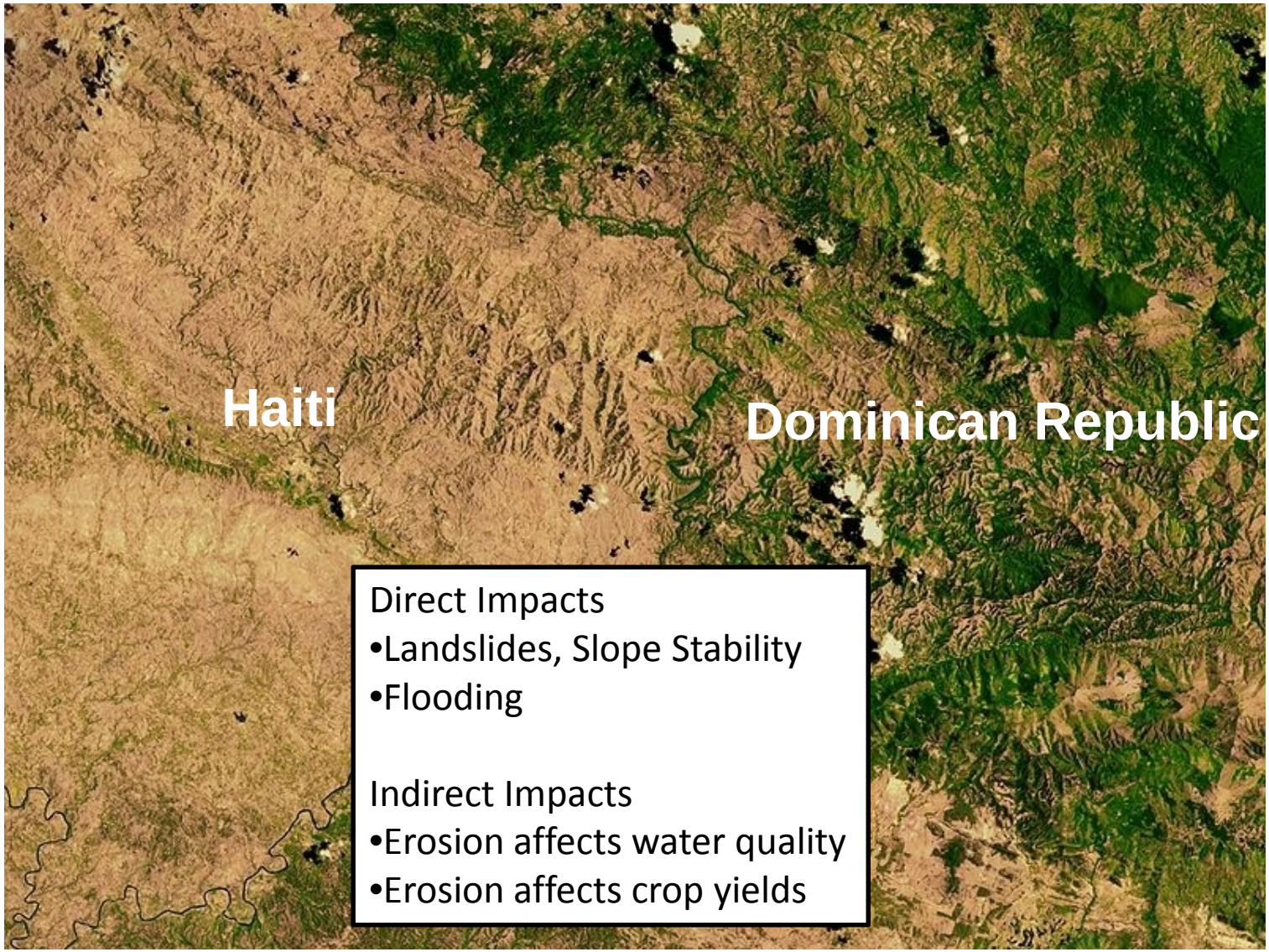
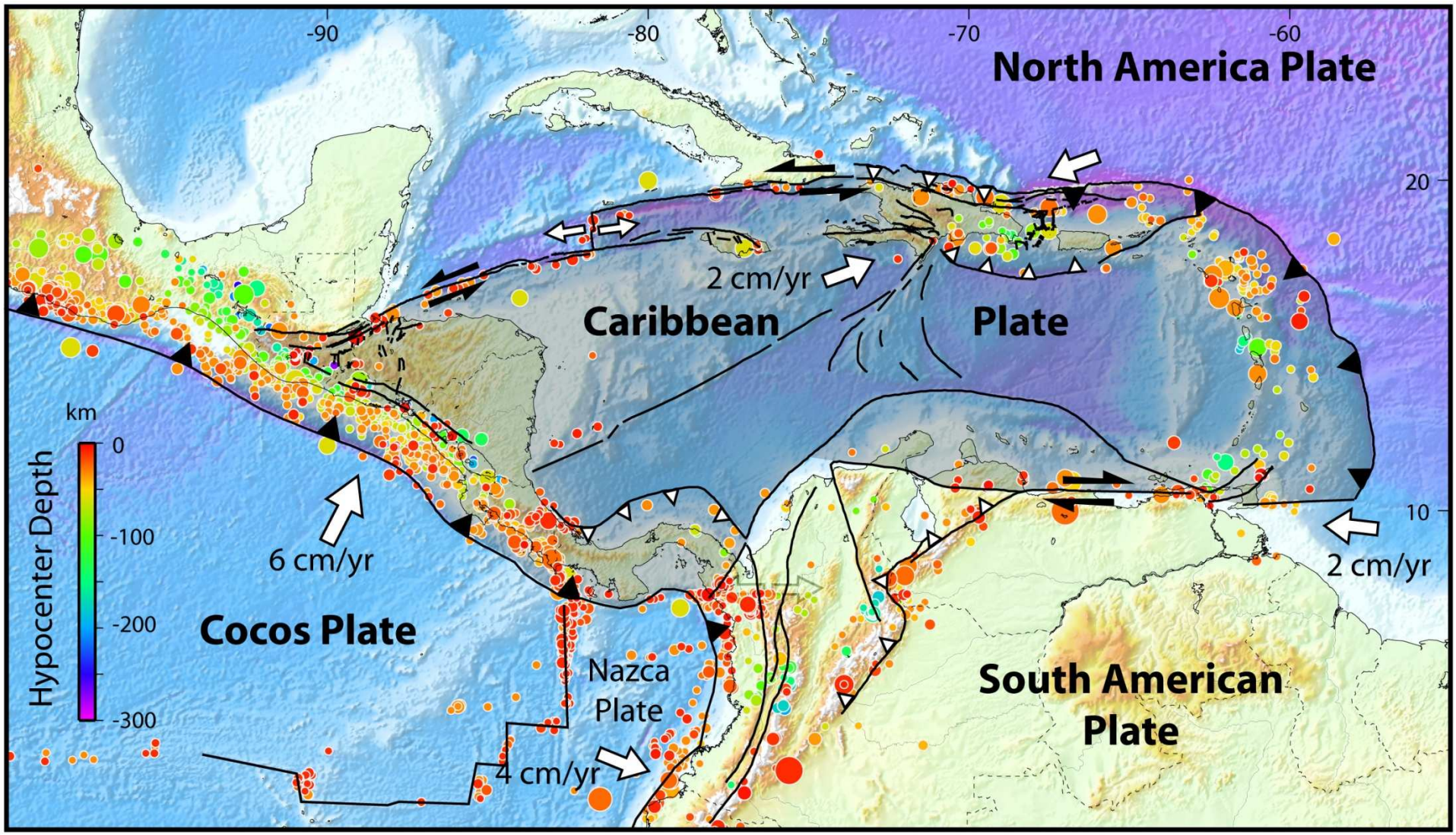
