# OTHER GEOLOGICAL HAZARDS

The Philippines, being a group of islands, has plenty of coastline and different types of islands. These islands vary in size and have diverse landscapes. Along the coasts, you'll find cliffs in the north and east, colorful sandy beaches, and salt marshes in various areas.

Coastal erosion is a significant concern here, caused by factors like wave strength and local weather conditions. The mountainous terrain, while rich in biodiversity, also brings the risk of landslides, whether natural or caused by human activity.

In some parts of the country, particularly where limestone and clay are common in the bedrock, ground subsidence is a threat. It's crucial for people to be aware of these risks and be prepared. Providing accurate, data-driven information is essential to help Filipinos stay ready for potential hazards.

## LESSON 1: GROUND SUBSTANCE

Ground subsidence is a common issue in urban areas, and it's often caused by human activities. In places like the Philippines, where urbanization is rapid, ground subsidence, including sinkholes, is frequently linked to excessive extraction of groundwater. This is a global concern, especially in large cities where millions of people rely on groundwater for daily activities like drinking, cooking, and bathing.

According to the United States Geological Survey (USGS), ground subsidence occurs when the support beneath the surface is removed, resulting in a loss of elevation. This can take various forms, ranging from small, localized incidents to broader events affecting larger areas. It's a phenomenon that requires attention, particularly in densely populated urban centers.

Land surface sinking, as highlighted by the International Hydrological Programme of UNESCO, is a significant issue globally, especially in densely populated deltaic regions. This phenomenon leads to costly damages.

Ground subsidence can stem from both natural and human-induced causes. Natural causes include tectonic movements and rising sea levels. However, human activities such as excessive extraction of groundwater and geothermal fluids, as well as mining activities like coal, sulfur, and gold extraction, and underground construction such as tunneling, also contribute to ground subsidence. These activities pose risks not only to the environment but also to infrastructure and communities.

The kind of ground subsidence known as a sinkhole happens when the rock beneath the land is either a salt bed, carbonated rocks, or limestone that was constantly
a protracted period of groundwater circulation. This prolonged exposure to groundwater has caused these

Certain kinds of rocks have the ability to disintegrate and eventually form underground chambers or caves. Once The earth's surface will eventually fall abruptly because these subterranean areas exist.

Sinkholes are formed in geological areas known as karst terrains, which are characterized by bedrocks made of limestone, dolomite, or gypsum. These types of rock can gradually dissolve when exposed to groundwater over time. In karst terrains, features like springs, caves, and sinkholes are common.

The formation of sinkholes begins when acidic water from soil and air seeps into the karst terrain. This acidic water easily infiltrates the rock, creating horizontal and vertical cracks and crevices that form a conduit system. This conduit, or underground river, is created by the pathways carved out by the acidic water. As a result, underground erosion occurs, leading to the formation of caves and, eventually, sinkholes.

**Types of Sinkholes**

| Type | Description |
|---|---|
| **Dissolution sinkholes** | Dissolution can be described as the process of dissolving of rocks, often by water or acid. This type of sinkhole forms from dissolution of the limestone or dolomite. Dissolution happens intensively where water first comes in contact with the rock surface. It can also occur where water passes through pre-existing openings, crevices or fractures in rocks. |
| **Cover-subsidence sinkholes** | In areas where the covering sediments contain sand and are permeable, cover-subsidence sinkholes can eventually develop. In areas where the covering sediments contain more clay, cover-subsidence sinkholes may still develop but may be undetected for longer periods of time. |
| **Cover-collapse sinkholes** | Cover-collapse sinkholes occur where the covering sediments contain a significant amount of clay. These sinkholes may develop abruptly (over a period of hours) and cause catastrophic damages. Over time, surface drainage, erosion, and deposition of sinkhole will develop into a shallower bowl-shaped depression. |
| **Human-induced sinkholes** | Some sinkholes are associated with human activities like groundwater pumping, construction, and land development practices. Sinkholes can also form when water diversion systems are developed for human activities. When the land is changed due to industrial activities, the weight of new materials placed on the surface can cause the collapse of the supporting material underground, causing a sinkhole. |

Ground subsidence can occur due to various factors, both natural and human-induced.

Natural causes include the dissolution and diversion of natural water drainage patterns. Additionally, dewatering or overdraining of organic soil and peat can lead to shrinkage, causing the ground to subside. Compaction of soil, whether due to natural processes or human activities, can displace air spaces, making the soil denser and more prone to subsidence.

