Introduction to Environmental Geology, 5e

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Chapter 5

Introduction to Natural Hazards

Lecture Presentation prepared by X. Mara Chen, Salisbury University

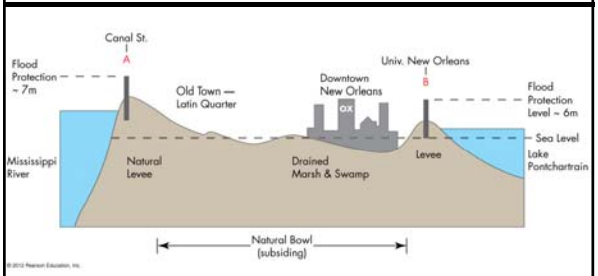
"natural" disasters?
just nature doing her thing
'til you add people...

Case History: Hurricane Katrina (1)

- Made Landfall in August 29, 2005 to the east of New Orleans
- Storm Surge: 3 to 6 m (9 to 20 ft)
- Diameter of serious damage path: About 160 km (100 mi)
- 80 percent of New Orleans under water
- Official number of deaths: 1,836
- Property damages: Tens of billions
- Estimated costs for recovering and rebuilding: hundreds of billions

Case History: Hurricane Katrina (2)

- Regional subsidence: 1 to 4 m (3 to 12 ft) per 100 yrs
- Sea level rise: 20 cm (8 in.) last 100 yrs due to global warming and extraction of GW, oil and gas
- Geographic location: Vulnerable to hurricanes, storms, and inland floods
- Aware of risks and warnings in place
- Insufficient funds for monitoring and maintaining the levee and floodwalls
- Poor coordination in initial emergency response efforts
- Rebuild: Better design and planning, better technology and knowledge, broader awareness



Natural Disaster, Hazards (1)

- Criteria: A particular event in which 10 or more people are killed; one hundred or more people are affected; a declaration of emergency is issued, or there is a request for international assistance
- Dangerous natural processes, including earthquakes, floods, volcanic activities, landslides, and storms

Natural Disaster, Hazards (2)

- The occurrences of natural disasters on a world scale are increasing
- Natural disaster causing great loss of life and/or property damage
- Earthquakes, floods, cyclones (hurricanes) killed several million people, with an average worldwide annual loss of life of about 150,000 people
- Annual average property damage exceeds $50 billion
- Impact risks, depending on the nature of hazards, spatial and temporal relations to human environment

Types of Natural Hazards

From NOAA 99044-CD

Why Natural Processes Become Hazards

- Natural processes become hazardous: When people live or work in areas where they occur
- Land-use changes, such as urbanization or deforestation
- Better environmental planning:Simply not to build on floodplains, earthquake prone areas
- Consumption of energy resources and climate changes

Hazard Magnitude and Frequency

- Magnitude: Intensity of a natural hazard in terms of the amount of energy released
- Frequency: Recurrence interval of a disastrous event
- Magnitude and Frequency: Generally an inverse relation between them
- More damages associated with hazards of moderate frequency and magnitudes

Magnitude, Frequency, and Impact Risk

- Magnitude and Frequency: Largely controlled by natural factors
- Impact risk: Controlled by both natural and human factors
- Low-magnitude and high-frequency hazards not always destructive, a high magnitude one almost certainly catastrophic
- Commonly, most impact risks from natural processes of moderate magnitude and moderate frequency

Mixed Blessings of Natural Hazards

- Not all hazardous processes exert harmful or deadly consequences
- Benefits: Creating new land, supplying nutrients to soil, flushing away pollutants, changing local landscape
- Fault gouge has formed groundwater barriers, producing natural subsurface dams and water resources

Damages of Natural Hazards (1)

- Death and damages: Great loss of human life, grave damages to property, changes in properties of Earth materials
- More life loss from a major natural disaster in a developing country; more property damage in a more developed country
- Catastrophe: Disastrous situations requiring a long process to recovery from grave damages

