Lecture 1
Introduction to Environmental Geology
Course Description

- Environmental Geology is a general education course that investigates the relationship between society and the geologic environment. The three areas of study will be: 1) geologic hazards such as floods, landslides, volcanoes and earthquakes; 2) geologic resources such as metals, stone, fossil fuels, and water; and, 3) environmental challenges such as waste disposal and ground water contamination. We will study these topics from a global perspective, paying particular attention to their importance in Egypt.
What is Environmental Geology?

- **Geologic Hazards**
  (earthquakes, floods, landslides, etc.)
- **Geologic Resources**
  (metals, stone, fossil fuels, water, etc.)
- **Waste Disposal**
  (sewage, solid waste, hazardous materials)
- Introduction to Environmental Geology – 3rd Ed
- Hazard City – 2nd Ed
Importance of Geologic Hazards

- 100,000 lives lost every year
- Billions of dollars lost every year

**Key Point:** The more you know about a geologic hazard, the greater your chances of avoiding injury or loss.
Prevent Loss Through

- Research to learn about hazards
- Educating key decision makers
- Educating the public
- Land-use and development decisions
• Geologic hazards are not random-striking events.

• They occur in specific places for specific reasons.

• If you can understand why they occur, you can predict where they will occur.
Three Weeks of Earthquakes
Living with Geologic Hazards

- Zoning
- Building Codes
- Engineering
- Insurance
- Education
What are Geology and Environmental Geology?

• **Geology** – (is the study of Earth) the study of the rocks that make up the earth's surface and interior, and the natural processes that shape the earth's surface over time. These processes include plate tectonics (i.e. continental drift), earthquakes, volcanism, landslides, and erosion, and other processes related to movement of the earth's surface or interior.
Environmental Geology

- **Environmental Geology** - the study of Earth's natural systems and their interactions with humans. It is applied geology.
- Help solve conflicts in land use
- minimize environmental degradation
- maximize the beneficial results of using our natural and modified environment.
- Includes the study of:
  - **Natural Hazards** (such as floods, landslides, earthquakes, and volcanic activity) in order to minimize loss of life and property.
  - **Landscape** for site selection, land-use planning, and environmental impact analysis
  - **Earth Materials** (such as minerals, rocks and soils) to determine their potential use as resources or waste disposal sites and their effects on human health.
  - **Hydrologic processes** of groundwater and surface water to evaluate water resources and water pollution problems.
  - **Geological processes** (such as deposition of sediment on the ocean floor, the formation of mountains, and the movement of water on and below the surface of the earth) to evaluate local, regional, and global change
Environmental Geology

- **Environmental Geology** - The study of the interactions between geologic processes and the surface and near-surface environment, particularly where such interactions are influenced by or otherwise impact living organisms.

- Environmental Geology focuses on the relationship between humans and their Earth environment. It is the study of human interaction with the land, with all its sociological, economic and political ramifications.

- Environmental geology as "applied" geology - brings collective geologic knowledge to bear on problems that are important to people. Examples will be provided throughout the course.
Environmental Geology

• As citizens of Earth, we have a vital relationship with our planet. While our population grows and our demands for resources increase, we place greater stress on the environment's ability to provide essential products and absorb waste materials.

• Environmental geology approaches these issues by considering the earth materials of landscapes, their physical and chemical processes, and the controls they exert on hydrologic, atmospheric and biologic processes.

• Environmental geology is a very diverse field. It encompasses natural hazards such as earthquakes, landslides, floods and volcanic eruptions; the engineering properties of Earth materials and problems involved in construction of structures such as dams, buildings and roads; coastal processes such as shoreline erosion and impacts of sea level rise, safe disposal of solid and liquid wastes; management of surface and ground water resources; and the impacts.
Environment

• **Environment** – total set of circumstances that surround an individual or community:
  • - physical conditions
    • air
    • water
    • gases
    • landforms
  • - social and cultural conditions
    • ethics
    • economics
    • aesthetics
Environment

- Environmental Awareness:
  - the way we perceive and respond to our natural environment

- Environmental Ethics
  - land ethic assumes we are the land’s citizens and protectors, not its conquerors
  - we are responsible for the total environment, we have a moral responsibility to the land
  - we are all brief tenants of this planet, yet humanity is an integral part of the environment
  - We have a moral obligation to the present and future earth community to preserve and protect the environment.
Fundamental concepts of environmental geology

- Humans are agents of geological change.
- The Earth is unique.
- The Earth is a closed system.
- Materials and energy tend to cycle from one reservoir to another.
- The physical structure and chemical composition of the Earth affect our lives in many different ways.
- Geologic processes and human beings operate on different time scales.
- Hazardous geologic processes are natural and have always existed.
- Risk is characteristic of the human-planet relationship.
- We are fundamentally dependent on Earth resources for the conduct of modern society.
- Earth resources are limited.
- Earth resources can be managed properly in a sustainable fashion.
- There is no "away" to throw things to; our garbage and pollution remains with us.
- Managing the environment means managing human behavior.
- Restoration and preservation are also part of the human-planet relationship.
Concept one: Population Growth