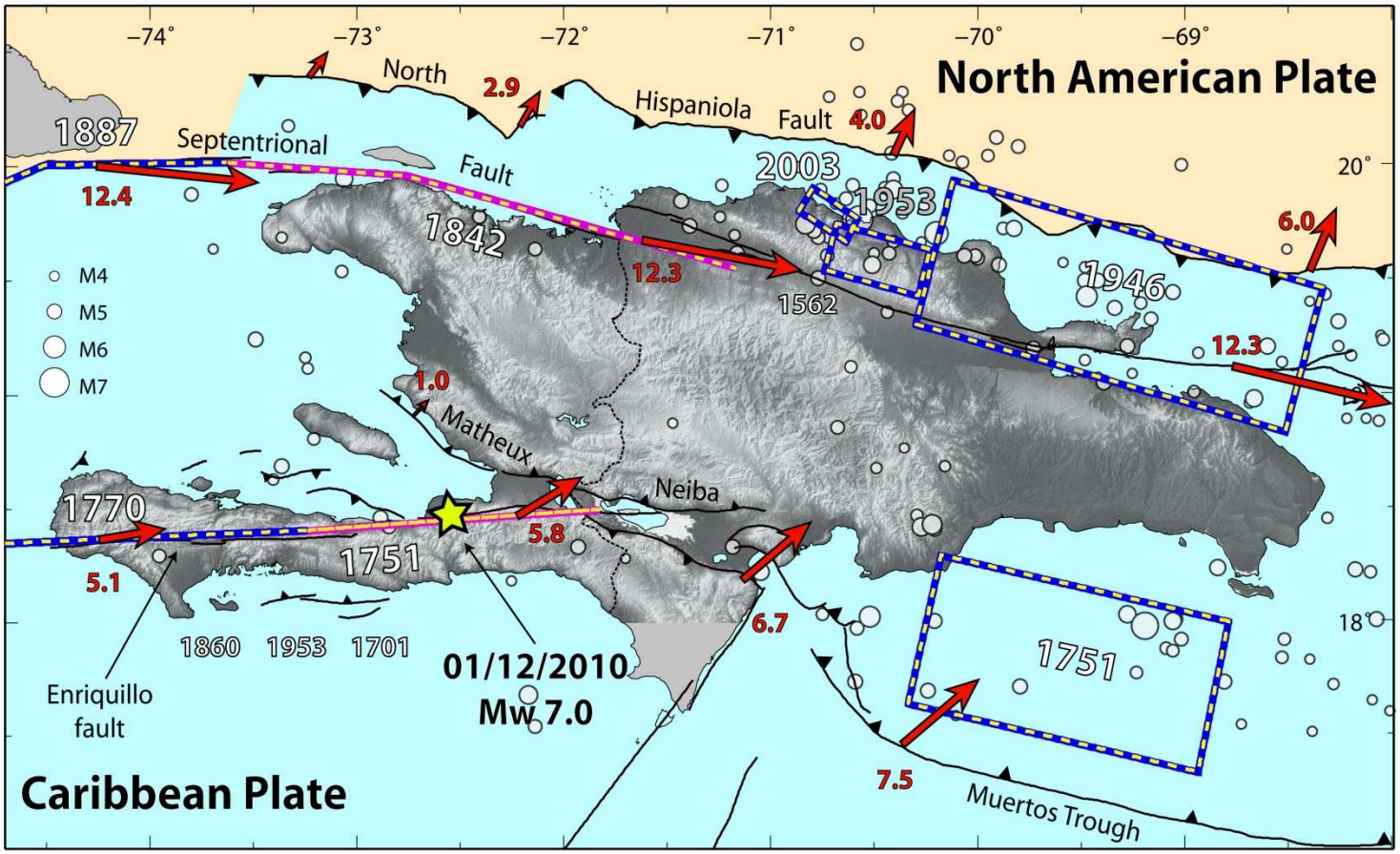