Catastrophic Potential of Hazards

TABLE 5.1 Effects of Selected Hazards in the United States

Hazard	No. of Deaths per Year	Occurrence Influenced by Human Use	Catastrophe Potential[b]
Flood	86	Yes	H
Earthquake[1]	50 + ?	Yes	H
Landslide	25	Yes	M
Volcano[1]	<1	No	H
Coastal erosion	0	Yes	L
Expansive soils	0	No	L
Hurricane	55	Perhaps	H
Tornado and windstorm	218	Perhaps	H
Lightning	120	Perhaps	L
Drought	0	Perhaps	M
Frost and freeze	0	Yes	L

[1]Estimate based on recent or predicted loss over 100-year period. Actual loss of life and/or property could be much greater.
[b]Catastrophe potential: high (H), medium (M), low (L).
Source: Modified after White, G. F., and Haas, J. E. 1975. Assessment of research on natural hazards. Cambridge, MA: MIT Press.

Table 5.1

Hazard Evaluation (1)

Fundamental Principles

- Most natural hazards: Identified and studied using the scientific method and predictable from scientific evaluation
- Risk analysis: A critical component in understanding impacts
- Different hazards are linked
- Hazardous events repetitive
- Importance of hazard planning and hazard mitigation

Hazard Evaluation (2)

- Study historic data: Hazards are repetitive events
  - Occurrence and recurrence intervals
  - Location and effects of past hazards
  - Observations of present conditions
  - Measuring the changes or rates of change
  - Historic trends of hazards

Hazard Evaluation (3)

- **Studying linkages:** Spatial and temporal links
  - Linkages between adjacent locations
  - Linkages between past, present, and future conditions
  - Linkages between hazards (e.g., volcano and mudflow)
  - Geologic setting and hazards (e.g., rock fractures and landslides)

Disaster Forecast, Prediction, and Warning (1)

- **Forecast:** The certainty of the event is given as the percent chance of happening
- **Prediction:** Sometimes possible to accurately predict when, where, type and size of the certain natural hazardous events
- **Warning:** A hazardous event has been predicted or a forecast has been made, the public must be warned

Disaster Forecast, Prediction, and Warning (2)

- Locations, precursors, probability of occurring
- Determining the probabilities of a hazardous event at a given magnitude
- Observing precursor events or signs
- Forecasting the hazard
- Warning the public

Disaster Prediction and Warning (2)

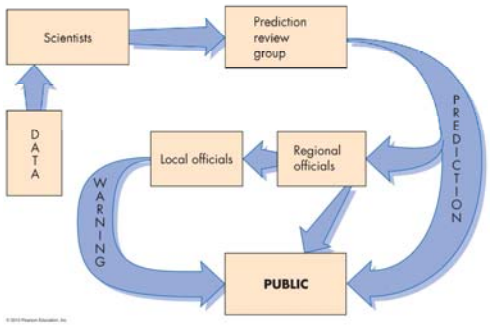


Figure 5.14

Scientists, Hazards, and the Media

- The media are generally more interested in the impact of a particular event on people than in its scientific aspects
- Good relations between scientists and the news media is a goal that may be difficult to always achieve
- Scientists have an obligation to provide the public with information about natural hazards
- Reports concerning people's lives and property should be conservative evaluations based on the evidence at hand
- Provide their readers, viewers, or listeners with accurate information that have been verified

Risk Assessment

- Risk determination
  - Type, location, probability, consequences
  - Risk estimate: Product of probability and consequences
- Risk Threshold: Acceptable risks
  - Put probability and consequences into perspective
  - Society's perception and willingness
- Limitations and opportunities of risk assessment

Risk Impact (1)

Hazardous Earth processes and risk impact statistics for the past two decades

- Annual loss of life: About 150,000
- Financial loss: > $50 billions
- More life loss from a major natural disaster in a developing country (2003 Iran quake, ~30,000 people)
- More property damage occurs in a more developed country

Risk Impact (2)

Risk impact estimation:

