Chapter 5
Introduction to Natural Hazards

Introduction to Environmental Geology, 5e

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Spokane Hazards???

- Discuss 3 possible hazards, disasters, or natural processes Spokane residents might be affected by.
- For each:
  - Discuss how humans might have increased the risk.
  - Discuss how humans might attempt to control and reduce the risk.
  - How are you personally prepared for each of these?

Chapter 5: Overview

- Increasing population and land use increase losses from a natural disaster
- Know why some Earth processes are hazardous (or beneficial) to humans
- Look at historic hazards and future risk assessment in determining threats
- Human perception and adjustment to hazards
- Discuss stages of recovery following disasters

Case History: Hurricane Katrina

- Made landfall 8/29/05, east of New Orleans
- Storm surge: 3-6m (9-20ft)
- Diameter of serious damage: About 100 mi
- 80% 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

- Regional subsidence: 1-4m (3-12ft) per 100 yr
- Sea level rise: 20cm (8in) last 100 years due to global warming and resource extraction
- Geographic location: hurricanes, storms, flood
- Awarness of risks and warnings in place
- Insufficient funds for monitoring and maintaining levees and floodwalls
- Poor coordination in initial emergency response
- Rebuild: better design and planning, technology, broader awareness

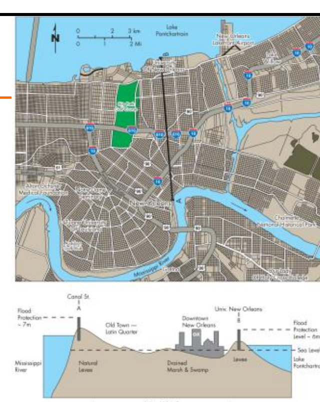


Figure 5.2

Figure 5.1

Natural Disaster

- 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:
  - Earthquakes
  - Floods
  - Volcanic activities
  - Landslides
  - Storms
- Impact risks, depending on the nature of hazards, spatial and temporal relations to human environment

Types of Natural Hazards

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.

From NOAA 99044-CD

Why Natural Processes Become Hazards

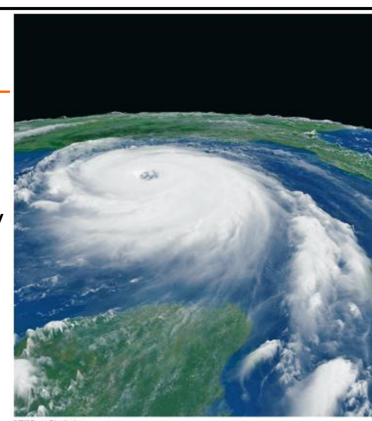
- Natural processes become hazardous: When people live or work in areas where they occur.
  - Population growth
- Land-use changes, such as urbanization or deforestation, removal of wetlands.
  - Environmental damages
- Consumption of energy resources and climate changes (not just CO_2).
- Better environmental planning: DO NOT build on floodplains, earthquake prone areas

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…how often the event occurs

- Magnitude and Frequency:
  - Generally an inverse relation between them
  - Largely controlled by natural factors
- Low-magnitude and high-frequency hazards- not always destructive, a high-magnitude one almost certainly catastrophic

Impact risk: Controlled by both natural and human factors.



Benefits of Natural Hazards

- Not all hazardous processes exert harmful or deadly consequences. Some are supportive.
- 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.

Figure 5.7a

Damages of Natural Hazards

- 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

Expansive, clay-rich soils are one of the most costly hazards = >$3 billion in 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[2]
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 150-year period. Actual loss of life and/or property could be much greater.
[2]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

(a)

(b)

Catstrophic potential?

Drought versus tornado.

Hazard Evaluation

Fundamental Principles:

- Most natural hazards are predictable from scientific evaluation
- Risk analysis – a critical component in understanding impacts
- Different hazards are linked
- Hazardous events are often repetitive and increasing in magnitude
- Importance of hazard planning and hazard mitigation…to minimize consequences

Hazard Evaluation

The Role of History:

- 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

Studying the history of repetitive events supports any hazard reduction plan.

