D GEOPHYSICAL HAZARDS

The human and natural worlds face a number of risks, and geophysical hazards are a constant threat in many parts of the world. Dynamic tectonic processes ensure that places at varying levels of development have to cope with the impact of volcanoes and/or earthquakes as well as different types of mass movement.

You may have already studied other risks such as extreme climatic events as part of Unit 2, so you should be familiar with the conceptual connections such as the processes involved, the effect on different places, the power of different stakeholders in coping with the risk and the events, and the possibilities to create resilience.

You should be able to show:

- ✔ how geological **processes** give rise to geophysical events of differing type and magnitude;
- ✔ how geophysical systems generate hazard risks for different **places;**
- ✔ how the varying **power** of geophysical hazards can affect people in different local contexts;
- ✔ how future **possibilities** can lessen human vulnerability to geophysical hazards.

D.1 GEOPHYSICAL SYSTEMS

You should be able to show how geological processes give rise to geophysical events of differing type and magnitude:

- ✔ Mechanisms of plate movement including internal heating, convection currents, plumes, subduction and rifting at plate margins;
- ✔ Characteristics of volcanoes (shield, composite and cinder) formed by varying types of volcanic eruption; associated secondary hazards (pyroclastic flows, lahars, landslides);
- ✔ Characteristics of earthquakes (depth of focus, epicentre and wave types) caused by varying types of plate margin movement and human triggers (dam building, resource extraction); associated secondary hazards (tsunami, landslides, liquefaction, transverse faults);
- ✔ Classification of mass movement types according to cause (physical and human), liquidity, speed of onset, duration, extent and frequency.

- **Convection currents** – the transfer of heat via movement of magma in the Earth's crust.
- **Subduction** – when a tectonic plate is forced underneath another tectonic plate into the mantle at a convergent plate boundary.
- **Rifting** – the creation of a crack or fault line in the Earth's crust as the lithosphere is extended and stretched.
- **Pyroclastic flow** – a rapidly moving mixture of hot gases, rocks and lava that is produced when a volcano erupts.
- **Lahar** – a flow of volcanic debris that has mixed with water and mud.
- **Liquefaction** – when a saturated land surface changes composition, moving from a solid to a liquid temporarily due to seismic activity in the Earth's crust.
- **Transverse fault** – when rocks move in opposite directions to one another creating tension and a release of seismic energy.

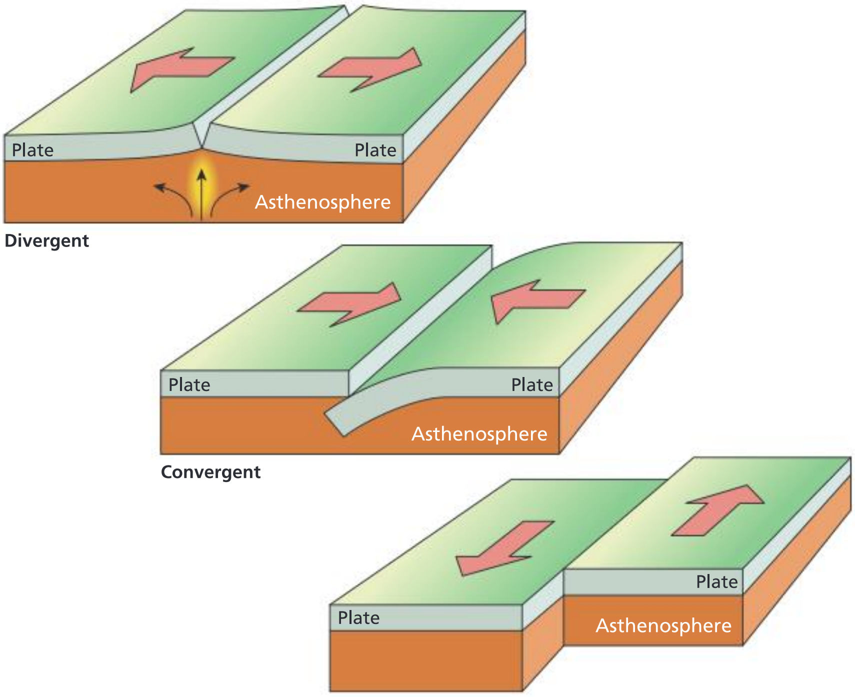
Mechanisms of plate movement

The Earth is a system that is constructed from a series of layers. Each of the layers has a different composition, and it is the interaction between these layers that drives the processes of tectonic movement within the Earth's crust. In particular, convection currents within the mantle affect the overlying lithosphere and this ensures that tectonic plates converge, diverge or compress against each other.

When the different types of movement occur, they result in the formation of various landforms and the creation of hazard events. For example, when oceanic crust converges against continental crust, the oceanic tectonic plate (a denser rock type) is subducted or forced underneath the continental plate into the mantle. This creates friction between the two plates and eventually leads to seismic energy being released. Subsequently an earthquake occurs, the land mass on the continental plate is forced to compress and fold mountains are formed. In addition, plumes of magma are formed as the oceanic plate melts in the mantle. These plumes, under pressure, will make their way to the surface via weaknesses in the continental plate. Upon reaching the surface, a volcanic eruption will occur.

