Introduction to Environmental Geology, 5e

Chapter 1

Philosophy and Fundamental Concepts

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Case History: Island of Hispaniola

- Good site for comparative study: Dominican Republic versus Haiti
- Biophysical differences: Rainfall, topography, land use/land cover
- Socioeconomic differences: History, population, economic activities, GDP output
- Reasons for degradation of Haiti's environment and subsequent inability to quickly rebuild after the 2010 large earthquake

Figure 1.1&1.2

Case History: Island of Hispaniola

TABLE 1.1 Comparison of Haiti and the Dominican Republic on the Island of Hispaniola with Puerto Rico and Cuba

Country	Approximate Area (km²)	Population (millions)	Median Age (years)	Population Growth Rate (percent)	Life Expectancy (years)	Population Density (persons per km²)	Forest Cover (percent)	Gross Domestic Product per Person ($)	Main Environmental Issues (highly generalized)
Haiti	27,800 (about the size of Maryland)	8.1	18	2.26	60	295	3.8	1,600	Extensive deforestation; serious soil erosion; inadequate safe water supply
Dominican Republic	48,700 (about two times the size of Vermont)	9.0	24	1.29	72	185	28.4	6,500	Water shortages; eroding soils; coral reef damage; deforestation
Puerto Rico	9,100 (about two times the size of Rhode Island)	3.9	34	0.047	79	437	46.0	18,500	Erosion; occasional drought with water shortages
Cuba	110,900 (about the size of Tennessee)	11.3	35	0.33	77	102	24.7	3,300	Loss of biodiversity; pollution; deforestation

Data from the United Nations and http://rainforests.mongabay.com.

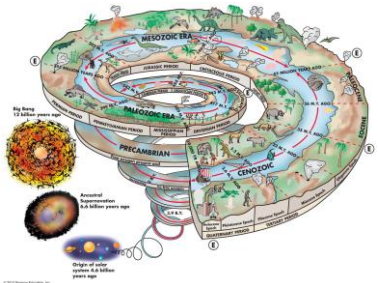
Table 1.1

Earth's Place in Space

- Earth: Geospatially isolated in the universe
- Origin of the universe and solar system
- Origin of Earth system: Lithosphere (geosphere), atmosphere, hydrosphere, and biosphere
- Facing limited resources: Energy, soil, ***fresh***water, forests, ocean fisheries, rangelands
- Global environment: Dynamic conflicts and integrated resolutions

Earth History

Inception: 4.6 billion yrs



Uniformitarianism

-versus

Catastrophism

Figure 1.A

Earth Environment (1)

- **James Hutton (1785):** Earth as a superorganism …*the oceans are the heart of Earth's global system, and the forests are the lungs*…
- **James Lovelock (1985):** Gaia hypothesis
  - Earth is an organism
  - Life significantly affects Earth's environment
  - Life modifies the environment for the betterment of life
  - Life deliberately or consciously controls the global environment
  - Interdisciplinary thinking

Environmental Sciences

- Environment: A complex system with physical, biological, geological, ecological, and geopolitical aspects.
- Requires multidisciplinary research: Environmental geology, environmental chemistry, global climate change, biological diversity and ecosystems, environmental economics, environmental ethics, environmental law, etc.
- Environmental crisis: Population, environmental hazards, resource limitations and contaminations, environment ownership (both in space and over time)

Environmental Geology

- Geology:
  - Study of processes related to the composition, structure, and history of Earth.
  - Relies on chemistry, physics, and biology.
- Environmental geology knowledge: *applied geology*
  - To better understand environmental problems
  - Geologic knowledge for problem solving
  - Minimize environmental degradation
  - Optimize the use of resources to maximize environmental benefits for the society

Environmental Geology Components

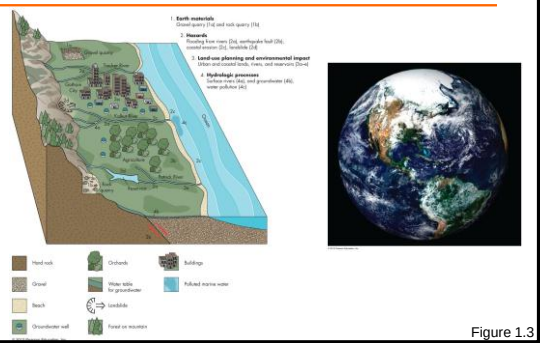


Figure 1.3

Fundamental Concepts

- Five fundamental concepts
  - Population growth
  - Sustainability
  - System and change
  - Hazardous Earth processes
  - Scientific knowledge and values
- Other concepts in environmental geology
  - Finite resources, health, obligation to future