Seismicity in the Caribbean



2010 Haiti Earthquake



- Mw 7.0 EQ, 4:53 PM, Depth = 8.1 miles
- Epicenter ~ 15 miles from P-a-P
- Population Affected ~ 3-4 Million

Rupture

- 10 seconds long
- East to West
- 30 KM long

2010 Haiti Earthquake

- 250,000-300,000 dead
  - Largest in History (per capita)– 5x more than the 2nd deadliest EQ (1972 Nicaragua)
- 13 out of 15 Gov't buildings collapsed
- 45% of police stations collapsed (60 % of prisoners escaped)
- 5000+ schools collapsed (41,000 casualties)
- 87% of Universities Collapsed
- 250,000 homes collapsed
- 30,000 commercial buildings collapsed
- 300,000 injured
- 1-1.6 Million Homeless
- Estimated Cost of $14 Billion
  - Largest Cost for Natural Disaster in History (as function of GDP)

Trip 1: EESU/UN MISSION

- Team of 10 Structural/Architectural Engineers
- Provide preliminary structural assessment for remaining standing *critical* buildings in Port-au-Prince
- Used ATC Tagging System (RED, YELLOW, GREEN)
- Inform responsible parties of recommendations regarding building occupancy
- Report findings to UNDP (United Nations Development Prog) coordinator and provide supporting documentation

Our Home for 7 Days

Trip1 : Rapid Building Assessment Team

- Hospitals/Medical Facilities: 34
- UN Office Buildings/Residences: 35
- Other private dwellings: 14
- Schools/Colleges: 7
- Warehouses: 6
- Commercial buildings: 5
- Orphanages: 2
- Government Buildings: 3
- Others:6
- **Total: 120**

~25% Red (unsafe), 25% Yellow (limited entry), ~50% Green (safe)

Ministry of Justice Courthouse

- Complete collapse of 3 story building
- 7 workers from courthouse still missing
- Minister of Justice needed to obtain critical documents
- Assessed the structural integrity of basement entry and cleared for rapid retrieval of critical documents

Trip 2: ASCE/EERI Earthquake Reconnaissance

- March 6-13
- Team of 28 structural engineers, city planners, architects, geographers, emergency responders.
- Goal: Document damage, collect data, and meet with local officials and engineers.
- Make recommendations on rebuilding
- Visited over 500 facilities
- Office buildings, homes, government buildings, historical structures, industrial buildings, ports, telecommunications, water, power, and hospitals
- PaP, Leogane, Petit Goave, Jacmel, St. Marc


