CHAPTER 7

Natural Hazards

Key words: Earthquake, tsunami, volcano eruptions, landslides, storms, floods, droughts, historical eruptions.

Introduction

Natural Hazards are phenomena or processes that can potentially affect human beings and their activities. Natural hazards can pose a significant danger to people, their properties and the environment they live in. It is important, therefore, to understand about natural hazards, as well as the risks associated with them, to help protect communities form their effects.

7.1. About earthquake risk and the protection of communities

An *Earthquake* is a sudden shaking of the Earth's crust caused by the sudden release of slowly accumulated strain in the bedrock, and which can cause significant damage to human structures. In ancient societies there were different myths and legends which tried to explain earthquakes. For instance for the ancient Greeks the giant Enceladus was responsible for earthquakes and for the Japanese it was a whale.

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The risk of earthquakes depends on:

- The local geological conditions of the area (e.g. solid rock or loose consolidated deposits, proximity of active fault zone).
- Distance from a potential epicentre.
- The type of building construction in the area and building regulations (and their enforcement).
- The population density of the area.
- The preparation of the population for emergencies.

The study of earthquakes is called seismology. To reduce the potential hazards of an earthquake, it is necessary to develop very strict building codes and include geological risk zoning and vulnerability mapping into building planning systems. This is because the majority of deaths from earthquakes are due to the collapse of human constructions.

7.2. About tsunami

Tsunamis are very large waves that can travel very quickly across the sea and can cause extensive damage along coastal areas, sometimes for thousands of kilometres. Tsunamis are usually generated by plate movements, undersea earthquakes, volcanic eruptions and landslides, and much more rarely by meteorite impact. Tsunamis are very destructive and cause considerable damage to ships, harbours, coastal installations, buildings and constructions near the coast, as well as the death of many people. They can also affect the aquatic fauna and flora in the coastal environment.

In the open sea, tsunamis are not dramatically higher than normal waves, as they are usually only about 1m high. However, as they travel towards the land and come nearer to the coast, they increase in height as the depth of the sea water decreases. Tsunamis transfer a huge amount of energy and they can reach a speed of 800km/h in the open sea, slowing down when they reach the coast as the water depth shallows. The speed of tsunamis depends on water depth rather than on the source of the wave. Typically, shortly before a tsunami wave hits the coast, the sea level near the shore drops, exposing the sea floor. According to NOAA (National Oceanic and Atmospheric Association of USA), *"...the largest tsunami on record rushed past Ishigaki Island, Japan, in 1971. It was an incredible 84.7 meters high tsunami wave. While it caused little damage, the giant wall of water relocated a 750-ton block of coral 2.4 kilometers inland".*

7.3. What happened in Japan after the Earthquake and tsunami of March 2011

On March 11, an earthquake of amplitude nine on the Richter scale, led to a huge tsunami, and 50 aftershocks, which destroyed extensive areas along the NE coast of Japan, from Chiba to Aomori (Honshu). The epicentre of the earthquake was located about 373 km NE of Tokyo. It was reported that at least 15,703 people died, 5,314 injured and 4,647 people were missing. 130,927 people were displaced and at least 332,395 buildings, 2,126 roads, 56 bridges and 26 railways were destroyed or damaged by the earthquake and tsunami (source *USGC-Earthquake Hazard programme*).

7.4. About volcanic eruptions and the risks and benefits of the volcanic activity

Volcanic eruptions are the ejection of igneous material from inside the Earth (lava, ash, pyroclastic flows, and associated gases) via a vent or fissure to the surface.

There are at least 1,300 volcanoes - perhaps more than 1500 - that are potentially active or have erupted in past 10,000 years. Some estimates of young seafloor volcanoes, however, exceed a million.

Although volcanoes threaten communities close to them, they can also bring some benefits, such as:

- Very fertile soils supporting agriculture.
- Creating new land areas (such as the island Nea Kammeni of the Santorini complex islands in Aegean Sea, Greece).
- A source of geothermal energy.

- Precious gems and volcanic sulphur.
- Providing decorative and light weight material for buildings.

Volcanologists study and record current volcanic activity using scientific instruments, including seismographs to detect the earthquakes that almost always precede eruptions. They also study past volcanic activity. The results of these studies are very important and help develop plans for those who live nearby and who may be affected by any future eruption.