Figure D.1.1 shows these different types of plate movement and how they connect within the Earth's geophysical system:

Figure D.1.1. Different types of tectonic plate movement



Note the presence of the continental rift zone in the diagram of divergent plates, which shows how a continental plate is being stretched.

Figure D.1.2. Mass movements in the Dolomites, Italy

Concept link

PROCESSES: Geological processes create geophysical events such as earthquakes, volcanic eruptions and mass movement. The extent of the processes, in terms of the intensity, will result in a range of different effects occurring at different scales. The spatial interaction between geological areas influences the speed of onset and other characteristics of the hazard.

Assessment tip

You should be able to describe and explain the processes that take place at convergent, divergent and transform plate boundaries and ensure that you include appropriate terminology. For example, tectonic plates move apart at divergent plate margins, such as the North American plate and the Eurasian plates, due to convection currents in the mantle. This allows magma to rise and solidify, which means that the sea floor spreads as the plates move apart under the Atlantic Ocean. Underwater shield volcanoes can be formed, which may reach above the water level over time due to further eruptions.

Test yourself

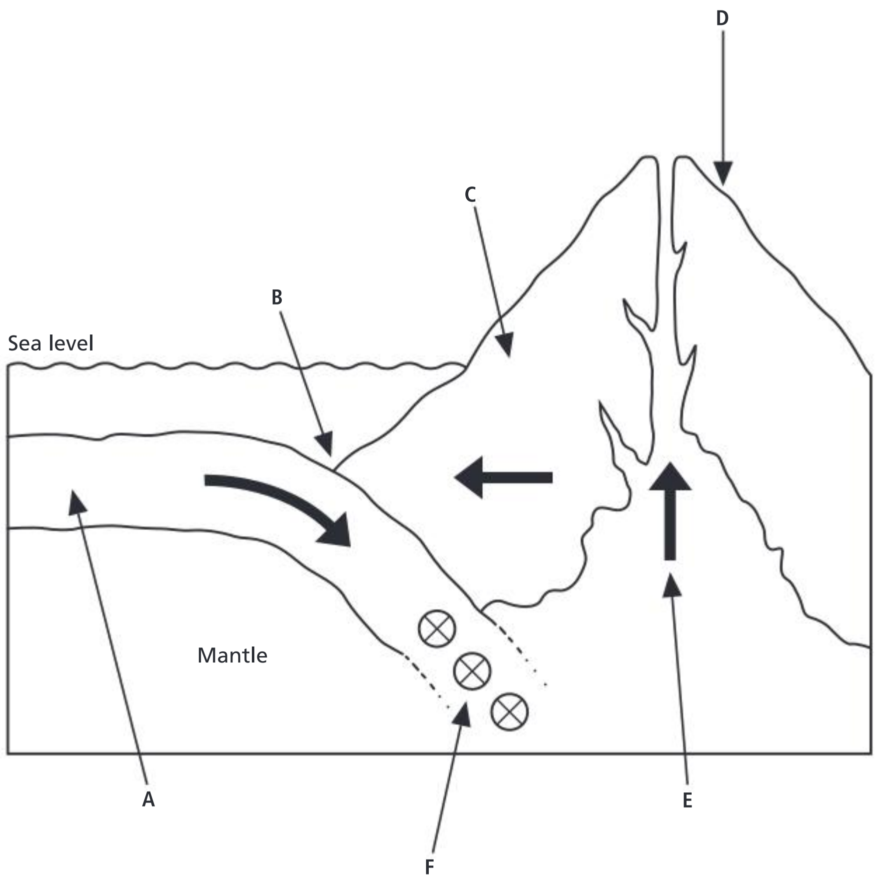
D.1 (a) State two types of volcano. [2]

(b) Describe the differences in terms of the lava emitted from the two types of volcano that you named in part (a). [2]

Characteristics of volcanoes

Composite volcanoes, shield and cinder volcanoes have different characteristics in terms of their shape, the type of eruption and the hazards created during and after an eruption. The hazards can be classified into primary (e.g. lava flows, pyroclastic flows, volcanic gases, ash fall) and secondary (e.g. lahars, landslides, flooding, tsunamis, food shortages).

▼ Figure D.1.3.



Test yourself

D.2 Copy figure D.1.3 and **annotate** to describe or explain the process that is taking place at each letter. [6]

Assessment tip

As with other examination questions for the optional themes on paper 1, this type of question provides an opportunity to draw an annotated diagram. Your diagram and your annotations need to be clear, and they should explain the processes and features.

Test yourself

D.3 Explain the formation of landforms at divergent plate margins. [2+2]

Characteristics of earthquakes

The point on the Earth's surface from where seismic energy emanates is called the epicentre. The true centre of the earthquakes is in the crust, called the focus. There are different types of seismic waves. P-waves compress and expand the ground like an accordion, affecting both liquid and solid surfaces. S-waves only travel through solid material and not liquid; they move from side to side as well as up and down. Surface waves form when P- and S-waves reach the surface, hence the name. Surface waves fall into two categories: Rayleigh waves which roll along the surface like a wave, and Love waves which move the surface from side to side.