EMSA


ImageCat, 2010

Government Buildings

Rubble/solid brick bearing wall with wood floor + slab framing

Ministry of Agriculture

Government Buildings

Ministry of Agriculture

Government Buildings

Presidential Palace

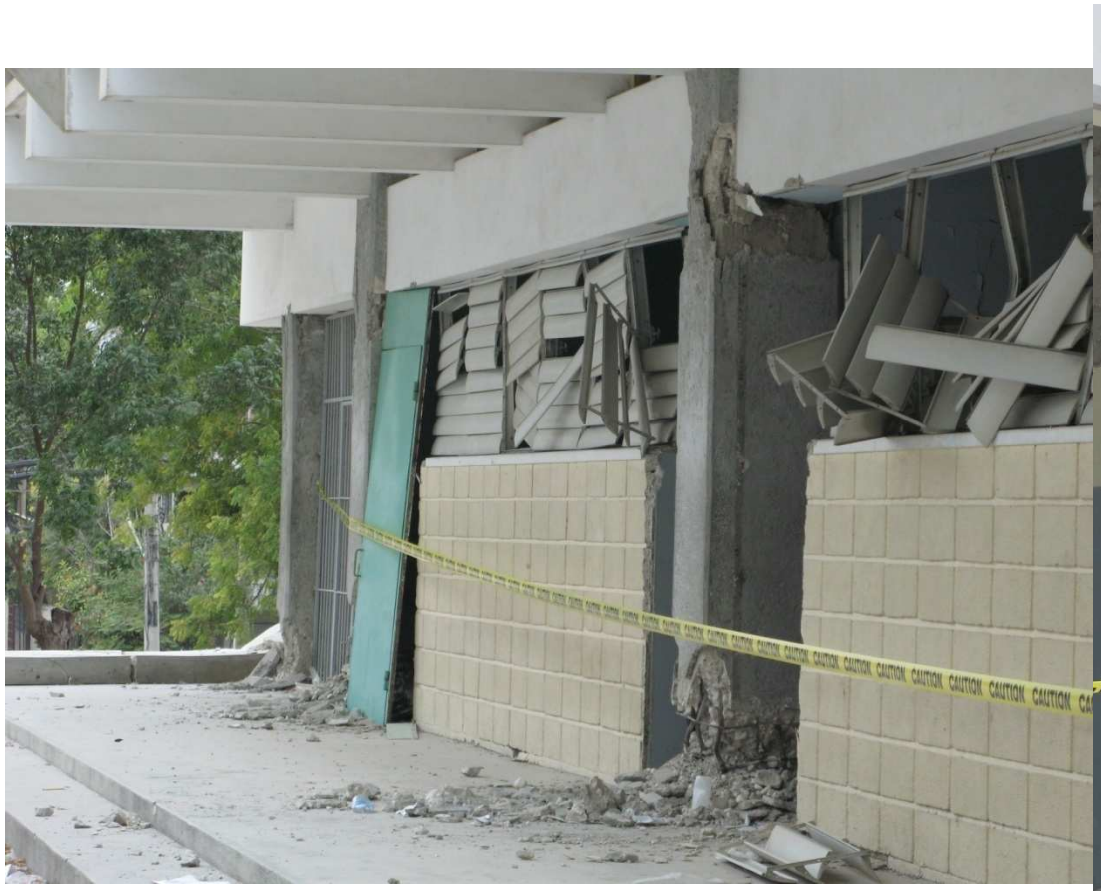
Damage to Schools

Most were RC MRF with hollow CMU infills

St. Louie de Gonzague School

Damage to Schools

Damage to Columns

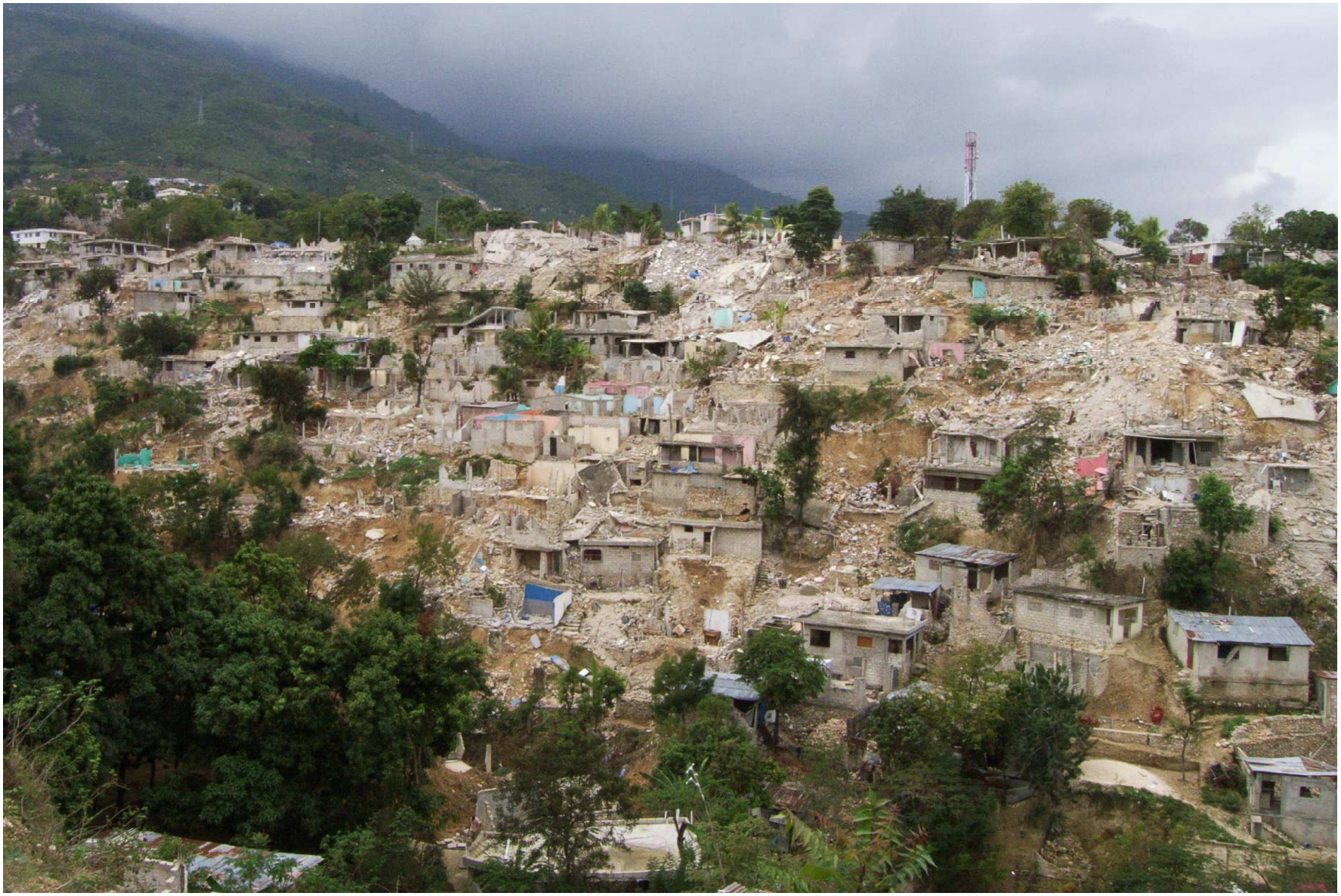


St. Louie de Gonzague School

Downtown PaP

Collapsed Apartment Bldg

Overcrowding in Haiti



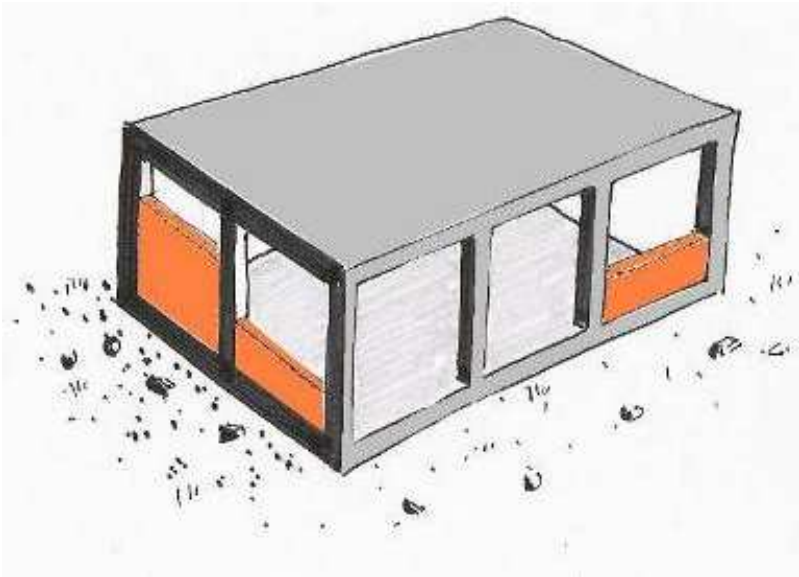
