Figure 3.21: *Mount Vesuvius crater: a tourist attraction*

Why do you think tourists like to visit volcanoes?

- **tourism** – volcanoes are features that interest many people and do attract tourists. Mount Vesuvius in Sicily (Italy) is a classic example, drawing hundreds of thousands of tourists each year (Figure 3.21). The hot springs found in volcanic areas around the world also attract visitors.

Finally, you should note that dense populations are also found in the high-risk areas of other natural hazards. Obvious examples are those river valleys and delta areas that suffer from regular and severe flooding. For example, the Ganges, Brahmaputra and Meghna delta where some 90 million people live (see Part **1.8**). Here, as with volcanoes, there are some benefits, such as fertile soils replenished by the regular flooding.

3.6 Mitigating the consequences of hazards

Mitigation (or **adjustment**) involves taking actions before, during and after a hazard event to reduce its possible consequences. It is all about learning to live with hazards and trying to minimise their potential impacts. At least six major steps or actions are involved here (Figure 3.22):

- **Risk assessment** – determining the probability of a particular hazard happening and the scale of its possible damage
- **Prediction** – putting in place monitoring systems that might give warning about an imminent hazard
- **Preparation (adjustment)** – finding ways of reducing the possible death toll and the scale of damage of property. Educating people about the hazards of the areas in which they live and what to do in case of an emergency is important here
- **Hazard event** – the natural hazard that has been anticipated and planned for happens
- **Recovery** – first emergency aid and then repairing the damage

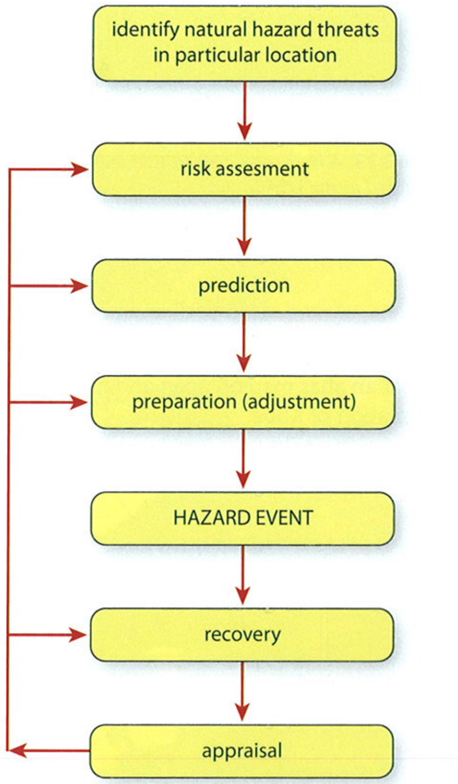
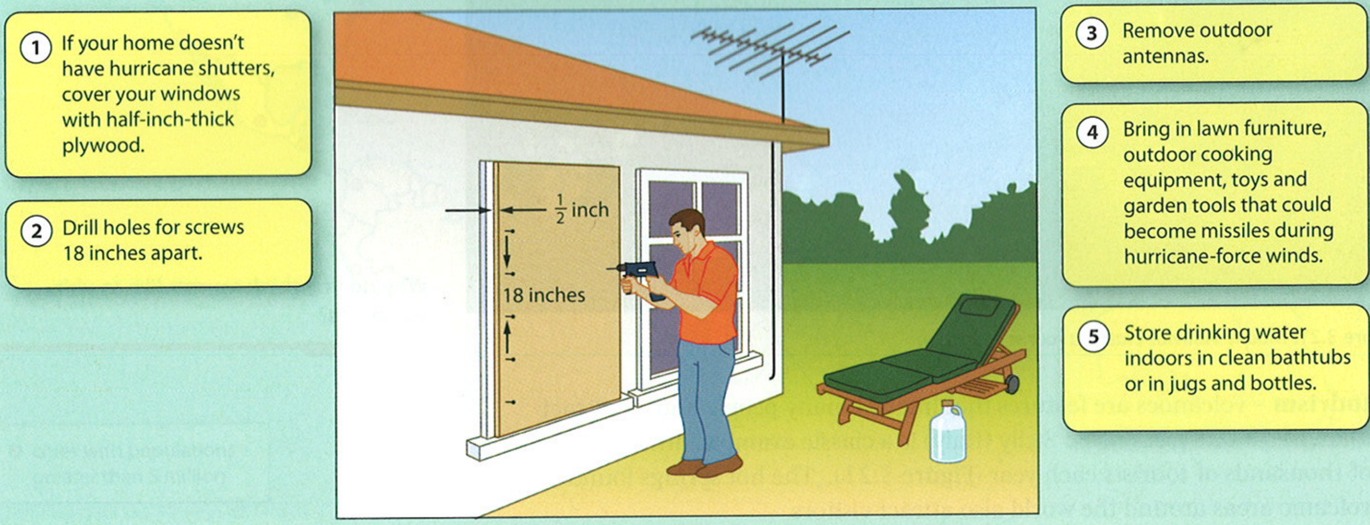