Classification of mass movement types

Human activity can increase the risk of seismic activity. The presence of fracking has been an issue in some areas as it has resulted in minor earthquakes, such as in parts of Oklahoma, USA. Dams are often built in areas where tectonic movement has taken place, and the valley is flooded. Water pressure in cracks behind the dam will increase, which creates weakness and instability in the underlying rock beneath the dam.

Content link
Option A.4 examines the pros and cons of constructing dams.

Mining can also create instability in the Earth's crust. Earthquakes can occur due to the extraction of fluids underground, such as water when mining coal for example, which creates subsidence and movement in the crust.

Figure D.1.4 shows the different types of mass movement.

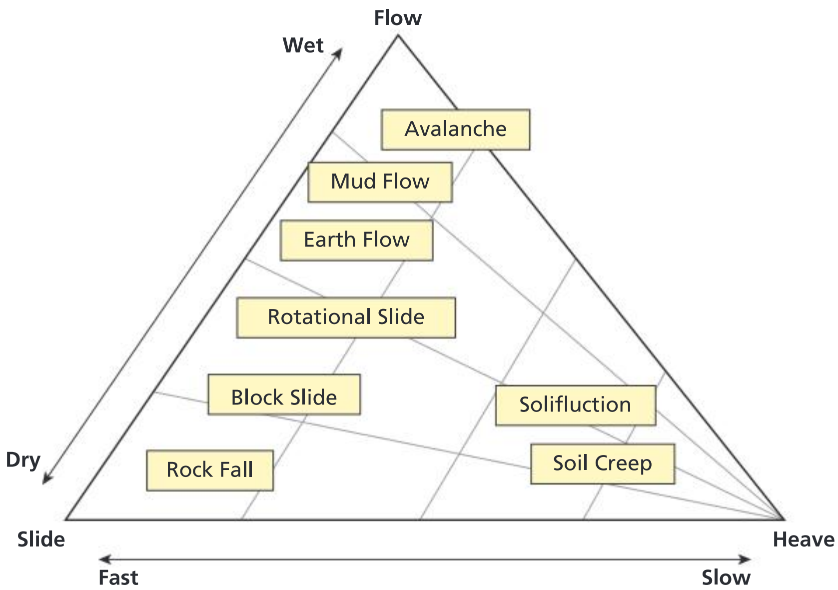


Figure D.1.4. Types of mass movement

Weathering also creates instability and enables different types of mass movement, and seismic energy causes unpredictability in a slope. Weathering can be categorized as mechanical, chemical or biological.

Table D.1.1. Categories of weathering

Mechanical	Chemical	Biological
Freeze–thaw	Hydrolysis	Chelation
Pressure release	Oxidation	
Salt crystallization	Hydration	
Thermal expansion/exfoliation	Solution	
	Carbonation	

Test yourself
D.4 Compare and contrast flows and slides. [2+2]

Freeze–thaw weathering can create instability due to the expansion and contraction when water freezes and melts in cracks, and can lead to rock falls on dry, steep slopes. Where there is more moisture to lubricate the surface, a rock slide can occur.

Content link
Connect this information with the effects of increasing temperature due to global warming described in unit 2.1.

A rock avalanche is the most rapid type of mass movement and can often travel down hollows where previous avalanches have taken place.

A rotational slip is concave in shape and normally occurs when a weak rock type such as clay becomes saturated. The clay will then slip as it gets heavy in conjunction with gravity.

Flows can be differentiated according to the size of the particles involved in the movement. In a debris flow, more than 50% of the particles are coarser than sand, whereas in a mud flow more than 50% of the particles are finer than sand. A lahar is an example of a mudflow.

Creep is a slow movement that is caused due to the expansion and contraction as well as heating and cooling of soil, as moisture is absorbed and then released via evaporation.

A slump occurs when rock or soil falls in blocks independent of a curved slip plane underneath.

Solifluction is the downwards movement of soil over a permanently frozen subsurface, and it is common where upper permafrost melts and moves over more frozen permafrost underneath.

Content link

Mass movements occurring in extreme environments is explored in option C.2.

Test yourself

D.5 Explain why some types of mass movement cause more problems for people than other types of mass movement. [4]

D.2 GEOPHYSICAL HAZARD RISKS

You should be able to show how geophysical systems generate hazard risks for different places:

- ✔ The distribution of geophysical hazards (earthquakes, volcanoes, mass movements);
- ✔ The relevance of hazard magnitude and frequency/recurrence for risk management;
- ✔ Geophysical hazard risk as a product of economic factors (levels of development and technology), social factors (education, gender), demographic factors (population density and structure) and political factors (governance);
- ✔ Geographic factors affecting geophysical hazard event impacts, including rural/urban location, time of day and degree of isolation.

Magnitude – the size and extent of a geophysical hazard.

Risk – the probability of a hazard event causing harmful consequences such as threats to life, property and infrastructure.

Governance – the ability for the local or national authorities to mitigate the risk from a geophysical hazard.

The distribution of geophysical hazards

Earthquakes and volcanoes tend to be located along the edges of major tectonic plates and as such they have a linear pattern. Mass movement linked to an earthquake or volcanic eruption will also take place in these same locations as well as in areas that are mountainous and areas where there have been land-use changes resulting in instability.