Low-rise and Residential

Most common: Concrete frame, concrete block infill or confined masonry.

Low-rise residential

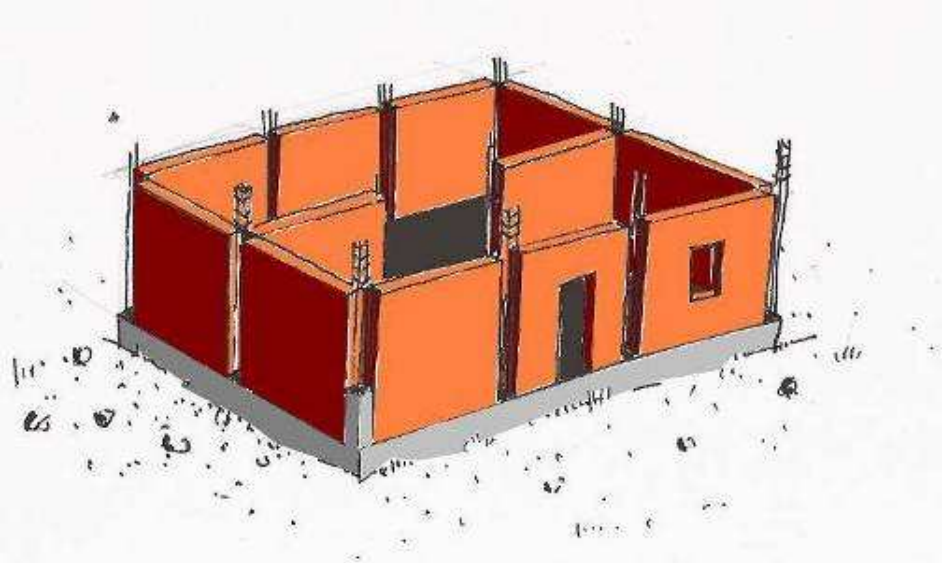
RC Frames w/ Masonry Infill

- RC Frame construction is completed first and masonry walls are built later. Confining elements are not designed to act as a moment-resisting frame; infill walls NOT load bearing



Confined Masonry

- Masonry walls are constructed first; subsequently, RC tie-columns are cast in place next. Finally, RC tie-beams are constructed on top of the walls, simultaneously with the floor/roof slab construction