Human activities such as subterranean mining or underground mining also contribute to ground subsidence by displacing materials beneath the surface.

Climate change can exacerbate ground subsidence through the thawing of permafrost. As permafrost thaws, it not only releases water but also erodes solid materials within its composition, causing the land to shrink and affecting both human infrastructure and natural features above its surface. Ground subsidence can have significant effects on various aspects of society and the environment.

In agricultural areas, subsidence can damage or destroy farmland, irrigation systems, and groundwater wells, leading to reduced agricultural productivity.

Industrial processes may also be affected, particularly in areas where subsidence disrupts infrastructure critical to manufacturing or resource extraction.

Infrastructure built on subsiding ground is at risk of damage or destruction. This includes roads, bridges, buildings, and other structures. In mining areas, tunnels and surrounding infrastructure are particularly vulnerable to collapse.

Furthermore, sudden subsidence events can pose immediate dangers to human safety, resulting in injuries and fatalities. Therefore, addressing and mitigating the impacts of ground subsidence is crucial for protecting both livelihoods and lives.

**Reducing the occurrence of ground subsidence involves both urban planning strategies and individual actions:**

Proper Urbanization: Governments should prioritize proper and planned urbanization. This means considering the risk of ground subsidence when building infrastructures, critical facilities, and transportation systems. Examples of urban planning considerations include:

- Exploring alternative sources to groundwater.
- Avoiding building infrastructure near land fissures.
- Directing drainage away from fissures.
- Prohibiting residential zones in or near areas prone to subsidence.

Water Conservation: Individuals can contribute by practicing water conservation to prevent overdraining underground water sources. This helps reduce the risk of ground subsidence caused by excessive water extraction.

By implementing these strategies at both the government and individual levels, we can mitigate the factors contributing to ground subsidence and work towards a more sustainable future.

**LESSON 2:**

LANDSLIDES

Landslides are unpredictable natural disasters that can occur anywhere and at any time, with devastating consequences. They have caused immense loss of life, injuries, and extensive damage to homes, businesses, and infrastructure globally. The economic disruptions caused by landslides run into billions of dollars, and the environmental damage can be long-lasting.

In addition to the immediate impacts, landslides often lead to the displacement of thousands of people, disrupting communities and causing significant social upheaval. In the Philippines, two notable examples of such disasters are the Cherry Hills Subdivision landslide in 1999 and the Guinsaugon debris avalanche landslide in 2006 in Southern Leyte. These tragic events serve as stark reminders of the destructive power of landslides and their profound effects on society.

| Major Types of Landslides | |
|---|---|
| **Fall** | When objects on cliffs or steep slopes lose stability or turn unstable, a fall split off from the primary rock. The materials, which can include various sized rocks and soil decline later by rolling, bouncing, or falling until they reach a flatter or lower surface. surfaces. |
| **Topple** | When a piece of material separates from a steep slope like this, **it topples.** visualize a spinning motion as it travels around a point of axis, forward and downward, like a cliff. Because of the mass's fissures or the material's weight, toppling may happen. produced by ice or water. Certain topples may also result in slides or falls. |
| **Slide** | A slide is the result of a separated mass of debris, like rocks, dirt, and Organic materials can occasionally travel on a surface that slopes downward. The amount of content grows as the mass descends away from its starting point. If the shifted mass is It is referred to as a **rotational landslide or slump** when it moves along a concave surface. If not, then when the mass known as a that glides outward and downward along a downward sloping surface **landslide in translation.** |
| **Flows** | A flow phenomenon occurs when materials from typically gentle slopes detach and move like a viscous liquid along a surface. Three common types of flows are:<br><br>**Debris Flow (Mudslide)**: This is a rapid movement of slurry, informally known as a mudslide, formed from water mixing with materials such as rocks, soil, and sometimes organic matter. Lahar flow, a type of volcanic mudflow, originates on the slopes of volcanoes and mobilizes loose accumulations of tephra (airborne solids erupted from the volcano) and related debris.<br><br>**Debris Avalanche**: This occurs when unstable slopes suddenly collapse, and fragmented debris rapidly moves downwards along the slope. Snow and ice can contribute to the movement, and if a significant amount of water is present, it can transform into a debris flow.<br><br>**Earth Flow:** The presence of silt or clay in the flow causes it to become more viscous earth movement. Earth flows can be swift and disastrous or very sluggish and nearly undetectable. |
| **Spread** | This is the result of a mass of rocks or dirt spreading laterally. This mass |

| | |
|---|---|
| | It is frequently possible to see movement of the rocks and soil when there is liquefaction or an tremor. |