Test yourself

D.6 Describe the distribution of different types of volcanoes. [3]

The relevance of hazard magnitude and frequency/recurrence for risk management

The magnitude of earthquakes and volcanoes can be measured, and events with a larger magnitude tend to be more infrequent. The Richter scale, created by Charles Richter in 1935, is designed to assess the magnitude of earthquakes. It is a logarithmic scale and measures factors of 10. For example, a quake that measures 4.0 is ten times more powerful than a 3.0.

Concept link

PLACES: Risks for people and places are increased due to a combination of natural and human factors which vary from place to place. The natural reasons tend to relate to relative distance to a volcano, a fault line, or a slope, whereas human reasons incorporate a number of socio-economic and political factors, quite often relating to the human development status of a place.

Test yourself

D.7 State the relationship between the magnitude of a hazard event and the frequency of its occurrence. [2]

D.8 Describe a scale that is used to measure the magnitude of the extent of a volcanic eruption. [3]

The Mercalli scale is used to measure the damage caused by an earthquake. More recently, in 1979, the Moment Magnitude scale was developed. It uses a greater range of variables than the Richter scale to assess the amount of seismic energy, specifically the movement of rock along a fault line and the area where a surface is ruptured. A seismometer is used to detect seismic waves.

The Volcano Explosivity Index (VEI) is used to measure volcanic eruptions. It is a complex measure that includes the amount of material emitted and the height of an ash column during an eruption. The eruption of Mount St Helens in 1980 was VEI 5 and Mount Pinatubo in 1991 was VEI 6. The Index is logarithmic, similar to the Richter scale, and the top of the Index is VEI 8, which is one million times more explosive than a VEI 2. The United States Geological Survey (USGS) has stated that a VEI 5 normally happens once every 10 years and is much more infrequent than a VEI 3 (which occurs several times a year). A VEI 1 will only emit 0.0001–0.001 km^3 of material during an eruption, while VEI 2 will emit 0.001–0.01 km^3 of material, 10 times more than VEI 1.

Geophysical hazard risk

A range of factors can increase the risk faced by people in relation to geophysical hazards. Some of these factors are:

- **Economic:** The level of economic development will dictate the quality of the emergency services that respond to a hazard event, the ability to fund an early warning system and the stabilization of a slope such that it is less susceptible to mass movement.
- **Social:** Educated people are more likely to understand warnings released by governments, for example, how to prepare for an earthquake. When an earthquake occurs, females are more at risk than males, as gender inequalities are exacerbated during natural disasters. For example, for every one male that died in the Indian Ocean tsunami in 2004, four females died. This was partly due to inequalities in education, which meant women were less likely to know how to swim and climb trees for safety, accordingly to a study by Oxfam. Universities in conjunction with the government may undertake research and monitoring in order to improve the knowledge of hazard risk within a country.
- **Political:** Policy decisions taken by governments often ensure emergency services are funded and prepared for a hazard event, as well as providing appropriate lines of communication in order to warn people. The rules and regulations that govern construction will also be an important factor, especially in urban areas where there is a greater population than in rural areas. For example, all new buildings in Chile have to be able to withstand a 9.0 magnitude earthquake.

Test yourself

D.9 Suggest how disparities in education can increase the risk from geophysical hazards. [4]

Geographic factors affecting geophysical hazard event impacts

There are also other factors that can increase risk, such as the day of the week and the time of day when an event occurs, as well as the distance between a centre of population and the location of the eruption, earthquake or mass movement.

Test yourself

D.10 "Social and economic factors are the sole causes of the impacts from geophysical hazard events." **To what extent** do you agree with this statement? [10]

Assessment tip

This may be an essay question rather than a short answer response, and the command term "to what extent" should prompt you to include evaluation. Here, for example, there is agreement and disagreement with the statement in the question.

D.3 HAZARD RISK AND VULNERABILITY

You should be able to show how the varying power of geophysical hazards can affect people in different local contexts:

- ✔ Two contemporary contrasting case studies each for volcanic hazards, earthquake hazards and mass movement hazards;
- ✔ For each geophysical hazard type, the case studies should develop knowledge and understanding of:
  - ✔ geophysical hazard event profiles, including any secondary hazards;
  - ✔ varied impacts of these hazards on different aspects of human wellbeing;
  - ✔ why levels of vulnerability varied both between and within communities, including spatial variations in hazard perception, personal knowledge and preparedness.

- **Vulnerability** – the susceptibility of a community to the impacts of a hazard event.

Case study: Volcanic eruption at Volcán de Fuego, 2018

Hazard event profile: Volcán de Fuego, a composite volcano in Guatemala, is one of three major volcanoes located close to the former capital, Antigua. It is known for being constantly active and with Vulcanian eruptions. At the beginning of June 2018 it erupted, producing lava, toxic gas, ash clouds, lahars and pyroclastic flows. The eruption was unexpected due to a lack of information and the fact that just one seismometer had been monitoring the volcano. More material was emitted than had been seen since 1974.

Impacts: The eruption immediately affected almost 13,000 people living in the vicinity of the volcano. There was an evacuation, but not before 110 people died. People were given temporary shelter. The UN Refugee Agency stated that more than 1.7 million people would be affected in the weeks following the eruption. La Aurora International Airport in the capital, Guatemala City, was closed for several days due to the amount of ash in the atmosphere. A local organization estimated nearly 3000 people may have died in total.