7.5. What happened in Pompeii after the Vesuvius eruption of 79 A.D.

The violent eruption of the volcano *Vesuvius* in August A.D. 79 was described by the Roman writer Pliny the Younger, who was an eye-witness. The ash and the pumice produced by the eruption covered areas up to around 30km from Vesuvius, including burying the Roman city of *Pompeii* and killing thousands of people. Some days before the eruption, small earthquakes took place. The old mountain was destroyed by the eruption and in its place a new one was created from the volcanoes products and the remains of the old dome. Pompeii was rediscovered during the 18th century and excavated. The area around Vesuvius remains one of the most dangerous volcanic areas in the world because of its density of people and settlements - the last eruption of Vesuvius took place in the 1944. Today Pompeii is a National Park and open to visitors.

7.6. About the eruption of the volcano of Santorini in the Late Bronze Age and its impact on the cultures and civilizations of the time

Santorini is a caldera-type volcano situated in the Aegean Sea and it is the most active volcanic centre in the South Aegean Volcanic Arc. Volcanism in Santorini began around two million years ago with the extrusion of lava from vents around the Akrotiri area. The five islands of the Santorini volcano formed from a variety of eruptions over a long period of time.
The Thera, Therasia and Aspronisi islands form a broken circle and they are the remnants of a formerly large single inland called in ancient time *Stroggili* (= “round”). Their present topography is the result of the Minoan eruption that happened between 1645-1625 B.C. Since that time, two further islands (Palaea Kammeni and Nea Kammeni) have grown up from erupted lava in the middle of the Caldera. Palaea Kammeni appeared during the eruption of 197 B.C. and during the volcanic activity of 1707 Nea Kammeni first appeared. The latest volcanic dome was created during activity in 1950.
Thera is the largest island with spectacular 300m high vertical cliffs on the inside of the caldera. These cliffs reveal the stratified deposits of many different eruptions through the last 500,000 years. The most important and famous eruption, however, of the Santorini volcano took place in the Late Bronze Age, between 1645-1625 B.C. It was a Plinian explosion so huge that the eruption column is estimated to have risen to around 30km and the ash was spread all around the Eastern Mediterranean (ash from this explosion has found in Egypt, 800 km away). Several metres of pumice blocks and ash covered the island area. Archaeological excavations near the area of Akrotiri have revealed the ruins of a Minoan town with very well preserved frescos and paintings, as well as many craft items. A tsunami around 30m high was generated by the eruption and reached the coast of Crete and destroyed the Minoan culture, the dominant civilization in the Mediterranean at this time. Historians believe that this volcanic eruption changed the political landscape of the ancient world. After this eruption the island was uninhabited for the next 300 years.
Many earthquakes followed this great eruption and caused the internal collapse of the crater,

which created the current geological caldera, which measures 12 km by 7 km, is 400 m depth and surrounded by 300 m high cliffs.

7.7. About landslides

Landslides are downwards movements of slope-forming material such as rocks, soils and artificial fillings under the influence of the gravity. They can occur in any terrain, where conditions allow gravity to overcome the forces of friction. Typically, mountainous areas are most at risk from landslides, but they can occur also in lowland areas where slopes developed in relative weak materials are developed, or have been de-stablised by road construction, excavation for buildings or in active quarries and opencast mines. Coastal areas can also be at a high risk from landslips as coastal erosion undermines coastal slopes and cliffs. The primary cause of a landslide is the saturation by groundwater of the slope material, leading to a loss of cohesion meaning that they can flow more easily. Other factors that affect slope movement are the gradient of the slope and its degree of consolidation.

Landslides are often related to:

- Volcanic activity
- Seismic activity
- Coastal erosion
- Tectonic conditions in the area
- Differences in lithologies within the slope
- Weathering and extreme climatic conditions or weather conditions
- Wildfires

Human activity can also be a very important factor due to de-stabilising of slopes by engineering works or construction or changes in ground water systems.
The amount of material moved during a landslide can be enormous. In some cases the volume of the slope material is so huge that entire villages can subside or be buried (e.g. in 1963 at Mikro Horio, Karpenissi-Greece where 13 people were killed).
Mitigating landslide hazard: 1) Avoid construction on steep slopes in weak geological materials or in areas at risk from natural erosion (e.g. due to rivers or the sea), 2) Install surface and deep draining to remove excess groundwater, 3) Reduce or control surface rainwater runoff, 4) Applying engineering techniques to stabilise slopes (e.g. following on from a thorough study of the geological, hydrological and geotechnical conditions of the area).