- The number one environmental problem is excessive human population growth.
- The reason this is true is because excessive numbers of humans is the ultimate or proximate cause of all other environmental problems. Another way to state this is that there were no environmental problems on Earth before humans evolved, and there were no serious environmental problems while human populations were relatively small.
- Human population is growing at an exponential rate- each year, population increases at a constant percentage of the present population.
  - 1960 – 2%/yr (pop. doubles in 36 years)
  - 1980 – 1.7%/yr (pop. doubles in 41 years)
  - 2000 – 1%/yr (pop. doubles in 72 years)
- World population ~5.9 billion, Increases by ~94 million/yr, and ~10,000 people are added each hour.
- Population growth is not evenly distributed:
  - highest rates in underdeveloped countries:
    - Africa, Asia, Latin America
  - it will be impossible to supply resources and a high-quality environment in the 21st century for all the world’s population
- Implications of Population growth
Concept one: Population Growth

- **Shortages**
  - food supplies, renewable, ‘elastic’ within limits
  - mineral resources – not generally renewable
  - land

- **Changes in global environment**
  - deforestation
  - Amazon River basin: 1987 (3 million square miles deforested)
    - Desertification
    - overgrazing
    - salinization by irrigation
    - over-cultivation

- **Pollution**
  - Sources
    - Individual
    - Industry
  - Types
    - Water Pollution
    - persistent substances, DDT, mercury, lead
    - nonpersistent substances, Organics
  - Air pollution
    - Primary types: CO2, hydrocarbons, SO2, particulates, NO2, NO3
Concept one: Population Growth

- Global warming and Ozone Depletion
  - Global warming – climate change
  - Causes
    - CO2, Other gases, CH4, NO2, NO3
  - effects:
    - temperature of atmosphere (Greenhouse effect)
    - Climate pattern changes
    - coastal flooding
    - Ozone (O3) depletion
    - Production in upper atmosphere
      \[ O_2 + EUV(sun) \rightarrow 2O, O + O_2 \rightarrow O_3 \]
    - Destruction caused by chlorofluorocarbons
  - effects
    - skin cancer rates
    - life on earth
Concept one: Population Growth

•- The role of Education is paramount in the population problem

•- As people become educated, the population growth rate is reduced.
Concept Two: Sustainability

- Sustainability is an environmental objective
  - We must sustain our environmental resources
  - We are concerned with the quality of the human environment, as earth processes will eventually ‘cleanse’ the natural environment by geologic processes.
  - Sustainable global economy (careful management and wise use of the planet and its resources)
  - Populations of humans and other organisms must live in harmony with natural support systems such as air, water, and land.
  - An energy policy is needed that does not pollute, and cause climatic change
  - A utilization plan or renewable resources such as water, forests, grasslands, fisheries that does not deplete the resource or destroy the ecosystem
  - A resource utilization plan for nonrenewable resources that does not damage the global environment, and provides for future generations
  - A legal, social, and political system dedicated to sustainability

To Achieve Sustainability:
- Develop effective population control strategies
- Completely restructure our energy programs
- Institute social, legal, political, and educational changes that have heir goal the maintenance of a quality local, regional, and global environment
- Institute policies (economic, tax, etc.) that encourage population control and wise use of resources
Concept Three: Systems

- Understanding the earth’s systems and their changes is critical to solving environmental problems.
- The earth is a system of systems:
  - Atmosphere
  - Hydrosphere
  - Biosphere
  - Lithosphere
- Principle of environmental unity:
  - EVERYTHING AFFECTS EVERYTHING ELSE
- The earth itself is an open system with respect to energy (sun as source)
- The earth is a closed system with respect to natural cycles
Concept Four: Limitation of Resources

- The earth is the only suitable habitat we have, and its resources are limited
  - Two major views:
  - Finding resources is not so much a problem as is finding ways to use them. Resources are where you find them.
  - Finite resources cannot support an exponential increase of people forever.
Concept Five: Uniformitarianism

- The physical processes modifying or landscape today have operated throughout much of geologic time. However, the magnitude and frequency of these processes are subject to natural and artificially induced change.

- Originally proposed by James Hutton in late 1700’s.

- Commonly stated as “the present is the key to the past”

- Also true is “the present is the key to the future”
Concept Six: Hazardous Earth Processes

• There have always been earth processes that are hazardous to people. These natural hazards must be recognized and avoided when possible and their threat to human life and property minimized.
Concept Seven: Aesthetic Considerations

- Both land- and water-use planning should strive to obtain a balance between economic considerations and the less tangible variables such as aesthetics.
- There are scenic values.
Concept Eight: Our Obligation to the Future

- The effects of land use tend to be cumulative, and therefore we have an obligation to those who follow us.

- The entire surface of the earth has been altered by human activity.

- Human activity (agriculture, urbanization, mining) moves more soil and rock per year than any other natural process – 40 – 45 gigatons (billion tons).

- Must develop conservation practices that provide soil for the future generations.
Concept Nine: Geology as a Basic Environmental Science

- The fundamental component of every person’s environment is the geologic component, and understanding our environment requires a broad-based comprehension and appreciation of the earth sciences and related disciplines.
Why is Environmental Geology Important?