Figure 3.22: *Steps for managing natural hazards*

- **Appraisal** – an examination of what happened after the event with many questions to be asked and answered. Were there emergency plans ready to put into action? How effective were the preparations that had been made before the event? What should be done to make them better in future?

Preparing your home for a hurricane

If you live along the Atlantic Ocean or Gulf of Mexico coasts you should be prepared for hurricanes before they threaten. With common materials, you can easily protect your home from hurricane-force winds.



Only stay if your home has been properly protected from wind damage and flooding. If you evacuate your home, pack food and water, cooking utensils, toiletries, medicines, blankets, important papers, valuables, a rope, flashlight and radio.

Figure 3.23: *A hurricane preparation leaflet distributed in the USA*

We have already looked at two case studies in Part **3.4** that illustrate the damage done by tropical storms, as well as the general management of those events. In this part of the chapter, we will consider another two case studies but of different hazards – an earthquake in an HIC and a volcanic eruption in a LIC. The focus will be more on management than damage.

Look at an atlas map of Japan and find the location of Kobe.

Case study: Kobe earthquake, 1995

Early in the morning of Tuesday, 17 January 1995 the shock waves of a huge earthquake roared through the port city of Kobe in Japan. Measuring 7.2 on the Richter Scale, it was the worst earthquake to hit Japan for 50 years.

- 6432 people were killed.
- Over 100 000 buildings were destroyed.
- 300 000 people were made homeless.
- Rail links, bridges, the main expressways, docks and port area were badly damaged.
- The cost of the damage was estimated at $200 billion.
- Over 300 fires broke out destroying 7000 homes and responsible for 500 deaths devastating an area of 100 km² in central Kobe.

The epicentre of the earthquake was near Awaji Island. Here only buildings were destroyed (Figure 3.24). The greatest destruction was where most people lived – in the cities of Kobe, Akashi and Ashiya. The famous bullet train tracks, motorways and bridges were all badly damaged (Figure 3.25). Broken gas pipes and electricity lines caused fires to rage throughout the built-up areas – especially among the many wooden houses.

The scale of the damage and the size of the death toll surprised many people. Japan experiences over 1000 earthquakes every year. Fortunately most are quite minor tremors, or occur deep underground or under the sea, and have little impact. However, the Japanese have long been very aware of the danger that major earthquakes bring. They take the earthquake threat very seriously. They have to in such a densely populated country. Their risk assessments are thorough. They spend a considerable amount of time, effort and money designing buildings and transport links to withstand earthquakes.

Japanese earthquake preparations also include holding regular earthquake drills in schools and places of work. Every year armed forces and emergency services are involved in a full-scale practice. It is a vital part of earthquake preparation that everyone should know what to do in such an emergency. The response time is particularly critical in order to rescue trapped and injured people.

No one would doubt that the Japanese are well prepared to face the earthquake hazard. The problem with all earthquakes is not knowing where and when exactly they will occur. It is generally agreed that the Kobe earthquake was well 'managed', but what lessons were learnt? Were there any things that might have been done before the event that would have reduced the death toll and damage?

The worst damage of the earthquake occurred in the old parts of Kobe where many of the buildings were erected before modern anti-earthquake building regulations came into effect. Lessons were learnt about the construction of raised expressways (Figure 3.25). Many lengths were badly damaged. The tracks of the bullet train were designed to be able to withstand earthquakes. However, these were broken in no less than nine places. Overall though, it was felt that the emergency arrangements worked quite well.