Human Population Growth (1)

- Number one environmental problem: Nearly 7 billion by the year 2010
- "Population bomb?" Exponential growth
- Exponential growth
  - Growth rate (G): Measured as a percentage
  - Doubling time (D): D = 70/G
- Above Earth's comfortable carrying capacity: Implications to- resources, land, waste
- Earth as the only current suitable habitat

Human Population Growth (2)

Uneven growth both spatially and temporally.

Figure 1.4

Human Population Growth (3)

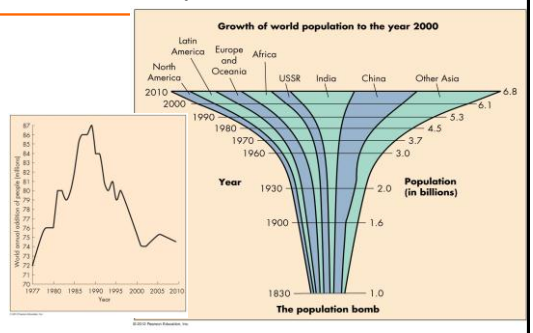


Figure 1.5a/b

Human Population Growth (4)

Uneven growing pace and distribution

- By 2050, 3 billions more people
- Almost all of the growth in developing countries
- No easy answer to the population problems
- Education is paramount, especially woman's education. As people become more educated, the population growth rate tends to decrease
- Good news: The rate of population growth is decreasing

Human Population Growth (5)

Why is it important to monitor and potentially "*control*" population growth?

Why might population growth in the future be difficult to predict?

How does the number of people on this Earth affect your quality of life?

Sustainability (1)

Sustainability: The environmental objective

- An evolving concept
- Expectation and reality
- Criteria variations in space and over time
- Is a long-term concept and has long-term implications
- Requiring careful resources allocation, large-scale development of new technology for resource use, recycling, and waste disposal

Sustainability (2)

Measuring sustainability

- Use and consumption of non-renewable resources
- Natural replenishment and renewable rates
- Global consumption versus replenishment of resources
- Development and improvement of human environment versus viable environment
- Doesn't result in crisis

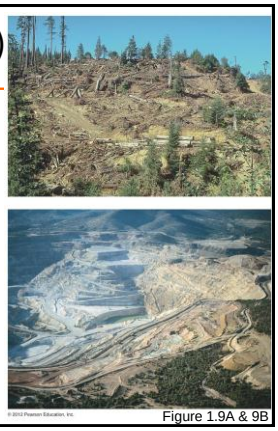


Figure 1.9A & 9B

Sustainability: The Death of Aral Sea (3)

- Once a prosperous vacation spot in 1960
- Water diversion for agriculture
- Dying sea surrounded by salt flats

Figure 1.B

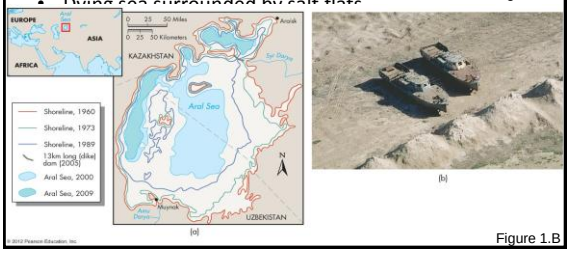


Figure 1.B

Earth's Systems and Changes (1)

- Earth is a dynamic system
- Earth processes are driven by two heat sources: internal and external…
- Four interconnected subsystems:
  - Geosphere (lithosphere in your book)
  - Hydrosphere
  - Atmosphere
  - Biosphere
- Four subsystems mutually adjust to function as a whole…for now…

Earth's Systems and Changes (2)

