# Chapter I: Relationships between Humans and Geological Phenomena in the Environment

## 1. Introduction to Environmental Geology

**Environmental geology** is a branch of applied geology that focuses on the interaction between **human activities** and the **geological environment**. It aims to understand how geological processes, materials, and structures affect human societies, and conversely, how human actions influence geological systems.

This discipline integrates knowledge from:

- **Physical geology**: Study of Earth materials and the natural processes that shape the Earth, such as volcanism, earthquakes, and erosion.

- **Geomorphology**: Study of landforms and the processes responsible for their formation and evolution.

- **Hydrogeology**: Study of groundwater, including its occurrence, movement, and quality within geological formations.

- **Engineering geology**: Application of geological knowledge to engineering works to ensure safe and stable construction.

- **Environmental sciences**: Interdisciplinary study of the environment, focusing on interactions between natural systems and human activities.

Environmental geology plays a key role in addressing modern challenges such as:

- **Natural hazards**: Natural processes or events that can cause damage to humans, property, and the environment.

- **Resource management**: Sustainable management of natural resources to satisfy human needs without exhausting them.

- **Environmental degradation**: Deterioration of the environment caused by natural processes or human activities.

- **Sustainable land use planning**: Organization of land use in a way that balances development, **environmental protection**, and long-term sustainability.

Its ultimate goal is to **reduce environmental risks**, **protect natural resources**, and **promote sustainable development** through informed decision-making.

# 2. Human–Environment–Geology Interactions

The relationship between humans and the geological environment is **dynamic and bidirectional**.

## 2.1 Influence of Geology on Human Activities

Geological conditions strongly control:

- **Settlement location (plains, valleys, coastal areas)**: People choose places to live based on flat land, water availability, and favorable geological conditions.

- **Agriculture (soil type, fertility)**: Geological materials control soil properties, which affect crop growth and agricultural productivity.

- **Availability of natural resources (water, minerals, energy)**: Geology determines where water, minerals, and energy resources are found.

- **Infrastructure stability (roads, dams, buildings)**: The type and structure of rocks and soils influence the safety and durability of constructions.

Examples:

- **River valleys attract populations** because they offer fertile soils and reliable water for agriculture and daily use.

- **Mountainous regions limit urban expansion** due to steep slopes but are rich in mineral resources.

- **Fault zones pose seismic risks** because they are areas where earthquakes are likely to occur.

## 2.2 Influence of Humans on the Geological Environment

Human activities can modify natural geological processes by:

- **Altering landforms**: Human activities such as excavation, construction, and mining change the natural shape of the land.

- **Changing sediment transport**: Dams, roads, and land clearing modify how sediments are moved and deposited by water or wind.

- **Modifying groundwater systems**: Over-pumping, wells, and urbanization disturb groundwater flow and reduce aquifer levels.

- **Accelerating erosion and slope instability**: Deforestation and improper land use increase soil erosion and trigger landslides.

These interactions often increase environmental stress and vulnerability when not properly managed.

## 3. Impact of Human Activities on Geological Processes

Human actions can significantly disturb natural geological processes, sometimes irreversibly.

### 3.1 Urbanization

- **Soil sealing reduces infiltration and increases surface runoff**: Pavements and buildings prevent water from entering the soil, causing more water to flow on the surface.

- **Increased flood risk in urban areas**: Faster runoff and reduced infiltration lead to frequent and intense urban flooding.

- **Modification of natural drainage systems**: Urban development alters rivers, channels, and natural water pathways.

### 3.2 Mining and Quarrying

- **Landscape deformation**: Mining and excavation change the natural shape of the land.

- **Ground subsidence**: Removal of underground materials causes the ground to sink.

- **Soil and water contamination**: Mining and industrial activities pollute soil and water.

- **Generation of waste materials (tailings)**: Mining produces leftover materials that can harm the environment.

### 3.3 Agriculture

- **Accelerated soil erosion**: Removing vegetation through deforestation or overgrazing increases soil loss.