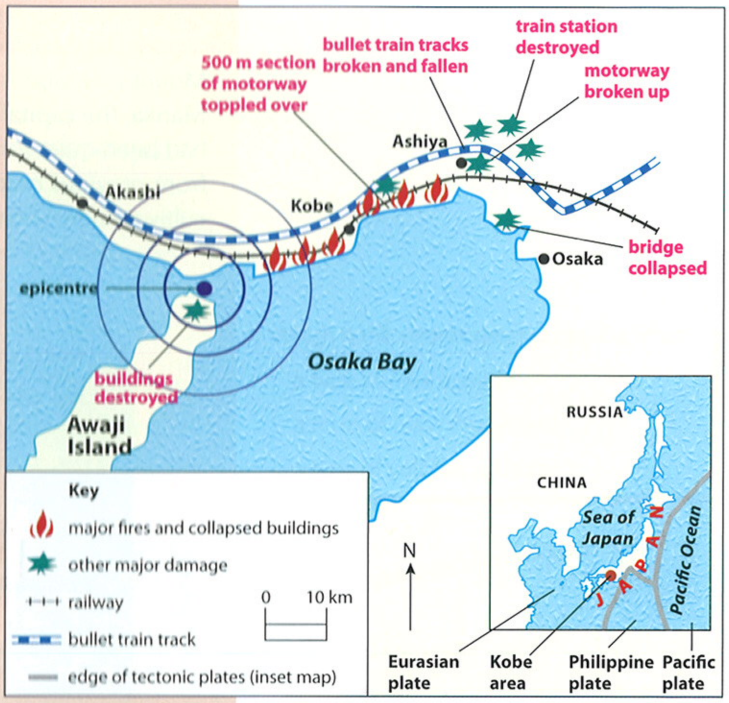


Figure 3.24: *Cause and effects of the Kobe earthquake*

Figure 3.25: *Some of the earthquake destruction*

Case study: The eruption of Mount Pinatubo

Mount Pinatubo is a volcanic mountain located about 100 km north-west of Manila, the capital of the Philippines (Figure 3.26). By June 1991, the volcano had been quiet for more than six centuries. During this time the ash and lava from previous eruptions had weathered into fertile soil which was used to cultivate rice. Then, suddenly, the volcano became active again (Figure 3.27).

Figure 3.26: *Mount Pinatubo in the Philippines*

Advance warning that the volcano was about to erupt gave the authorities a little time to evacuate thousands of people from the nearby town of Angeles. Some 15 000 American airmen and women also left the nearby Clark Air Base. The level of activity increased and finally on 12 June the volcano sent a cloud of steam and ash some 30 km up into the atmosphere. However, more deadly than this steam and ash were the flows of burning gases that descended from the crater at speeds of over 200 km/h (Figure 3.27). They are known as **pyroclastic flows** and are commonly the main killers of people during a volcanic eruption (see Figure 3.8 on page 70).

Why are pyroclastic flows so deadly?

Figure 3.27: *Pinatubo erupts and produces this fast moving pyroclastic flow*

The eruption caused serious problems:

- Ash fell to a depth of 50 cm near the volcano, and for the 600 km radius around the volcano it was over 10 cm deep.
- The volume of ash in the atmosphere turned day to night and hampered the rescue operations.
- Torrential rain accompanied the eruption, and much of the ash was rained back to earth as mud, causing thousands of buildings to collapse under its weight.

- Power supplies were cut and roads and bridges were left unusable, as was the water supply which was quickly contaminated.
- Some 350 people were killed, mostly by pyroclastic flows.

However, the trail of destruction did not end there. When a volcano erupts, much cinder, ash and lava falls on the slopes around the crater. The lava solidifies, and the cinder and ash remain in a loose and unstable condition on the upper slopes. This is what happened after the 1991 eruption. Some years later, after people had returned to their former homes, heavy rain washed this loose material down the volcano sides. This occurred after typhoons hit the Philippines in 1993 and 1995. The local people were inundated by mud avalanches known as **lahars**. In September 1995, 65 000 people were forced to flee from their homes. One lahar was nearly 3 m high. Bacolor, a town of 20 000 people, was turned into a wasteland by mud and ash. Helicopters had to be called in to rescue people trapped by the lahars (Figure 3.28).

Which is the correct description of a lahar:

- a type of river erosion
- a form of mass movement
- a type of volcanic eruption?

The effects of the 1991 eruption were thus felt long after the volcano became dormant again. Thousands of people found themselves living in refugee camps for the second time in four years. Malaria and diarrhoea quickly spread in those camps. The cost to the Philippines was immense. Crops, roads and railways, business and personal property were destroyed, amounting to over $450 million.