Vulnerability: Guatemala is a poor country and the area around the volcano is predominantly rural. The volcano erupts approximately 15 times a year, so the people are used to periods of uncertainty.

Concept link

POWER: While some geophysical hazards can be predicted, the power of geophysical hazards can ensure that places still face a tremendous amount of devastation. Earthquakes in particular can severely impact places, especially if it is challenging to implement measures to reduce the vulnerability of people living there.

▼ **Figure D.3.1.** An eruption occurs at the Volcán de Fuego, Guatemala

Preparedness: The volcano has been monitored and volcanologists from the National Institute of Seismology, Volcanology, Meteorology and Hydrology of Guatemala (INSIVUMEH) informed the government at 6am that there was a risk of an eruption with pyroclastic flows to follow. But the warnings from the government were only issued after the eruption began at 3pm. The rural settlement of El Rodeo was covered with ash and volcanic rock, and over a hundred people died. Residents were critical of the authorities for not warning them about the impending disaster. Locals in these rural communities are given some limited training regarding evacuation procedures. If the government does not issue an order to evacuate, the responsibility lies with these groups to decide whether to leave. However, some people were evacuated, namely people at an upmarket tourist resort called La Reunion after the owners saw the information from INSIVUMEH.

Case study: Earthquake in Nepal, 2015

Hazard event profile: Nepal has experienced many earthquakes in its history, since it lies in an active seismic zone. The Indian plate is being subducted underneath the Eurasian plate, which creates tension, and eventually pressure is released in the form of seismic energy. The epicentre for the 7.8 earthquake in 2015 was quite shallow at a depth of 7 miles. It was 48 miles from Kathmandu and occurred just before midday. A series of aftershocks followed, including a 6.7 shock the day after the original earthquake.

Impacts: Almost 9,000 people were killed, 20,000 were injured and overall 8 million people were affected. Some 600,000 homes were destroyed and over 250,000 homes were damaged. Water and electricity were not available in many places a week after the earthquake. An avalanche occurred on Mount Everest which engulfed the south base camp and killed 19 people.

Vulnerability: Nepal has a high population density living in a mountainous region, so it is challenging to reach areas that are affected by earthquakes or landslides. Buildings are poorly constructed and the people are poor, with almost half of the population struggling to buy food. Kathmandu is built on a former lake bed, so it is susceptible to seismic waves. During the 2015 earthquake, liquefaction occurred.

Preparedness: Fortunately, hospitals in Kathmandu had been retrofitted in order to withstand earthquakes, and staff had received training in a hospital emergency training plan. But the authorities were surprised at the magnitude of the earthquake and rural areas were much less prepared than urban areas.

Case study: Mass movement in Rwankuba, Rwanda 2018

Hazard event profile: On 6 May 2018 a major mudslide occurred in Rwankuba, Rwanda. It happened after a period of heavy rain which fell continually throughout the previous night.

Vulnerability: Rwanda is one of the most densely populated countries in Africa with many of its population living at the foot of one of several mountains in the country. Due to deforestation, the slopes of these mountains are susceptible to mass movement and so people are at risk. These rural communities depend on agriculture, and there is a lack of drainage on the slopes. Prior to 6 May, a number of other landslides had taken place with deaths and injuries recorded. The west of the country had received above average rainfall. Population density is growing due to increased life expectancy and a relatively high total fertility rate (approximately 3.7 in 2018).

Preparedness: The government had asked people to leave the areas that were at risk, but they did not follow that advice and decided to stay in their villages. Rwanda was one of the first countries in the world to adopt the Sendai Framework Monitor, which reduces the risk of disasters by implementing local development plans, particularly in relation to flooding, landslides and lightning strikes.

Impacts: 18 people were killed, 12 were injured in the villages of Rubazo, Bisesero and Gatsata, and 300 people were made homeless.

Test yourself

D.11 Using a specific case study, **explain** the causes and consequences of a rapid mass movement. [3+3]

D.12 Suggest reasons why communities often underestimate the probability of a tectonic hazard event occurring. [4]

D.13 Explain the ways in which vulnerability to a geophysical hazard can be reduced. [2+2]

Assessment tip

Geophysical hazards include volcanic eruptions, earthquakes and mass movements, and each of these can be discussed. An earthquake will provide more opportunities for developing explanations.

Assessment tip

Try to discuss examples and case studies that have taken place in your lifetime. There have been a range of hazard events that have occurred, and you should be in a position to discuss eruptions, earthquakes and mass movement in detail.

Better answers should present a discussion of the relative damage caused by the initial hazard event and that caused by secondary effects; concluding remarks may agree or disagree with the statement.

Assessment tip

You should ensure that the example you have chosen for question D.11 represents rapid mass movement, and while the human causes should be explained, natural factors should also be included. The consequences could be categorized into the economic, social and environmental impacts. The consequences should be explained.

D.4 FUTURE RESILIENCE AND ADAPTATION

- **Resilience** – the capability of a place to recover from the impacts from a geophysical hazard.
- **Slope stabilization** – ensuring a slope is not susceptible to mass movement by implementing a strategy.