Figure 5.11

Hazard Evaluation

Studying linkages: spatial and temporal links

- Linkages between adjacent locations
- Linkages between past, present, and future conditions
- Linkages between hazards (volcano and mudflow…or hurricane and flooding)
- Geologic setting and hazards (rock fractures or earthquakes and landslides)

Forecast, Prediction, and Warning

- **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

Forecast, Prediction, and Warning

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

Forecast – Predict - Warn

Disaster Prediction and Warning

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 difficult goal.

Scientists have an obligation to provide the public with information about all natural hazards in the area.

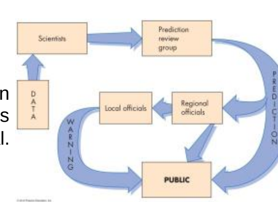


Figure 5.14

Risk Assessment

- Risk determination
  - Type, location, probability, consequences
  - Risk estimate: product of the probability of that event's occurring multiplied by the consequences should it actually occur
- Risk Threshold: Acceptable risks
  - Put probability and consequences into perspective
  - Society's perception and willingness
- The risk that an individual is willing to endure is dependent upon the situation and the individual.

Risk Impact

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 killed)
- More property damage occurs in a more developed country

Risk Impact

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

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

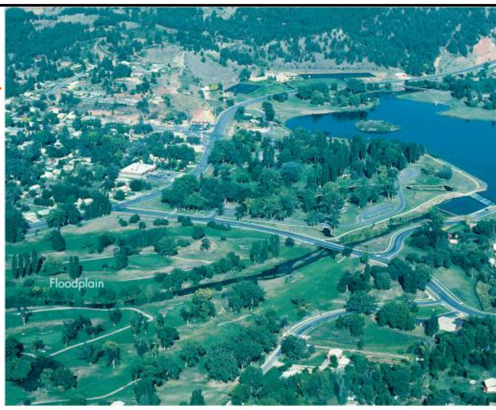
Reactive response and recovery priority

- 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

Anticipatory Response: response to a hazardous event with an intention to avoid or minimize its damages.

- Effective 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

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

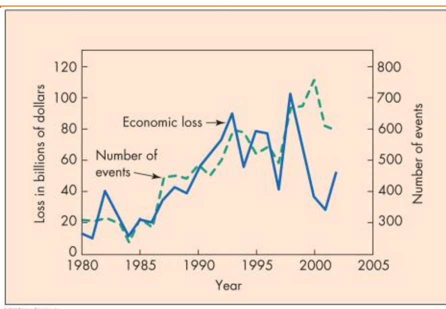


Figure 5.19

Global Climate and Hazards

- Increasing sea level
- Increasing ocean temperature
- Increasing rates of coastal erosion
- Generating food production shifts
- Change in amount and location of precipitation
- Desertification
- Increasing the impact of storm events

Population Growth and Natural Hazards

Is population growth a cause for natural disasters?

- Under debate – population may be a trigger for some natural disasters, e.g., floodplains
- In certainty – human settlement and development into danger zones is critical
- Mexico City – 23 million people in ~890 mi^2 (Spokane is 210k in ~60 mi^2)

Are we fully capable of artificially controlling natural hazards?

Land-Use Change and Natural Hazards

Land-use change amplifying the impact risks of natural hazards:

- Deforestation and fire-
  - Honduras before Hurricane Mitch, 11,000+ deaths
- Massive deforestation in major river basin-
  - 85% forest loss in Yangtze River, 4000+ deaths)
- Inappropriate construction code in tectonic earthquake zone-
  - 2003 Iran earthquake, ~300,000 deaths
- Poor construction and urban planning-
  - Haiti, 2010 earthquake, above 300,000 death

Land-Use Change and Increase in Natural Hazards

Figure 5.20

Figure 5.21

Applied and Critical Thinking

Nevado del Ruiz:

1. Discuss why this natural hazard became a catastrophe.
2. Discuss the aspects of the hazard preparedness plan.

Can humans eventually control the impact risks of natural hazards? Explain your rationale.