Figure 3.28: *Filipinos flee the lahar, September, 1995*

The Philippines is a LIC and had little money to spend on rebuilding the part of Luzon devastated by the eruption. As a result of reviewing the hazard event, the authorities of Central Luzon decided to focus on:

- protecting against further lahars and flash flood damage by building dykes and dams
- establishing new work for the farmers and other workers well away from the danger area
- creating new towns and villages away from the disaster area.

The great cost of these adjustments could not be borne by the people of Luzon alone. The area benefited from two types of international aid:

- emergency aid after both the eruption and the lahars
- development aid to assist with the three objectives listed above.

These two case studies show that there are 'two worlds' when it comes to natural disasters. The need for adequate preparation in areas where there are hazards was underlined in 2010 with two severe earthquakes. The one in Haiti measured 7.0 on the Richter scale and hit the capital city of Port au Prince. It killed around 250 000 people. The second one was well over 8 on the Richter scale and reckoned to one of the biggest ever recorded. It hit the well-populated central area of Chile and killed up to 1000 people. The casualty difference was partly explained by the fact that Chile had used its previous experience of earthquakes to be better prepared for the one in 2010.

Research the 2010 Haiti and Central Chile earthquakes to compare, in more detail, the damage they caused.

Rank the three hazards in terms of human ability to predict them.

Predicting hazards

Prediction is a key activity when it comes to preparing to cope with (manage) natural hazards (see Figure 3.22 on page 81). It sounds a simple task, but in reality it still lies virtually impossible. We know where earthquakes are most likely to occur. However, those plate margins occupy a large area of the world. We have little idea of where exactly along them the next earthquake is going to take place. Volcanic eruptions are a little easier. We know where most of the world's active volcanoes are located. However, we do not really know which one of them is likely to become the next major volcanic disaster. As for tropical storms, we know where they are most likely to occur and at what time of the year. Once they have been detected, they can, as we saw in Part **3.4**, be tracked and their likely future course plotted.

Let us look a little more closely at predicting the two tectonic hazards. For **tropical storms**, look back at Part **3.3**.

Volcanic eruptions

We think we know where most of the world's active volcanoes are located (see Figure 3.5 on page 68). However, the problem here is that some volcanoes may erupt only after hundreds or thousands of years of being quiet (**dormant**). So it is very difficult to predict eruptions. However, sometimes there are warning signs. Near the time of an eruption, the magma beneath the volcano comes close to the surface. This will cause:

- the escape of gases, particularly sulphur dioxide, which can be monitored with special equipment
- an increase in the number of small earthquakes in the locality which can be measured with special equipment
- a swelling of the sides of the volcano.

The problem is that monitoring equipment is very expensive and could be in place for generations without detecting any signs. Perhaps the best way is for people living near volcanoes to keep a regular watch for any changes which may possibly indicate a coming eruption.

Earthquakes

Scientists know where earthquakes will strike – along the active plate margins (see Figure 3.4 on page 67). They find it much more difficult to say when they will happen. Before some earthquakes, the land may be seen to rise or tilt. Sometimes the water level in wells is seen to fall. If local people notice these changes they can alert everyone to reach places of safety, well away from buildings.

Although hazard prediction may be a science, it is still very much in its infancy. Those who benefit most are probably people who live in the hazardous environments of HICs. It is these areas that have the technology and can afford the equipment that is needed.

If these changes do not occur, or are not seen, there is very little chance of predicting an earthquake. There have been recent improvements in detecting changes in electrical signals and in registering radioactive emissions. In order to register such changes many more scientific stations or satellites capable of recording these indicators are needed.

Preparing for hazards

If scientists were able to predict when earthquakes are shortly to happen, many lives would be saved. Even if earthquakes could be predicted accurately, they would still damage buildings. Recent earthquakes in different parts of the world, together with laboratory testing, have allowed engineers and architects to develop buildings that can cope with all but the most powerful earthquakes.

Figure 3.29 shows how different building materials respond to shock waves:

- wooden houses may burn in the aftermath of an earthquake, as they did in Kobe
- bricks fall out of buildings, so they are not good building materials in earthquake zones
- concrete is much better as long as it is reinforced by strong, flexible steel bars
- high-rise buildings with flexible steel frames do survive, but falling glass and bricks can cause injury and death.

Earthquakes may be the most difficult hazard to predict, but at least they are a hazard that does allow some adjustment or preparation.