You should be able to show how future possibilities can lessen human vulnerability to geophysical hazards:

✔ Global geophysical hazard and disaster trends and future projections, including event frequency and population growth estimates;

✔ Geophysical hazard adaptation through increased government planning (land-use zoning) and personal resilience (increased preparedness, use of insurance and adoption of new technology);

✔ Pre-event management strategies for mass movement (to include slope stabilization), earthquakes and tsunami (to include building design, tsunami defences), volcanoes (to include GPS crater monitoring and lava diversions);

✔ Post-event management strategies (rescue, rehabilitation, reconstruction), to include the enhanced use of communications technologies to map hazards/disasters, locate survivors and promote continuing human development.

Content link

You will study megacities in unit 1.

Test yourself

D.14 Describe the distribution of areas at very high risk. [3]

D.15 Identify three highly populated areas that are in areas at very high risk. [3]

D.16 The world's fastest-growing cities are located in Niger, Burundi, Nigeria, Burkina Faso, Tanzania, Mali and Angola. Using figure D.4.1, **state** whether this will mean more people are susceptible to seismic hazard risk. [1]

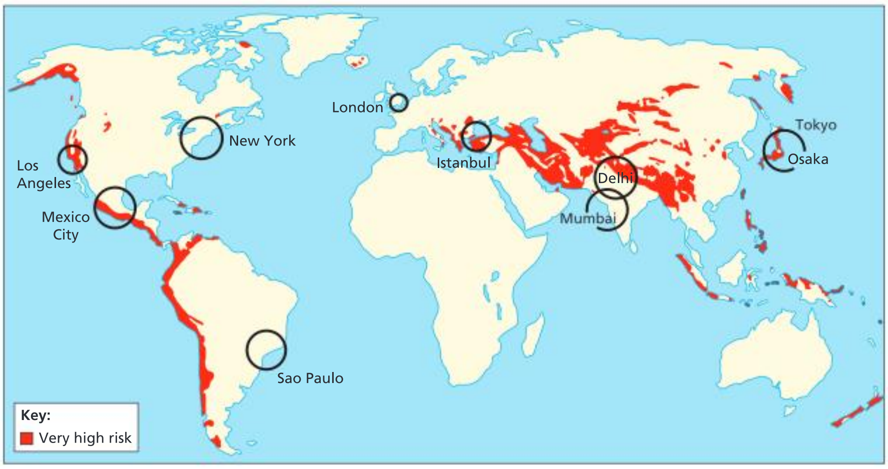
Assessment tip

It should be noted that the information in question D.16 only mentions growth rather than the total number of people living in these cities and also does not state the location of these cities within each country. Some parts of countries are more at risk than others.

Global geophysical hazard and disaster trends and future projections

The following map shows those areas at risk due to seismic activity and also the location of megacities.

▼ Figure D.4.1. Megacities (circled), and areas at risk due to seismic activity



Geophysical hazard adaptation

Historical analysis can help to inform city authorities about areas that are more at risk from earthquakes, although the unpredictability of this type of hazard makes land-use zoning a challenge. However, zoning can be used to protect areas from landslides and volcanic eruptions. Areas at risk from mass movement and eruptions can be zoned so that people do not live and work in those areas. The island of Montserrat has a number of areas that people are not allowed to visit unless the level of seismic activity is low.

Pre-event management strategies

There is a range of strategies that can be implemented in order that the future impacts from a geophysical hazard can be reduced. Quite often these strategies are only implemented after a hazard event has taken place, since the risk may not have been known previously or the impacts were unforeseen. In addition, the level of knowledge about the different strategies may have been limited or the expertise not available. One example is modifying construction codes so that buildings are built to withstand a higher magnitude earthquake. This involves modifications such as steel reinforcement, base isolators, movable hydraulic joints, strategies to reduce building shaking, shatterproof glass, deep foundations. By including these things when designing buildings in order that seismic energy is absorbed, they should not collapse or suffer damage during a seismic event.

Concept link

POSSIBILITIES: Pre- and post-event strategies can be implemented involving a range of different stakeholders and the use of technology in order to reduce the risk and vulnerability of places. These possibilities not only include financial input, but also the education of citizens who also need to take ownership of responsibility for safeguarding themselves.

Test yourself

D.17 Discuss how building design can be the most effective way for people to reduce their vulnerability to earthquakes. [2+2+2]

Assessment tip

If the command term for this question was "evaluate" then it would be possible to offer an alternative view by stating that land-use zoning, early-warning systems, evaluation planning and increased education would represent more effective ways of reducing vulnerability.

In terms of secondary hazards, a warning system can alert places about an impending tsunami. Sensors on the sea bed send data to buoys on the ocean surface which is then transmitted via satellite to warning centres.

A slope can be modified in order that the land does not slip, for example by stabilizing it with a metal mesh to prevent rock falls.

Table D.4.1 summarizes the other ways in which a slope can be stabilized.