- **Soil compaction and degradation**: Heavy machinery and poor land use reduce soil quality and fertility.

- **Salinization in irrigated areas**: Excess irrigation causes salt buildup, harming crops and soil.

### 3.4 Dams and Water Exploitation

- **Modification of sediment transport**: Dams and reservoirs change how rivers carry and deposit sediments.

- **Reservoir-induced seismicity**: Large reservoirs can trigger earthquakes due to added water weight and pressure.

- **Groundwater depletion and land subsidence**: Overuse of groundwater causes the ground to sink and damages structures.

### 3.5 Climate Change (Anthropogenic Influence)

- **Intensification of erosion processes**: Human activity and climate change speed up soil and rock loss.

- **Increased frequency of landslides and floods**: More extreme weather and unstable slopes cause more disasters.

- **Coastal erosion due to sea-level rise**: Rising seas erode beaches and coastal land.

# 4. Role of Geology in Sustainable Development

Sustainable development aims to meet present needs **without compromising future generations**. Geology provides essential tools and knowledge to achieve this goal.

## 4.1 Sustainable Resource Management

- **Rational exploitation of mineral and water resources**: Using resources carefully to avoid waste.

- **Prevention of resource depletion**: Managing resources to ensure they last for the future.

- **Assessment of renewable and non-renewable resources**: Identifying which resources can be reused and which are limited.

## 4.2 Land-Use Planning

- **Geological mapping to identify suitable construction zones**: Using maps to choose safe locations for buildings and infrastructure.

- **Avoidance of hazard-prone areas**: Planning construction away from landslides, floods, and earthquakes.

- **Soil and slope stability analysis**: Checking soil strength and slope safety before building.

## 4.3 Environmental Protection

- **Pollution control and remediation**: Reducing pollution and cleaning contaminated sites.

- **Waste disposal site selection**: Choosing safe locations for landfills and waste storage.

- **Protection of aquifers**: Preventing contamination and overuse of groundwater.

### 4.4 Risk Prevention

- **Identification of geological hazards**: Recognizing areas at risk from earthquakes, landslides, floods, etc.

- **Integration of geology into development policies**: Using geological knowledge to plan safe and sustainable projects.

- **Support for environmental impact assessments (EIA)**: Providing geological data to evaluate the effects of development on the environment.

Geology thus acts as a **decision-support science** for sustainable planning.

## 5. Concepts of Geohazards and Vulnerability

### 5.1 Geohazards

Geohazards are **natural geological processes or phenomena** that pose a threat to human life, property, or the environment.

Main types include:

- **Earthquakes**: Sudden shaking of the ground caused by fault movement.

- **Landslides**: Downhill movement of soil and rock on slopes.
- **Volcanic eruptions**: Release of lava, ash, and gases from a volcano.
- **Floods**: Overflow of water that submerges land.
- **Coastal erosion**: Wearing away of shorelines by waves and tides.
- **Ground subsidence**: Sinking of the land surface, often due to groundwater extraction or mining.

A geohazard is characterized by:

1• **Location**: Where the hazard occurs.

2• **Magnitude**: The strength or size of the hazard.

3• **Frequency**: How often the hazard happens.

4• **Triggering factors**: Events or conditions that cause the hazard to occur.

## 5.2 Vulnerability

Vulnerability refers to the **degree of potential loss** resulting from the occurrence of a geohazard.

It depends on:

- **Population density**: More people in an area increases potential damage.
- **Quality of infrastructure**: Stronger buildings reduce vulnerability; weak structures increase risk.

- **Socio-economic conditions**: Wealth, education, and resources affect the ability to cope with hazards.

- **Level of preparedness and awareness**: Knowledge, planning, and early warning systems reduce losses.

## 5.3 Risk Concept

Risk is commonly defined as:

**Risk = Hazard × Vulnerability × Exposure (engeux)**

Reducing risk can be achieved by:

- **Limiting exposure (land-use regulation)**: Avoid building in hazard-prone areas.