- To human life: Potential loss and injury of life
- To property: Damage and destruction
- To society: Services and functions of society
- To economy: Manufacture, mining, commercial, real estate, etc.
- To natural environment: Direct or indirect adverse impact

Human Response to Hazards (1)

Reactive response

- Primarily after the hazardous event
- Recovery phases: Search response, rescue, restoration, and reconstruction
- Recovery period: Recovery length depending on the magnitude of hazard and impact intensity

Human Response to Hazards (2)

Reactive response and recovery priority

- Critical needs: Emergency operations, critical infrastructure, hospitals, shelter, food, and water supply
- Essential function: Transportation, communication, education, and other services
- Improvement and development: Rebuild damaged structures and develop better structures

Human Response to Hazards (3)

Anticipatory Response: Perceiving, Avoiding, and Adjusting to Hazards for avoiding or minimizing the impacts of disasters

- Land-use planning
- Insurance and other regulations for safety measures
- Evacuation
- Disaster awareness and preparedness: Individuals, families, cities, states, or even entire nations can practice

Human Response to Hazards (4)

General response in a given location

- Combination of reactive and anticipatory response
- Artificial control of natural processes
- Taking no or little action, being optimistic about chances of making it through disasters

Global Climate and Hazards

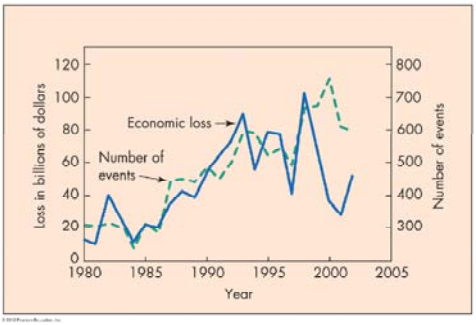


Figure 5.19

Population Growth and Natural Hazards

- Increase in population puts a greater number of people at risk
- Asia suffered the greatest losses from 1985 to 1997, with 77 percent of the total deaths and 45 percent of the economic losses
- Deadly catastrophes resulting from natural hazards linked to changes in land use, Hurricane Mitch in 1998, flooding of the Yangtze River in 1998, and Hurricane Katrina in 2005
- In quest: Artificially controlling some natural hazards

Land-Use Change and Natural Hazards (1)

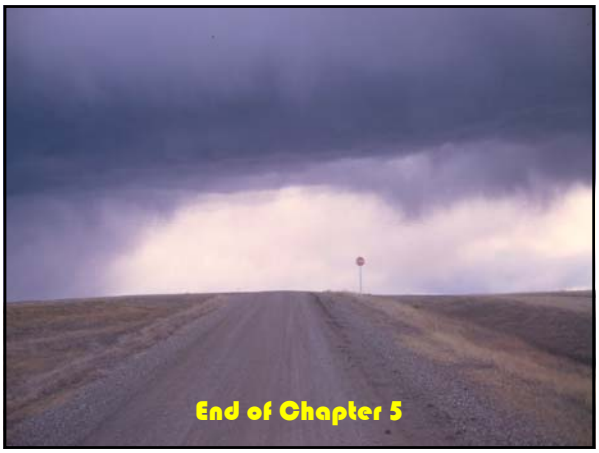
- Land-use change amplifying the impact risks of natural hazards
- Deforestation and fire in Honduras before Hurricane Mitch, 11,000+ deaths
  - Massive deforestation in major river basin (e.g., 85 percent forest loss in Yangtze River, 4000+ deaths)
  - Inappropriate construction code in tectonic earthquake zone, 2003 Iran earthquake, ~300,000 deaths
  - Poor construction in Haiti, 2010 earthquake, above 300,000 death

Land-Use Change and Increase in Natural Hazards (2)

Figure 5.20

Applied and Critical-Thinking Topics

- List all the natural hazardous processes in the are where you live. What is done? What is more to be done?
- Construct a U.S. vulnerability map of natural hazards by state, or construct a state map by county.
- What is the difference between forecasting and warning
- Can humans eventually control the impact risks of natural hazards? Explain your rationale.


End of Chapter 5