Table D.4.1. Strategies for stabilizing slopes

Strategy	How it works
Removing groundwater	This can be achieved by using pipes to remove water or by pumping out the water. Different soil types can make it more challenging to achieve this.
Improving surface drainage	The removal of areas that will allow water to accumulate and the drainage of water from a surface via the use of pipes.
Removing material	The excavation of soil and rock at the top of a slope can reduce the pressure that may cause a landslide.
Installing piles	Metal beams are installed in the ground that is underlying the unstable soil and rock in order to create stability.
Constructing walls	A wall built from concrete, rock or logs is often used with the installation of piles if material slips between the piles.
Removing unstable material	If the soil is liable to move, it is replaced with material that is less liable to move. This could be soil or rock that is less prone to weathering.
Afforestation/reforestation/ planting vegetation	The planting of vegetation can help to stabilize a slope and remove moisture from the soil.

Volcanoes are monitored with GPS technology that monitors seismic movements and the release of volcanic gases.

Figure D.4.2. Earthquake-resistant pipeline

Figure D.4.3. Slope stabilization in Brunei

Post-event management strategies

Case study: Earthquake in Nepal, 2015

Rescue: The government immediately began to search for people in collapsed buildings. International charities such as Christian Aid, Oxfam and the Red Cross sent teams to help and the Red Cross opened a blood bank in Kathmandu. Facebook users notified friends and family that they were all right via a Safety Check feature which over 8.5 million people used. Over US$15 million was donated using Facebook. Google's Person Finder used crowdsourcing information to log people who had been rescued in order to reconnect them with family members. The Ushadidi internet-based platform was used to collect information about the immediate needs of people affected. Helicopters were used to assess the damage and help rescue people.

Rehabilitation: Temporary shelters were provided for those made homeless. Markets were restored in order that access to food improved as summer crops were harvested. Temporary schools made of bamboo and tarpaulin opened after a month and helped children process the traumatic event.

Reconstruction: Those whose homes were destroyed received 200,000 rupees, and people affected were given access to an 'Earthquake Victim Special Loan' of 25,000 rupees in the Kathmandu Valley. A plan was proposed to ensure that buildings were resistant to earthquakes and a National Reconstruction and Rehabilitation Fund (NRRF) was created to raise US$2 billion to fund the reconstruction. A year after the earthquake, towns and villages outside of Kathmandu remained severely damaged with debris still present. This was due to the amount of legislation and government conditions that had to be satisfied. Two years after the earthquake, only 5% of homes had been rebuilt and many school buildings were still only temporary structures.

Additional post-event responses: Families received 40,000 rupees to cremate a family member, whilst 25,000 rupees was given to those requiring hospital treatment and an amount was provided to those that were made disabled. External funding of approximately US$4.1 billion came via grants and loans, although the government was very slow in releasing this money for projects. Violent clashes took place as people objected to a rapidly introduced first Constitution for the country, and these had to be dealt with by the authorities while politicians focused on the Constitution, which delayed the creation of a National Reconstruction Authority.

Content link

The use of the Ushahidi platform in building resilience is explored further in unit 6.3.

Test yourself

D.18 Explain how a place is able to increase preparedness before a geophysical hazard event involving mass movement. [2+2]

D.19 To what extent are volcanic eruptions easier to predict but more difficult to respond to than earthquakes? [10]

Assessment tip

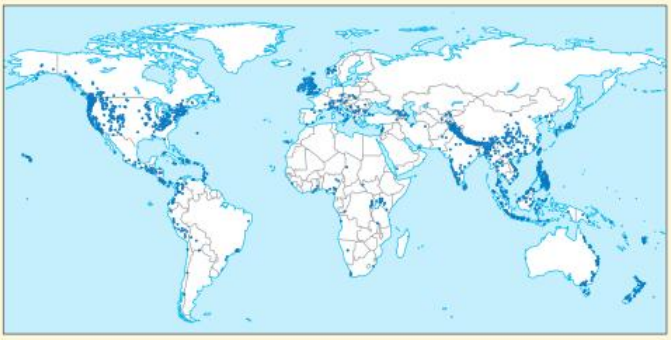
A "to what extent" type question, such as D.19, would require an essay or extended response since it requires evaluation. You have the option to discuss the causes, the effects and the responses alongside a range of variables such as building design, early warning systems and other forms of being prepared and responding. Time management is therefore very important and allocating a set time of approximately 22–25 minutes for your essay response at the end of each option is imperative.

Both volcanoes and earthquakes must be discussed, and you should ensure that your paragraphs have a focus. For example, one paragraph could explain how volcanic eruptions are more measurable and predictions can be made based on the changes and release of gases. Your next section could then discuss the responses.

Examples of how to predict earthquakes and volcanic eruptions should be included.

QUESTION PRACTICE

Examine the figure on the right, which shows the location of 5,741 rainfall-triggered landslides from 2007–2013, in blue.



a) **Describe** the global distribution of landslides. [2]

b) **Suggest** two social factors that can increase a person's vulnerability to earthquakes. [2 + 2]

c) Using an example, **explain** two negative impacts of a volcanic eruption. [2 + 2]

Essay

Examine the role of technology in increasing the resilience of places that are susceptible to geophysical hazards. [10]

How do I approach these questions?

a) 2 marks are available for this question and therefore two separate points are required.

b) When social factors are discussed in Geography, they relate to health and education primarily. You should state two factors that are distinct from each other and then you explain each of them, making a clear link to increasing risk. You may want to also include an example at the end of each point.

c) Four marks are awarded for two separate points, with development of these points. Bear in mind that there are short-, medium- and long-term effects. Avoid discussing positive effects, such as fertile soil, as this is irrelevant to the question. Ensure that you refer to an example, as stated in the question. As the command term is "explain", the two impacts stated must be developed to show how people and places were affected negatively.