- **Reducing vulnerability (resilient infrastructure)**: Construct buildings and infrastructure to withstand hazards.

- **Monitoring and early warning systems**: Detect hazards early to alert people and reduce damage.

# Chapter II

## Detailed Analysis of Geological Factors in Land Use

The study of geological factors is fundamental in land-use planning, urban development, agriculture, public works, and natural hazard management. The subsurface forms the foundation of all human activities; its nature and behavior determine the stability, safety, and sustainability of projects.

# I. Lithological Factors (Rock Type)

Lithology directly influences mechanical strength, permeability, weathering behavior, and terrain stability. For example;

## 1. Igneous Rocks

Examples: granite, basalt.

- Very high mechanical strength.
- Low compressibility.
- Generally suitable for heavy foundations (dams, high-rise buildings).
- However, fracturing may reduce stability.

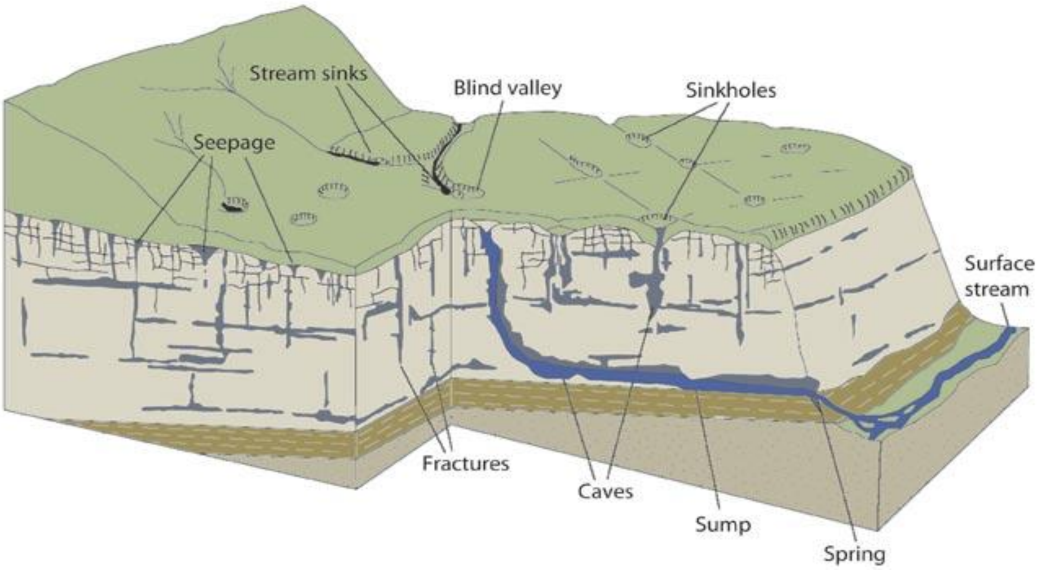


## 2. Sedimentary Rocks

Examples: limestone, sandstone, marl, clay.

- Compact limestone: good foundation material but sensitive to karst processes.
- Sandstone: good resistance if well cemented.
- Marl and clay: highly sensitive to water → swelling and shrinkage.

Marl formations in northern Algeria are often responsible for landslides.