## FACTORS THAT INFLUENCE LANDSLIDE DEVELOPMENT

Rock and soil characteristics that make them brittle or susceptible to movement are among the **geological elements** that affect landslides. For example, because they will separate from the main material more readily, materials that are worn and broken are more likely to cause landslides. Sections of ground that are prone to landslides may also be affected by permeability and material stiffness. The form and slope of the land, tectonic and volcanic activity, erosion and deposition, water, the amount of vegetation on the rock and soil surface, and the boundaries of the affected land mass are **morphological elements** that affect landslides.

Landslides are also influenced by **human** factors like as construction activities that alter the geological and the land's physical characteristics. mining, excavation, constructing dams and roads, Among the human activities that raise the vulnerability are deforestation and irrigation landslides in many regions.

## THE CAUSES OF RAINFALL-INDUCED LANDSLIDES

Landslides are primarily caused by three natural phenomena: seismic activity, volcanic activity, and water (rainfall). Of those three, the amount of water resulting from rainfall has been rising since 1980 (UNESCAP & UNISDR (2002). The formation of landslides is mostly dependent on rainfall. Slope is one of the main reasons for landslides worldwide is water saturation. Water increases due to steep terrain and some slopes' weak geological features. When the hilly area experiences torrential rainfall, the soil particles become looser and the friction of the ground.

Landslides cause flooding and debris flow to happen at the same time. The floods could result in a landslide brought on by valley and stream channel obstructions. These obstructions support a sizable accumulation of water, and flash floods will happen when it collapses. The accumulation of solid waste as a result of landslides can also have an impact on how stream diversion develops and ultimately result in localized deterioration elsewhere.

The construction of houses and businesses atop slopes, along with the related road expansion, surface environment alterations, and drainage system modifications can increase the risk of landslides on slopes

There are several observable signs that may indicate an impending landslide, providing some level of predictability. These signs include changes in the physical aspects of an area, whether they are part of man-made structures or natural features:

**Cracks and Bulges:** Cracks or bulges appearing on concrete or paved roads and sidewalks can signal potential instability in the ground.

**Damage to Infrastructure:** Broken water pipes and other underground fixtures may indicate movement and shifting of the ground, potentially leading to a landslide.

**Movement of Structures**: Structures that are normally fixed, such as fences, telephone poles, and other ground level structures, may show signs of movement or tilting, suggesting instability in the surrounding area.

Monitoring and recognizing these warning signs can help mitigate the risks associated with landslides by allowing for early intervention and evacuation measures to be implemented.

## LESSON 3: COASTAL EROSION

The Philippines, being an archipelago with over 7,000 islands, boasts diverse coastlines. From cliff edges in Batanes to beach barriers across the country and salt marshes nationwide, it's rich in coastal features. However, these features also make it susceptible to coastal erosion.

**Coastal erosion** is the gradual breakdown and removal of coastal materials due to waves, tides, and human activities. It's a global issue, with 15 square kilometers of coastline receding annually due to rising sea levels and climate change. Human development along coastlines exacerbates this problem.

Despite the allure of waterfront properties, many houses are built without adequate measures to prevent or mitigate the risks of coastal erosion. This lack of preparedness poses significant disaster risks for coastal communities.

An additional crucial element is the establishment or growth of tourism infrastructure along the shorelines, including lodging facilities, cottages, and other establishments that fuel the devastation of coastal regions. The Department of Environment and Natural Resources (DENR) in January 2018 was given the task of renovating and cleaning up the island of Boracay in Malaybalay, Aklan. The aforementioned decree placed special emphasis on the island's coastline regions and addressed unsuitable
sewage networks at numerous island establishments.

## TYPES OF COASTAL EROSION

**Mechanical Erosion of Waves:** The primary erosion element is the **mechanical action of the coastal environment**, via storm waves or waves with a lot of energy. When energy is scarce, the waves' erosive power is diminished, yet they nevertheless make a substantial contribution to the weathered material removal. In addition to using waves to remove loose particles, two main results are the erosion of rock surfaces and the variations in pressure that are brought about on rocks by the waves.