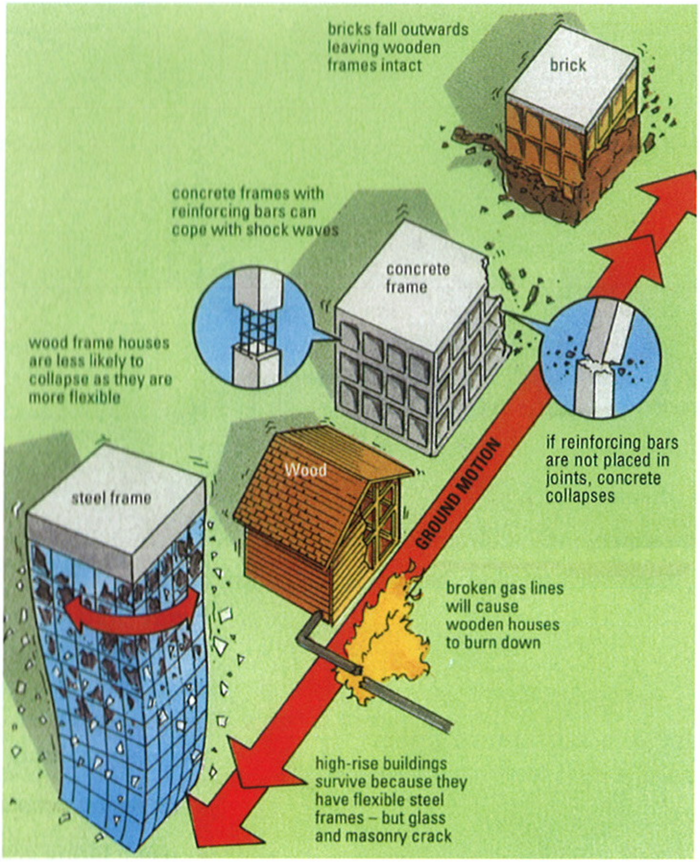


Figure 3.29: *Building to survive earthquakes*

What advantages do old wooden houses have in earthquake situations? What is their downside?

With volcanoes, a certain amount can be done on the day to control lava flows by erecting barriers and cooling lava fronts with water. An obvious adjustment is to ensure that all buildings have sloping roofs to prevent the accumulation of ash. With tropical storms, it is important that walls are built to protect coastal areas against storm surges. Buildings constructed of concrete reinforced by steel bars are most likely to withstand the very strong winds. Cyclone shelters built in this way are increasingly being provided in LICs.

With two of the hazards – volcanoes and tropical storms – putting in place early warning systems gives people a chance to make sure they are ready to do what is necessary. With all hazards, education plays an important role in making people aware of emergency procedures – what to do during the actual event and in the immediate aftermath when panic and chaos often prevail.

3.7 Responding to hazards

Hazard response works on two time scales. There is the matter of what is done immediately after a natural hazard has struck – the **emergency response**. Later, there is a **review response** in which the whole natural hazard event is looked at. What happened this time? What needs to be done to restore the disaster area? What needs to be done so that next time the damage is less and death toll lower?

In your own words, briefly define these terms that appear in Figure 3.30:

- disruption
- disaster
- recovery.