Residential Timber Construction

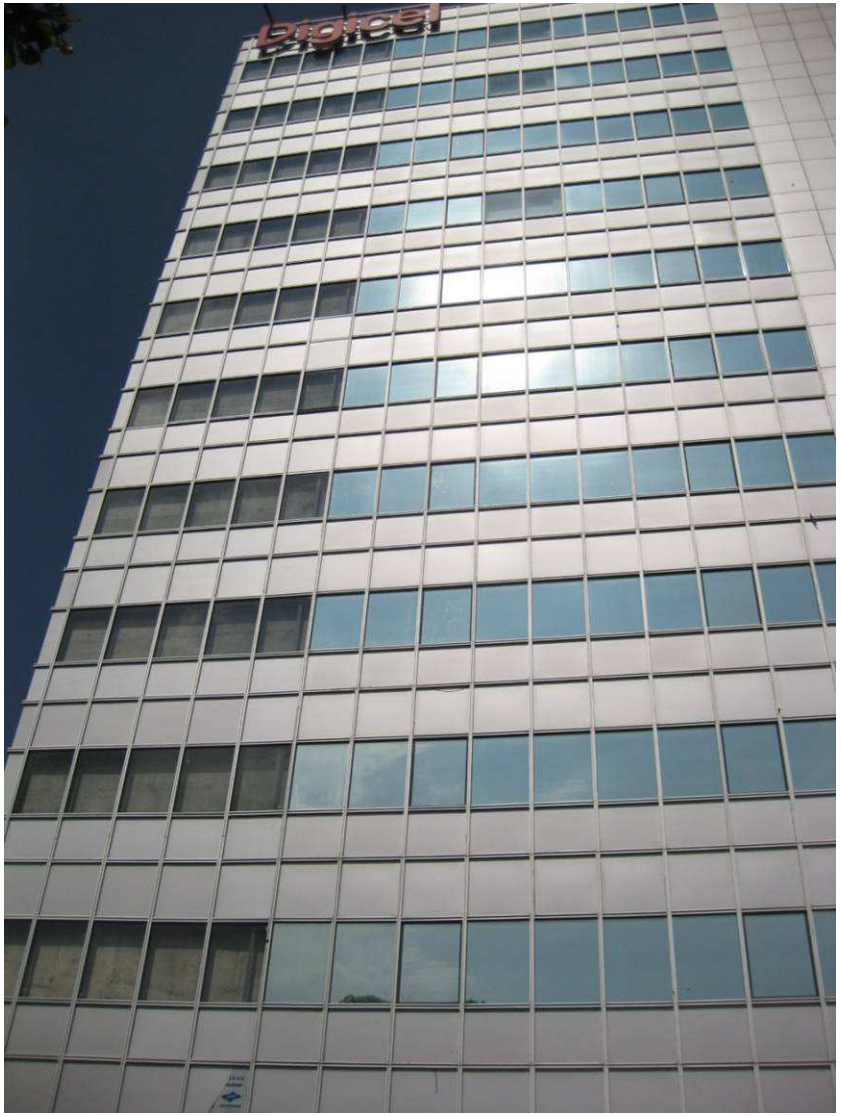
- All-wood buildings are very light and flexible.
- 10% require demolition, 75% moderate-major repair and/or retrofit, 15% minor repair

Common Vulnerabilities

- Inadequate structural systems
  - Soft stories
  - Lack of symmetry
- Quality of Construction
  - Lack of trained/skilled labor
  - Lack of Heavy machinery
- Quality of Materials
  - Quality of cement, sand, water
  - Smooth steel bars
- Lack of Details
  - Insufficient longitudinal reinforcement
  - Lack of transverse reinforcement

Success Story - Digicel Tower

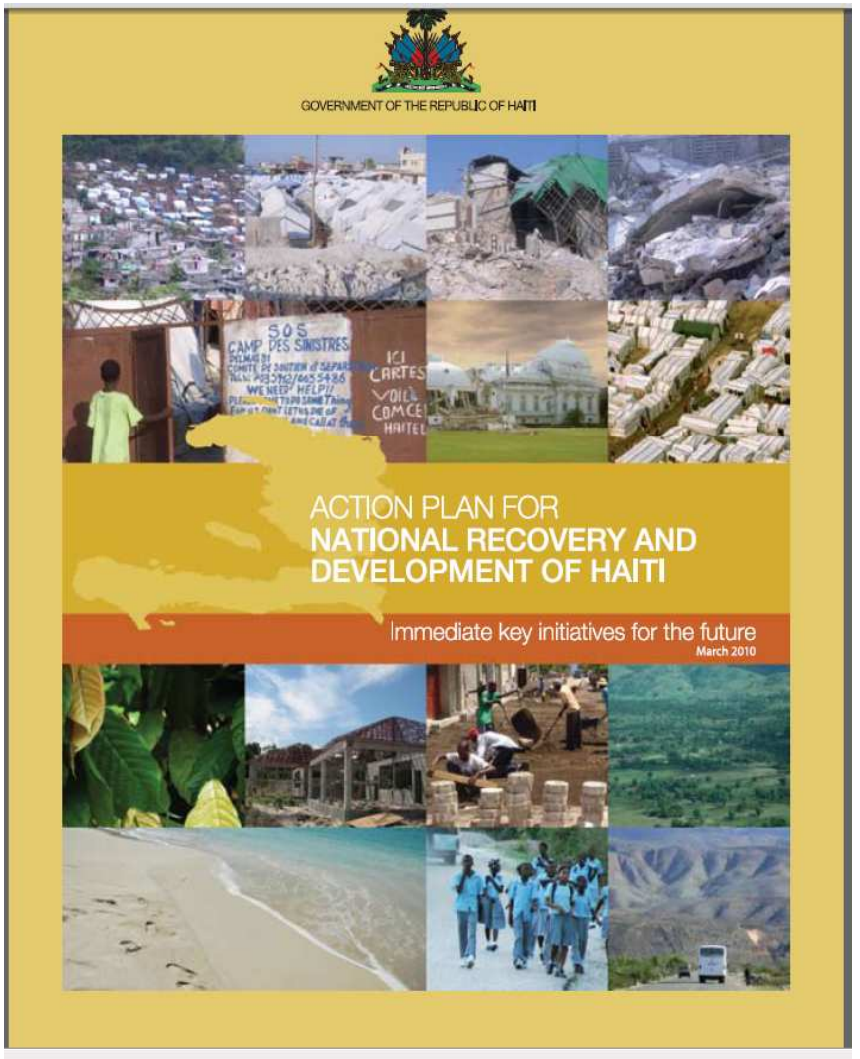
- Digicel is largest cellular phone company in Haiti.
- 12 story concrete framed, curtain wall tower with two adjacent concrete framed, concrete block infill buildings and a space frame tower.
- Designed according to ACI 318
- Tower performed well while adjacent buildings were heavily damaged