**Weathering:** Rain, tides, wave swash, and salt spray all alternately wet and dry coastal cliffs and intertidal coastal platforms. They thus provide an ideal habitat for a variety of weathering processes, both chemical and physical.

**Bioerosion:** Rocks and minerals are removed by bioerosion, which is the result of organisms. Because tropical places' marine ecosystems have a high level of biodiversity, their rocks and sediments are more vulnerable to coastal erosion. Rocks are used by marine life as a source of energy and as a place to live. For example, substrates made of limestone are involved in the biochemical and biophysical mechanisms in animals with shells, such as corals. The geographical distribution of marine organisms along the rock surface is a major element influencing the rate of bioerosion. This distribution is mostly determined by the available moisture, which is mostly determined by tidal currents and wave action.

**Mass movement:** Rocky shoreline steep slopes are unstable and prone to mass motions based on the characteristics and composition of the rock.

## FACTORS THAT INFLUENCE COASTAL EROSION

**Climate:** The term "climate" refers to an area's weather patterns and influences coastal physical features including storm surges, waves, and underwater currents. Coastal currents and wind waves are related to wind regime. The wave height increases with wind strength. More erosive activities result from higher waves.

**Lithology of Rock**s: The rock's resilience to erosion from the sea and subterranean impact the material's ability to withstand weathering and erosion. Base materials may be washed out of the shorelines as a result of a rock being exposed to waves.

**Global sea level rise:** Although it is a natural event, human activity can global warming brought on by human development activities that hasten the earth's warming process. Sea level rise is impacted by global warming, which also causes the ocean's water to expand thermally and melt ice sheets in the polar regions. Countries and coastal towns worldwide are at risk due to this extraordinary rise in sea level. This issue primarily affects three ecosystems: wetlands flooded, coastal aquifers contaminated with salt, and coastal erosion.

**Man-made interventions:** Coastal regions are important places for human activity. They can be used as valuable real estate, leisure areas, tourist attractions, and military bases. Because of this, the consequences of these human advances become more likely to affect coastal areas. Sand mining is another notable human activity that is detrimental to coastal regions and their residents.

## LESSON 4: BOLIDE IMPACT

A **bolide** is a general name for **any celestial body that enters the earth's surface and produces a fireball.** A comparatively larger bolide is referred to as a superbolide. A bolide may erupt upon impact or generate a crater when it strikes the earth. The characteristics of the foreign body that enters the Earth, such as its size, composition, density, and capacity to survive the journey, determine the bolide impact. While a metallic bolide can produce a large crater, a stony bolide can flatten the impact site without leaving a crater formation. Every day, bolides penetrate the surface of the Earth.
Some bolides enter during the day, when the intense sunshine obscures their gaze; others fall into the wide expanses of uninhabited land and water. One of the eleven thousand (11, 000) projected bolides in our solar system could potentially enter our atmosphere at any time.

The only natural disaster that has the power to quickly kill billions of people or to destroy property owned by people and economic systems, so jeopardizing civilization, is a bolide impact. The landing area's geological, geophysical, and geochemical components are all impacted.

Impacts from **superbolides** may cause crater formation. Superbolides have historically accelerated the occurrence of sea level rise and climate change. Boiling earth impacts are also associated with intense tectonic activity, earthquakes, and increased volcanism. These effects of bolides on the environment have the potential to cause a worldwide mass extinction and environmental hazards.

## EXAMPLES OF DEFLECTION TECHNIQUES

Several strategies to prevent or lessen the effects of a bolide crash were proposed by Harris, A.W., et al. (2015). In order to prevent larger NEOs like asteroids, either reduce its size, speed, or direction changes to totally prevent contact. Technologies such as moving the NEO with a laser beam, refocusing solar energy on it with enormous lenses or mirrors, and colliding the NEO with another object are examples of technologies that can achieve those goals. a NEO to alter its trajectory or divert it.

Space agencies are preparing for the possibility of bolides by conducting experimental missions. On July 4, 2005, an impactor from the NASA Deep Impact mission successfully collided with Comet 9P/Tempel 1's nucleus. and brought the intricate

The 6-km-diameter nucleus's massive mass and the non-gravitational forces acting on it made it impossible to measure any changes in the comet's course as a result of the hit. However, the mission was successful in hitting its target and demonstrated the sophisticated autonomous guidance required to achieve it.