Essay

The use of technology has helped places to increase their resilience to a range of geophysical hazards and this involves both primary and secondary hazards. You will have studied a range of examples in the final part of this unit for different geophysical hazards. The command term is "examine" which means that you should discuss an assumption that technology is increasing resilience in places by perhaps findings issues. Key concepts such as "possibility" and "power" could be discussed as well as spatial interaction since geophysical events can cover large areas and information can be shared between places.

SAMPLE STUDENT ANSWER

a) Landslides tends to be found along linear patterns such as at the edge of plate boundaries with a large concentration in the Philippines, west coast of the USA, and in the UK.

Marks 2/2

b) The education of people in an area can help people cope when an earthquake strikes. This is because people will have been trained in how to protect themselves and also where to evacuate to when escaping a building. Therefore places where people have not been educated in this area are at a greater risk and are more vulnerable. Government funding into early warning systems will ensure that people have information to be able to evacuate from buildings. Mexico City is an example of a place that receives early warnings from Mexico's Pacific coastline.

The first point is valid and is developed but the second point, while including accurate knowledge, refers to an economic factor rather than a social factor.

Marks 2/4

c) The eruption of Volcán de Fuego caused significant effects to the people of Guatemala. A primary effect was the loss of life to the people living and working close to the volcano and 100 people died. Villages were buried in ash and mud which covered houses, and people also needing rescuing from these houses and 4,000 people had to live in shelters in the days and weeks after the eruption took place.

- ▲ Appropriate example
- ▲ 1 mark: relevant effect with accurate detail for the example
- ▲ 1 mark: another relevant effect with some detail

2 marks for the two negative effects given and 2 further marks for the development of these points.

Marks 4/4

Essay

Examine the role of technology in increasing the resilience of places that are susceptible to geophysical hazards.

Technology has developed in the last 20 years and there have been many advances in increasing knowledge about the causes and effects of geophysical hazards. Technology can use hardware and software to try and reduce the risk from geophysical hazards. Geophysical hazards can be volcanoes and earthquakes. This essay will discuss the different ways in which technology helps to increase resilience in places in order that people and property are able to survive when an event takes place.

When an earthquake strikes, the introduction of technology has helped people to react more quickly and be able to evacuate from an area at risk. In order to warn people about incoming tsunamis, NOAA has installed a system of 39 buoys across the Pacific Ocean which will transmit information when a tsunami is created. The information is transmitted to a Tsunami Warning Center, such as in Alaska, and alerts are sent out via the media. This enables people to evacuate an area as the warnings are issued at least 3 hours before the tsunami reaches land. This ensures that moveable items can be moved, therefore reducing the risk and increasing the resilience for a place, such as major cities along the west coast of the USA.

Another strategy that is more proactive than reactive (the tsunami alert is a reactive strategy) is constructing buildings that can withstand major seismic waves. There are different techniques for making buildings more resilient:

- ▲ Knowledge demonstrated
- ▼ Mass movement should also be included
- ▼ This term should be defined in the introduction to show knowledge
- ▲ Clear and valid point
- ▲ Evidence provided in relation to technology
- ▲ Further detail provided for this type of technology
- ▲ Connects with the question
- ▲ A valid point with knowledge about the categories for strategies (proactive, reactive)

deep foundations, dampers, and a reinforced structure. An example of a building that has deep foundations is the Transamerica building in San Francisco, which is a city that is prone to major earthquakes. The building looks like a pyramid and its foundations are sunk 52 feet underground which prevents the building from collapsing. Dampers have been constructed in one of the world's tallest buildings, the Taipei 101 building in Taiwan, which can swing up to 5ft inside the building to counteract the swaying of the building during an earthquake. Finally, the Torre Mayor building in Mexico City is constructed with reinforced concrete and steel which provides a rigid framework for the building. These buildings have further construction techniques in their design since more than 1 technique is needed to ensure resilience. People living and working in these buildings and the surrounding area will feel more secure knowing that these buildings will not collapse and there is no need to evacuate them during an earthquake.

When a volcanic eruption takes place, technology is used via the media to alert people that live near the volcano about the threat from ash or lava. This is something that happens in countries at different levels of development and it was used when Mount Kileaua in Hawaii erupted in 2018 when television was used to warn people.

Overall, technology has been used in order that places are able to become more resilient prior to and during a geophysical event. These measures have been implemented in places at different levels of development.

▲ Knowledge about resilient construction

▲ Three appropriate examples with accurate information

▲ Links to the question

▲ Appropriate example

▼ Limited detail for this example and the point being made is quite simplistic

This response is much stronger for earthquakes than volcanoes, and there is a lack of balance. Examples are included throughout with some detail provided although more detail would ensure that the response obtained a higher mark.

Marks 7/10