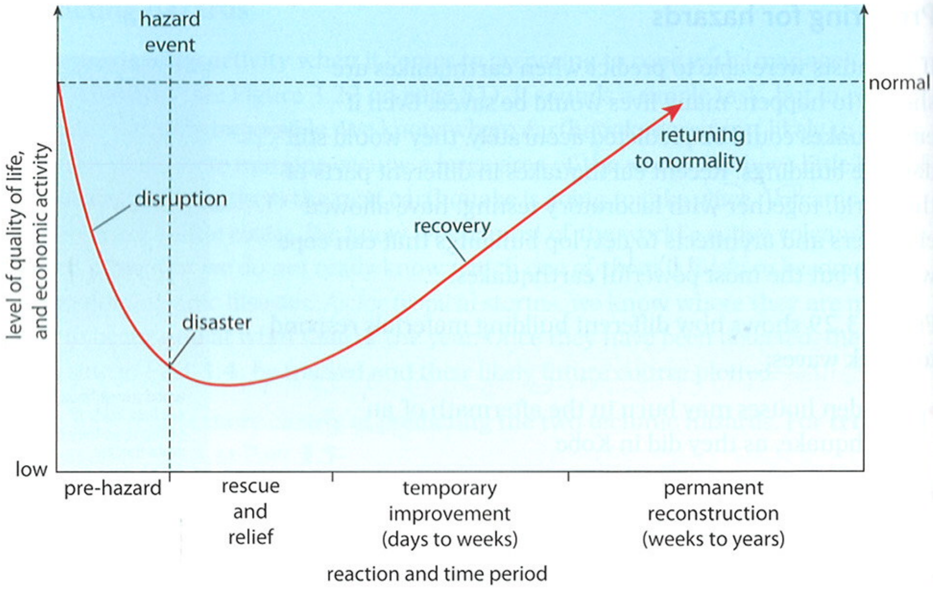


Figure 3.30 *Sequence of events following a hazard*

Figure 3.30 shows the sequence of events immediately following a hazard. First of all, it is important that emergency services are able to identify quickly the worst hit areas and to access those areas. Time is critical if injured and trapped people are to be rescued. Different types of emergency services will be involved. There will be teams specialising in:

- releasing people and bodies trapped in collapsed buildings (Figure 3.31)
- using lifting gear and diggers to clear away rubble
- restoring basic services such as water, sewage, gas, electricity and communications
- providing medical help and counselling victims
- organising the distribution of emergency rations of food, water and clothing
- providing transport for emergency supplies – this is often done by the armed forces.

The important thing here is that all these services and others are well coordinated. This is often where emergency relief breaks down. If the disaster is a major one, it is likely to attract relief from international organisations, such as UN agencies, and voluntary organisations such as Oxfam and the Red Cross. A lack of coordination was one of the criticisms made following the Haiti earthquake (2010). However, the situation there was made more difficult by the damage done to the main airport and the seaport, by a weak government and by the great poverty of the people affected.

Explain how and why each of the following would hinder emergency aid:

- airport and seaport damage
- weak government
- widespread poverty
- little coordination.

After the emergency has been dealt with, the next stage of recovery (see Figure 3.22 on page 81) involves deciding what needs to be done to restore the disaster area back to normal – if it is decided that that is the right thing to do (Figure 3.32). It is possible that the area is believed to be too high risk and that it should be abandoned. This is where organisations such as the World Bank can play an important part in the recovery phase providing loans to rebuild infrastructure.

Figure 3.31: *Emergency services in operation*

Figure 3.32: *A restored disaster area that was badly hit by the 2004 tsunami*

The final stage is appraisal (see Figure 3.22 on page 81). This is the 'inquest', looking back at the disaster and first assessing how well or otherwise the emergency operations worked. Then the appraisal should consider whether there is anything more that could be done to reduce the impact if a similar event were to occur again. Attention will focus on the adjustments, by raising a range of questions. Can buildings in the area be made more hazard proof? Should areas be given greater protection, perhaps in the form of strengthened sea walls? Should settlements be relocated? Should the layout of urban areas be changed? This is where the United Nations International Strategy for Disaster Reduction (UNISDR) can help. It is able offer sound technical advice.

The human spirit is rather optimistic when it comes to natural hazards. First, there is often widespread feeling that the 'lightning will never strike here'. Secondly, there is the widespread belief that 'lightning never strikes the same place twice'. Without that optimism, people would find it difficult to live with the brutal truth that natural hazards can:

- strike at any time
- occur in virtually any place
- be more devastating than the one before.

Surprise is one of the nastier aspects of natural hazards!

If there was no such optimism, do you think people would still live in hazardous environments? Give your reasons.

End of chapter checkout

Checklists

Now you have read the chapter, you should know:

- ✓ what a hazard is
- ✓ the different types of hazard
- ✓ the global distribution, causes and characteristics of tropical revolving storms
- ✓ the global distribution, causes and characteristics of volcanic activity
- ✓ the global distribution, causes and characteristics of earthquakes
- ✓ how extreme weather conditions are measured
- ✓ the type and scale of damage caused by hazards
- ✓ the short-term impacts of natural disasters or hazards
- ✓ the long-term impacts of natural disasters or hazards
- ✓ the reasons why people continue to live in areas where there is a high hazard risk
- ✓ how hazards are managed
- ✓ how people predict and prepare for hazards
- ✓ how people respond to hazards immediately afterward an event and in the longer term
- ✓ how the risk of flooding is controlled

Make sure you understand these key terms:

Adjustment: changes designed to react to and cope with a situation, such as the threat posed by a hazard.

Earthquake: a violent shaking of the Earth's crust.