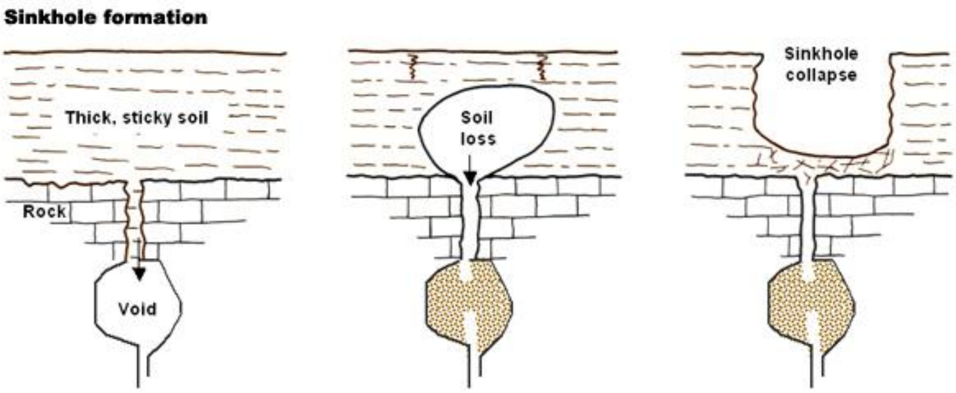
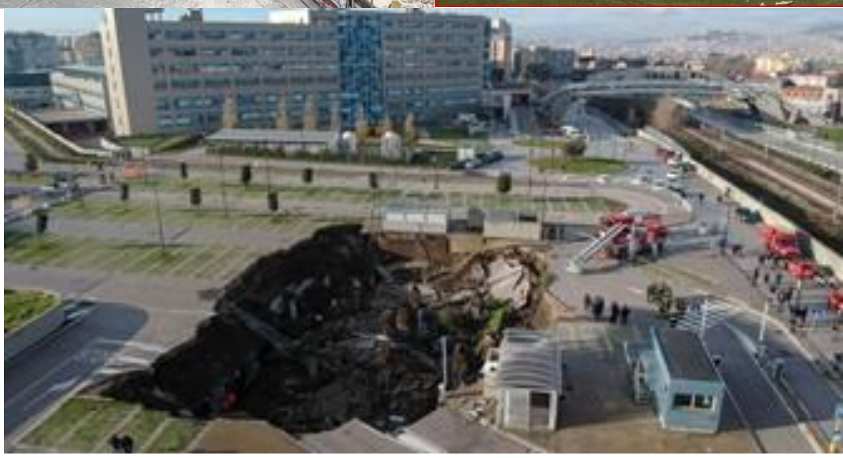




*Illustration courtesy the Pennsylvania Department of Environmental Protection.*



# 3. Metamorphic Rocks

Examples: schist, gneiss.

- Variable strength depending on foliation.
- Foliation planes may act as sliding surfaces.

# II. Structural Factors

Tectonic structures control slope stability and stress distribution.

## 1. Folds

- Layers dipping toward open slopes favor landslides.
- Synclines may accumulate groundwater.
- Anticlines may form resistant ridges.

## 2. Faults

Faults are zones of weakness:

- Rock fragmentation.
- Preferential groundwater circulation.
- Seismic hazard.

## 3. Fractures and Joints

- Increase permeability.
- Facilitate weathering and erosion.
- Reduce the overall strength of the rock mass.

# III. Geotechnical Factors

The mechanical properties of soils determine their capacity to support loads.

## 1. Cohesion

Ability of soil particles to remain bonded.

## 2. Internal Friction Angle

Resistance to sliding.

## 3. Plasticity

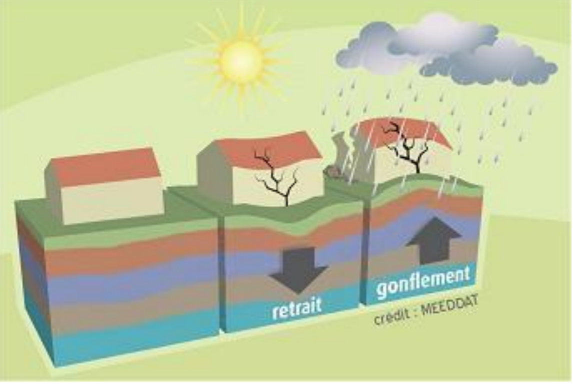
Plastic clay soils may undergo significant deformation.

## 4. Water Sensitivity

Water reduces soil strength and increases its weight.

Expansive clay soils may cause:

- Building cracks
- Foundation uplift
- Road instability



# IV. Hydrogeological Factors

Groundwater plays a major role in land use.