• Concept of "Spaceship Earth"- near zero net flux of material onto and off from planet implies that resources are finite. In the past 20 years, the sheer numbers of humans and their increasing demand for material goods have done the following:

• Lead to severe degradation of the natural environment that supplies our renewable resources such as food, wood, and water.

• Lead to rapid exhaustion of non-renewable resources

• Placed humans in competition with other species for basic resources such as space, food, and water.

• Forced humans to live in areas of significant natural hazards.
Collision Course of Humans and the Environment

- One emphasis of this course is the rapid increase in human population and migration of people into geologically hazardous environments about which they understand little or nothing. Examples include building in areas prone to hurricanes (i.e. 100,000 people left southern Florida in the year after Hurricane Andrew blasted Dade County), urban development in earthquake-prone regions such as Los Angeles County, overbuilding in the flood plains of major rivers, development in areas of high coastal erosion, and building in areas where the land surface is unstable. These topics concern the exposure of large populations to infrequent, large-scale catastrophes.
Collision Course of Humans and the Environment

• Some of this course will focus on the slow, small-scale processes such as loss of top-soil through poor farming practices and the resultant decline in food production that affects many people. We often fail to notice or heed subtle warning signs from our environment until they reach crisis proportions and begin to degrade the quality of life of many more people than are ever affected by catastrophic events.
Population and Resources

- Population now stands at 5.6 billion, over double that of 1950. It took humanity until 1830 to reach a total population of 1 billion, 1930 to reach 2 billion (100 year interval), 1960 to reach 3 billion (30 year interval), 1975 to reach 4 billion (15 year interval), 1986 to reach 5 billion (11 years), and ~1998 to reach 6 billion (12 years). Every year, ~90 million new people must be supported, equivalent to a nation the size of Mexico. The additional resources required to sustain the additional people at even a minimal level of existence is staggering. Since 1984, global grain production has increased at a level of 12 million tons per year, only one-third the 38 million tons per year of additional grain required by existing population growth over the same period.
Population and Resources

• Even as population increases, requiring more food, clean water, and resources, the space required by and waste generated by additional people takes the farmland required to feed them, drives species into extinction, impoverishes our biological heritage, and pollutes our environment. Current estimates are for 25% of all species to go extinct in the next few decades. Such a loss of biological diversity has been exceeded only once in the earth's 4 billion year history.
What we are leaving for other species?

- Stanford U. biologists estimate that earth's potential annual production of all biological matter is 150 billion tons. Man has directly destroyed 12% of that through pollution, urbanization, and deforestation, and utilizes over 25% of the remainder directly for food and other material production. The human species thus now diverts 40% of planetary biological production for its own use, raising serious questions about what we are leaving for other species.
Everyone must understand the term "carrying-capacity"

- Ultimately, everyone must understand the term "carrying-capacity", which is the number of people in a given area that can be supported by its environment at some predefined standard of living. If we were to strive for a standard of living comparable to that in the U.S., the earth has enough resources to support roughly half the present global population of 5.6 billion. At present, as many as 40% of the people on earth live in poverty and the earth's natural resource base is so diminished and over-exploited that the prospect of increasing production enough to give everyone an adequate standard of living often seems dismal.
Everyone must understand the term "carrying-capacity"

- The encroachment of humanity on wildlife habitat and general decrease of open, quiet space raises serious philosophical questions about the obvious tradeoffs between maximum carrying capacity and the right of other species to exist as well as the innate human need for undisturbed, quiet natural places
Teaching Goals

• Facing these gloomy statistics, why aren't we all just sipping margaritas on the beach and waiting for the end of the world? Because it is human nature to face challenges. For us, the challenge this semester is to give you a much better understanding of important physical processes in geology, their impacts on humans, and ways in which humans can mitigate natural hazards. We also will discuss resource issues that I believe will dominate the political and social arena during our lifetimes, and we'll discuss the positive role that individuals and institutions such as the government can play in issues regarding resource conservation and hazard mitigation
Objectives

• 1. To give you the tools to become a better steward of Earth, and a more constructive manager of the land and its population.

• 2. To be educated enough to know the right questions to ask when faced with environmental issues.

• 3. To learn to access information and tell the difference between reliable and unreliable information.

• 4. To depict the role of Geologists in today's society.
Objectives

5. To present knowledge that will be useful for life, whether forming opinions on environmental issues, selecting a home site or other property, evaluating a business, or appreciating and understanding your surroundings.

6. To sharpen your observational skills and expand your horizons by introducing you to the complexities of geologic systems and processes, and developing your ability to "see" in three dimensions.

7. To prepare you to consider many environmental issues facing society, such as resource utilization, water use and conservation, and land-use planning.
Learning Outcomes

• Understanding of the terrestrial foundation on which societies are built.
• An understanding of the vastness of geologic time, and the varying rates of geologic processes.
• To understand the occurrence of natural hazards and methods of hazard mitigation.
• An understanding of the range of scales of geologic problems, from the global to the microscopic.
• Appreciation that Earth resources are limited and Earth has a limited capacity to sustain life.
• A better appreciation of Earth's beauty.