Emergency aid: help in the form of food, medical care and temporary housing provided immediately after a natural disaster.

Epicentre: the point on the Earth's surface that is directly above the focus of an earthquake.

Hazard: an event which threatens the well-being of people and their property.

Infrastructure: the transport networks and the water, sewage and communications systems that are vital to people and their settlements and businesses.

Lahar: a flow of wet material down the side of a volcano's ash cone which can become a serious hazard.

Natural disaster: a natural event or hazard causing damage and destruction to property, as well as personal injuries and death.

Natural event: something happening in the physical environment, such as a storm, volcanic eruption or earthquake.

Plate movement: mainly the coming together and the moving apart of tectonic plates.

Prediction: forecasting future events or changes.

Pyroclastic flow: a devastating eruption of extremely hot gas, ash and rocks during a period of explosive volcanic activity; the downslope flow to this mixture is capable of reaching speeds up to 200kph.

Risk assessment: judging the degree of damage and destruction that an area might experience as a result of a natural event.

Storm surge: a rapid rise in sea level in which water is piled up against the coastline to a level far exceeding the normal. It tends to happen when there is very low atmospheric pressure and where seawater is pushed into a narrow channel.

Subduction: the pushing down of one tectonic plate under another at a collison plate margin. Pressure and heat convert the plate into magma.

Tropical revolving storm: a weather system of very low-pressure formed over tropical seas and involving strong winds and heavy rainfall (also known as a cyclone, hurricane or typhoon).

Tsunami: a tidal wave caused by the shock waves originating from a submarine earthquake or volcanic eruption.

Volcanic activity: the eruption of molten rock, ash or gases from a volcano.

See the Glossary in the Active Book for more definitions

Questions

Try testing yourself with these questions:

1 a) What is a 'hazard'?
b) Name the four main types of hazard.
c) Give an example of each type.

2 In your own words and with the help of hazard examples, explain what is meant by 'risk' and 'adjustment'.

3 a) What is a 'tectonic plate'?
b) With the help of labelled diagrams show the difference between a destructive and a collision plate margin.
c) What are the outcomes at each type of plate margin?

4 Using Figures 3.4 and 3.5, identify those parts of the world where the most
a) volcanoes, and
b) earthquakes occur. Are the two locations the same?

5 a) What is the difference between the 'focus' and the 'epicentre' of an earthquake?
b) Why is it that earthquakes pose a particular threat in coastal areas?

6 a) What are the hazards associated with volcanic eruptions?
b) Do you think it is volcanic eruptions or earthquakes which pose the greater threat to human life? Give your reasons.

7 a) Tropical storms are known by different names in different parts of the world. Give three of these alternative names.
b) What conditions are necessary for the development of a tropical storm?

8 Give two weather features as a tropical storm passes.

9 When are tropical storms most common in the Northern Hemisphere?
- June and July when sea temperatures are warming
- April and May when sea temperatures are cool
- September and October when sea temperatures are warmest?

10 a) What is the 'Saffir-Simpson scale'?
b) What are the three main types of damage caused by tropical storms?

11 Describe how tropical storms are tracked and their future paths predicted.

12 Describe the three main factors that affect the amount of damage and destruction caused by a particular hazard.

13 Do you agree that the impact of natural hazards is directly related to population densities? Give reasons for your answer.

14 Explain why tropical storms generally cause more damage in LICs. Use the case studies of Hurricanes Mitch and Floyd to support your answer.

15 Which do you think is the scarier natural hazard – an earthquake or a tropical storm? Give your reasons.

16 Give four reasons why people continue to live in high-risk locations.

17 a) What are the possible benefits of volcanic eruptions?
b) Can you think of any other hazard that brings benefits?

18 a) Draw a labelled diagram showing the six steps involved in the management of a hazard.
b) Describe in more detail what happens at one of those steps.

19 Describe the different ways in which the Japanese prepare for earthquakes.

20 What lessons were learnt from the Kobe earthquake?

21 Explain why the eruption of Mount Pinatubo was so devastating.

22 a) Describe the ways in which people try to predict earthquakes and volcanic eruptions.
b) How successful do you think those ways are?

23 Choose two natural hazards and compare them in terms of how people prepare for them.

24 a) With the use of examples, explain what is meant by 'emergency aid'.
b) Name some organisations that provide emergency aid.

25 Why are organisations like the World Bank and the United Nations important to long-term recovery from a hazard event?