7.9. About floods

Floods are one of the most common natural hazards and they can be either *coastal* or *river floods* depending on their causes.

Coastal floods often happen when the sea overflows coastal land due to a storm event, or more rarely a tsunami. Events causing coastal flooding include:

- Storm events, often seasonal
- Exceptionally high tides
- Sea level rise due to a climatic change
- Tsunamis
- Local tectonic activity

A combination of exceptionally high tides and storms often causes coastal flooding; exceptionally, however, tsunamis can cause flooding many hundreds of metres inland. In such cases, the seawater moves inland with such a huge force that it crushes everything in its path. Coastal flooding can lead to many social, economic and environmental impacts in the affected area.
River floods are the most common floods and they occur when the river flow is high and the water overtops the river banks and covers the land around. Factors causing river floods are:

- Heavy rainfall
- Permeability of rocks
- Topography of landscape
- Dam overflow or dam collapse
- The melting of ice and snow during the spring.

Every year river floods are responsible for damage to property and agricultural production and the loss of human life.

7.10. About droughts

Drought is a period when there is not enough rainfall for an unusually long period of time, which affects the hydrological equilibrium of the area. During a drought, streams dry up, soils dry out, the level of groundwater sinks, plants die and there is not enough water for people and animals. Sometimes droughts are related to high temperatures which increase evaporation and water loss. When these phenomena continue for an unexpected long period, settlements and the general environment are put at risk.
There are 4 types of Drought: 1) *Meteorological drought* (decrease of rainfall), 2) *Hydrological drought* (decrease of water reserves), 3) *Agricultural drought* (impact on the agricultural production) and 4), the more dangerous type, *Starvation drought.*

7.11. About storms

The term storm includes many weather phenomena such as rainstorm, snowstorm, thunderstorm, hailstorm, windstorm, tropical cyclone, whirlwinds and tornados. Storms can have negative impacts on people and properties as they can cause flooding, block road and other transport systems, lead to wildfires and create dangerously powerful storm waves in coastal areas. Whirlwinds and tornados are some of the most dangerous natural phenomena because of their particular characteristics, such as very low atmospheric pressures which lead to very strong winds. Atmospheric pressures can drop to 100 mbar and the wind speed can rise to 230 km/h, and sometimes to 400 km/h, in a tornado.

7.12. What we can do to avoid being exposed to Natural Hazards

School education should aim to develop a “culture of prevention”. Students (i.e. future citizens) can be made aware of natural hazards. As adults, they may be able to take preventive measures and avoid activities that could destroy the balance of ecosystems and harm the natural environment. In this way they will be able to reduce the risk of turning natural phenomena into the natural disasters which cause enormous losses of human lives, infrastructure and property.

7.13. How we can defend against geological risks

Natural Hazards related with the geological processes include:

- Earthquakes – and secondary effects such as tsunamis and aftershocks (smaller earthquakes)
- Volcanic eruption (lava flows, tephra, pyroclastic flows and gases)
- Landslides
- Rock falls
- Floods (river/coastal)
- Droughts
- Salinisation of water supplies

Geological hazards will never go away. A prepared society, however, can make them less damaging, by preparing emergency plans and instructions for citizens to follow when they strike. Learn, share, join together and be ready to reduce geological risks to our society.

Intended learning outcomes:

- Know about different types of natural hazards (e.g. earthquakes, volcanic eruptions, etc.).
- Describe the causes and dangers associated with specific natural hazards (e.g. earthquakes, tsunami, volcanic eruptions, etc.).
- Know about historical and recent large-scale natural disasters and their impacts on human society, infrastructure, property and the environment.
- Know how to be ready to prevent, confront and mitigate the impacts of natural hazards in varying circumstances.
- Be aware of natural hazards and establish a "culture of prevention".

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