## 1. Depth of the Water Table

- Shallow water table → flood and settlement risks.
- Deep water table → better foundation conditions.

## 2. Permeability

- Permeable formations: good infiltration but rapid pollution risk.
- Impermeable formations: increased runoff → erosion.

## 3. Karst Processes

In limestone terrains:

- Formation of underground cavities
- Sinkholes
- Sudden collapses

# V. Morphological Factors (Relief)

Slope strongly influences land use:

- Steep slopes → landslides and accelerated erosion.
- Gentle slopes → more suitable for urbanization.
- Alluvial valleys → fertile soils but exposed to flooding.

# VI. Major Geological Hazards

Land use planning must integrate hazard assessment:

## 1. Earthquakes

Active zones in northern Algeria.

## 2. Landslides

Frequent in marly regions.

## 3. Water Erosion

Accelerates soil degradation in agricultural lands.

## 4. Subsidence

Ground sinking related to groundwater overexploitation or underground cavities.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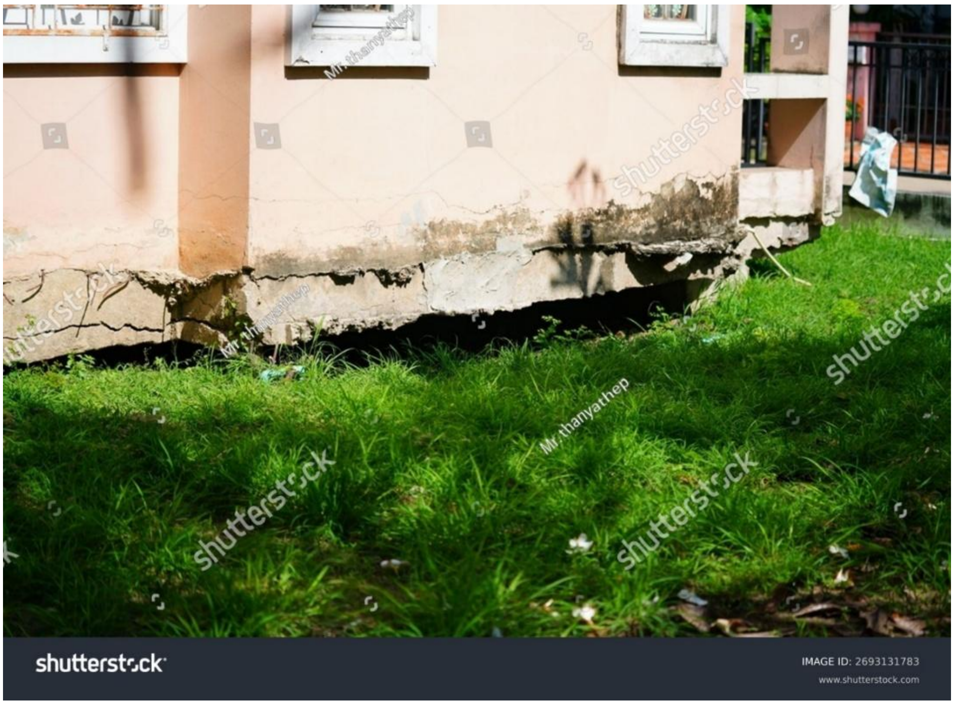
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# VII. Geological Resources and Development

Geological factors also determine:

- Location of quarries
- Availability of drinking water
- Construction materials
- Mining potential

They therefore influence regional economic development.

# VIII. Importance for Land-Use Planning

A proper geological analysis allows:

✓ Avoiding unstable areas

✓ Selecting appropriate foundation techniques

✓ Reducing maintenance costs

✓ Preventing natural disasters

✓ Ensuring sustainable development

# General Conclusion

Geological factors form the scientific basis of any territorial planning. A preliminary study including:

- Geological mapping
- Geotechnical investigation
- Hydrogeological analysis
- Hazard assessment

Is essential before any land use or development project.