Critical Issues and Challenges to Recovery in Haiti

Lack of Clear Rebuilding Plan

- Too broad
- No sense of how to implement plan
- No support for plan



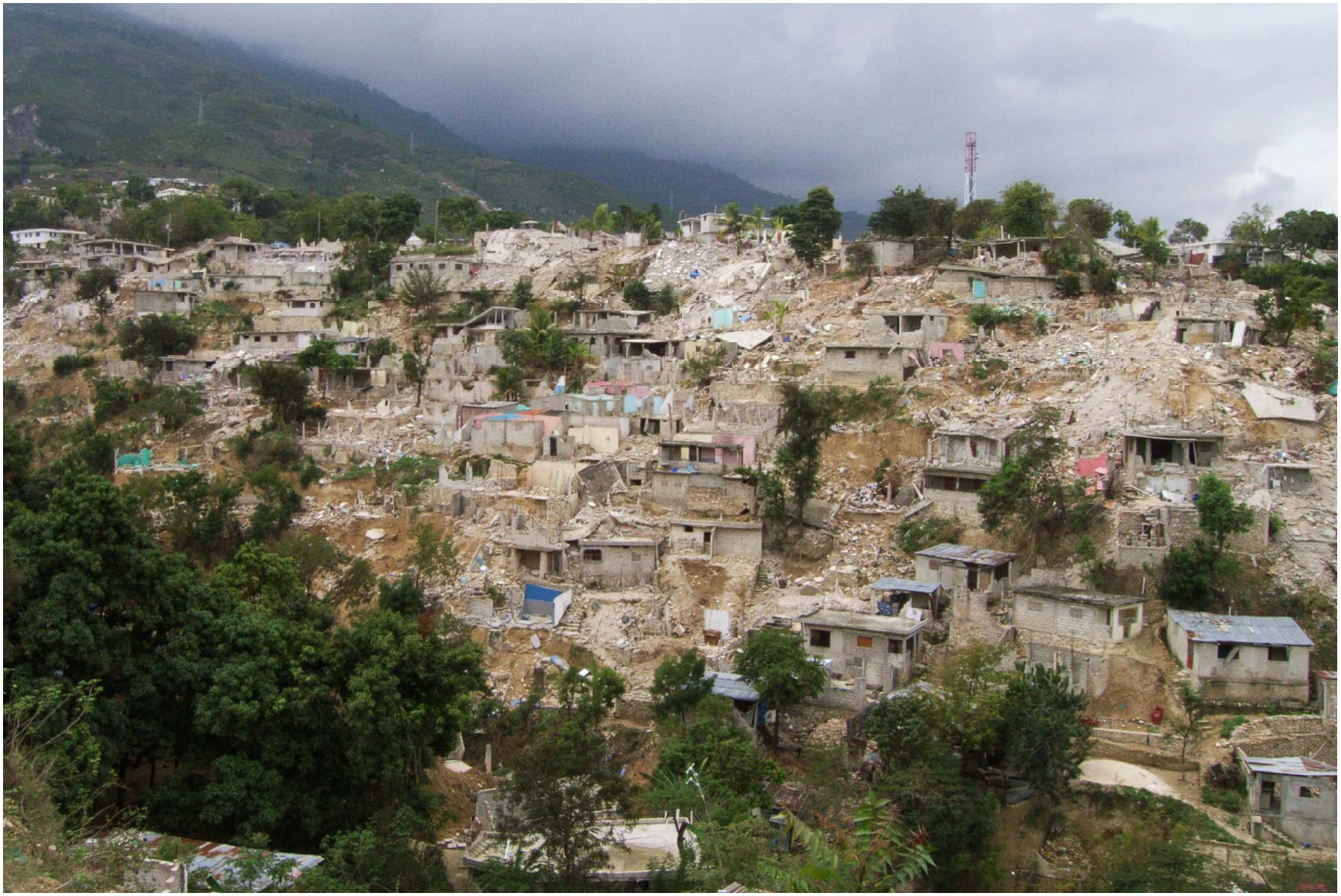
Need to Build Capacity in GoH

Debris Removal & Management

- 20 million cubic meters remaining

Multi-Hazards

Concerns Over Topology



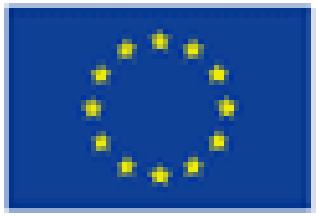
Land tenure issues

Land Scarcity in PaP

Health and Security

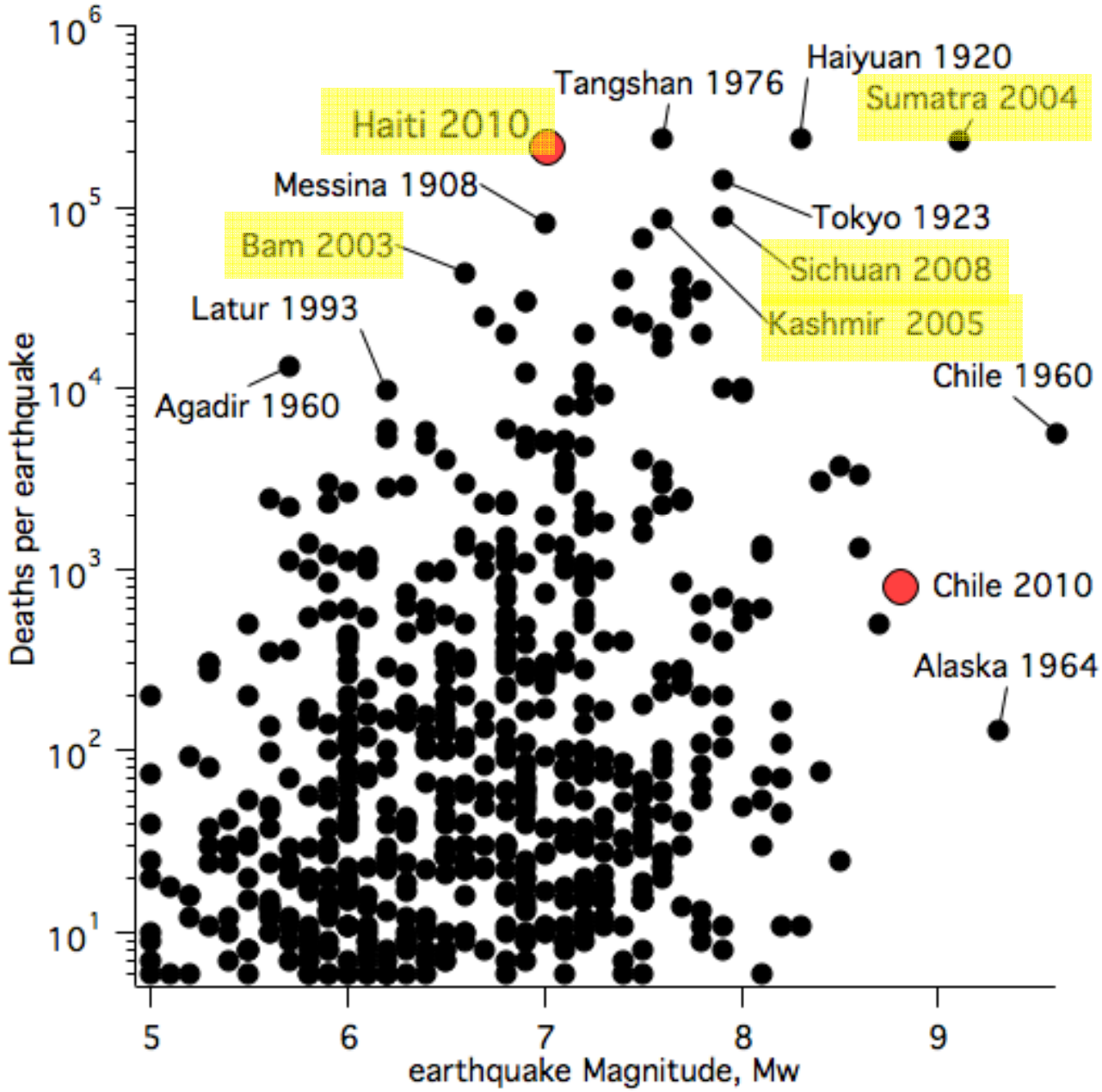
- Cholera outbreak
- Security in camps
- Kidnappings
- Security following elections

Donors need to speak w/ One Voice



Observations

- The social, economic, and environmental conditions in Haiti before the EQ created an extreme vulnerability to natural hazards.
- The grand challenge is how we can design these communities so that they more resilient, more sustainable, and more socially just.
- Population growth and rapid urbanization in hazardous areas, coupled with the impacts of climate will result in more frequent and extreme disasters unless proactive steps are taken.



Graph R. Bilham

Concluding Remarks (1)

- Risk reduction must become a priority in Haiti and needs to be linked with poverty reduction and sustainable development.
  - Public and private sector
  - Must be part of education system
  - Must build capacity at every level
  - Community and individual participation is key

Concluding Remarks (2)

- We need to use latest technologies and science-based evidence to identify, assess, and reduce risks
  - Multi-hazard risk maps
  - Community-based risk maps
  - Knowing HOW to build and WHERE to build
  - Focus on critical infrastructure (schools, hospitals, etc)
  - Use local materials
  - Using local technologies (Haiti-cell phones)
  - Working with local media

Working w/ Local Media

Concluding Remarks (3)

- Being prepared will save lives and reduce the impact from future events
  - Evacuation drills
  - Education at all levels
  - Coordination between NGOs, GoH, and Communities
  - Documenting lessons learned

Acknowledgements

- Financial support from NSF, EERI, USGS, ASCE, NEES, MAE for reconnaissance
- Government leaders in Haiti
- University Professors in Haiti
- People of Haiti