- System conditions: open vs. closed
- System input-output analysis
- System changes: rates of change, types of change, scale of change…
- For example, **rate of change**: average residence time for measurable item-
  - T = S/F
  - Where, T=residence time, S=total size of stock, F=average rate of transfer
  - See Figure 1.12, 'residence time of water'

Earth's Systems and Changes (3)

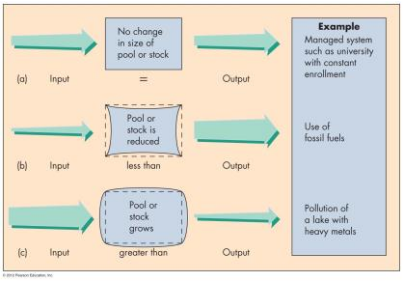


Figure 1.11

Predicting Future Changes

- Uniformitarianism
  - The present is the key to the past
  - The present is the key to the future
  - Changes of frequency and magnitude: Geological processes and human activities
- Environmental unity: Chain of actions and reactions …*both locally and globally.*
- Earth system
  - Gaia hypothesis: Earth is a living organism
  - Complex and interrelated subsystems
  - Global perspective on environment

Hazardous Earth Processes (1)

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

- Annual loss of life: About 150,000
- Financial loss: > $20 billion
- Millions of **lives** lost during the past 20 years, from a major natural disaster in a developing countries (2003 Iran quake, ~30,000 people, 2004 Asia tsunamis, ~300,000)…famine.
- More **property** damage occurs in a more developed country

Hazardous Earth Processes (2)

Risk Assessment Plan:

- Hazard identification
- Risk assessment – type, probability, and consequence of impact
- Risk management and mitigation

Risk Perception:

- Public attitude and acceptance of risk
- Public awareness and action

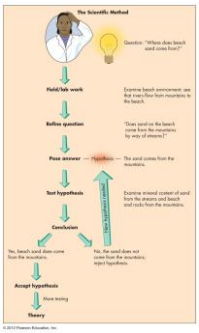
Hazardous Earth Processes (3)

How has the impact of natural disasters changed in the last 50-100 years?

Science and Solution

- Science: Accumulated knowledge
- Knowledge: Basis for decision making
- Scientific methods: Formulate possible solutions to environmental problems
- Scientific design: Structure more suitable for certain environmental settings
- Scientific info: Public awareness and environmental regulations

Scientific Knowledge and Values (1)



Most scientists are motivated by a basic curiosity about how things work…

Figure 1.14

Scientific Knowledge and Values (2)

- 3-D environmental problems
- Changes of environment in the 4-D (time)
  - Expansiveness of geologic time
  - Broad spectrum of geologic processes
  - Great variations in rates of geologic processes *(see table 1.4 for examples)*
- Scientific methods for complex, multidisiplinary environmental problems

Closer Look: Knowledge, Imagination, and Critical Thinking

- Knowledge: What is known
- Imagination: No limits, leading to out-of-the-box thinking of the unknown
- Scientific investigation: Needs critical thinking
- Critical thinking: Significance, logic flow, relevance, breadth and depth, clarity, fair test

Geological Time Dimension

- The important variable that distinguishes geology from other sciences
- Varied rate and size of geological processes: mm/yr to km/s and micrometers to kilometers
- Humans are a super agent of change
  - Holocene epoch with industrialization and global

Figure 1.15

Culture and Environmental Awareness

- Land ethic "*…we are responsible to the total environment, the larger community…*"
- Precautionary principle – recognizes that scientific proof is not always possible, and management practices are needed to reduce or eliminate environmental issues.
  - Lead to a proactive approach with an emphasis on environmental unity

Isn't it better to be safe than sorry?

Solving Environmental Problems

- Difficult processes
- Environmental problems tend to be complex
- Rapid changes, slow recognition, slower actions
- Some changes are of irreversible nature
- Environmental policy links to environmental economics in infancy

Figure 1.D (b)

Applied and Critical Thinking Topics

- Why are people in Haiti so vulnerable to major natural hazards?
- Would an exponential negative growth of human population be a solution to many environmental problems?
- What is sustainability?
- Is it quality or quantity?
- Are there any conflicts between global environmental unity and regional economic development?