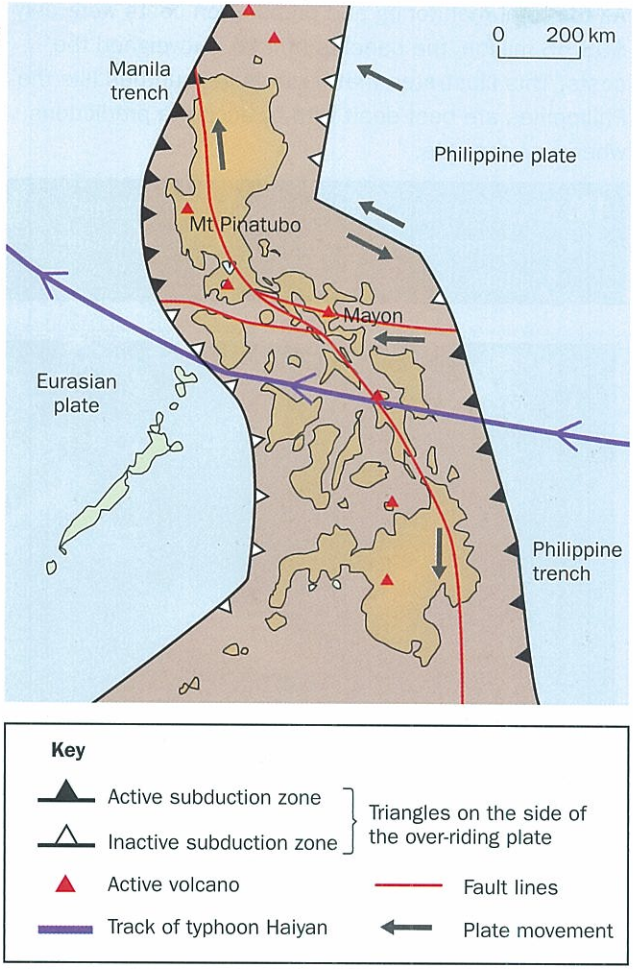

Fig. 9.53 Some of the hazards in the Philippines. The main plates are crushing small plates between them. The map does not show the many areas prone to landslides and floods or the tracks of other typhoons that cross the country anywhere from east to west

The country's population has risen from 19 million in 1950 to almost 100 million, so increased deaths are inevitable as an increasing number of people live in vulnerable locations.

Some of the severity of the frequent flooding has been blamed on inadequate drainage systems, but deforestation has been more damaging. The original cover of tropical rainforest, the barrier to landslides and mudflows, has been almost entirely cleared for export income. After disastrous flooding, landslides and typhoon deaths in 2011, the government, like several governments before, banned any new cutting of natural forests – but large amounts of illegal logging still occurs.

The need to use funds for restoration and recovery after each of the 20 or more typhoons that afflict the country each year continues the cycle of poverty. There are no resources left to put in place measures to protect against the next disaster. The country lacks funds to construct many expensive canalised channels which would move flood waters away quickly.

Whereas many emergency shelters, well-stocked with food and water, are set up within easy reach of communities in HICs, they are few and more spread out in poorer countries like the Philippines. Few people can afford insurance to cover possible losses.

The country also does not have the same amount of technology or technological knowledge available as a rich country.

The eruption of Mt Pinatubo, Philippines, June 1991

Mt Pinatubo is a stratovolcano on the island of Luzon where the South China Sea plate, part of the Eurasian plate, subducts eastwards under the Philippine Sea plate.

Luzon is a very densely populated island, with one million people living within 30 km of the volcano. It had not erupted in 500 years, so it is remarkable that the second biggest eruption of the 20th century caused relatively small loss of life.

The first sign of activity was in April 1991 when many small earthquakes accompanied the emission of thousands of tonnes of noxious sulphur dioxide gas. On 15 June there was a cataclysmic explosion of 5 cubic km of material. The ash cloud rose 35 km into the air and the typhoon affecting the area at the time blew ash in all directions, covering a very wide area. Pyroclastic flows of hot gas and ash moved at high speed down the slopes and giant lahars swept rapidly down valleys onto the lowlands as intense typhoon rains mixed with ash deposits.

Impacts on lives and property

Only 847 people were killed, 300 by roofs collapsing under the weight of wet ash accumulations, 100 by lahars and the rest from disease due to poor sanitation in the evacuation centres. Over 1 million people lost their homes and the cost of the eruption was about $US 700 million.

Droplets of sulphuric acid formed in the ash cloud and caused $US 100 million damage to flying aircraft. Manila airport closed for a time.

As annual rainfalls of up to 4000 mm occur on the volcano, lahars removed about half the deposits on the slopes during the next four rainy seasons. They caused more destruction than the eruption by burying towns and the lowlands under 3 cubic km of material in four years, making 200 000 people homeless, destroying the 1991 harvest, roads and bridges. The buried farmland was unusable for many years.

Reasons for the unexpectedly low loss of life

Prediction, monitoring and risk perception successfully kept the death toll small.

- In March 1991 scientists installed seismometers, tilt meters and other monitoring equipment on the volcano. They drew hazard maps and geologists studied the area and discovered that lahars had been a hazard in the past.
- The population was informed that a serious threat existed. Daily bulletins about the alert level were issued on TV, radio and in newspapers.
- On April 7, people living within 10 km of the volcano were evacuated.
- On June 7, scientists warned that a major eruption was imminent. People were evacuated from the zone within 10–20 km of the volcano.
- On June 13, people were evacuated from the 20–40 km zone.
- 200 000 people were evacuated to the Velodrome in Quezon City, one of the evacuee camps provided by the government.
- Soon after the eruption, a new lahar hazard map was produced and a system to monitor and warn of future lahars was established.

Monitoring and preparation before the eruption was thought to have saved at least 5000 lives. Large potential financial losses were prevented by moving aircraft and other expensive equipment to safe areas.

As the total monitoring and preparation costs were only $US 56 million, the benefits of it far outweighed the costs. This illustrates that hazards in countries like the Philippines are best dealt with by accurate predictions whenever possible.

18. Compile a table to list the social, economic and environmental impacts of the1991 Mt Pinatubo eruption.

Fig. 9.54 The ash cloud emitted during the Plinian eruption of Mt Pinatubo in 1991

The human factor in vulnerability to hazards

Vulnerability and the number of hazardous events has increased and can be predicted to continue to rise because population growth is forcing people to live in places where they are more vulnerable, such as on steep hillsides in squatter settlements on the edge of cities in LICs. The most vulnerable are the poorest in society, who have little opportunity to do otherwise and who may be relatively poorly educated and completely unaware that they are living in a potentially dangerous location. The rich can afford to move quickly out of danger and can afford to regain a normal life more rapidly after a hazard event. Also, the very young and elderly are weaker and less able to migrate or withstand the effects of a hazard on their health.

Vulnerability also depends on:

- → The degree of technical ability to monitor the hazard and to take preventative or protective actions to minimise it. **Prevention** is achieved by taking action to avoid the adverse impact of the hazard whereas **mitigation** attempts to limit the adverse impacts.
- → The degree of education and practising of emergency drills gives awareness of how to minimise potential danger.
- → Individuals are less likely to be well-prepared than communities with organisations which take on responsibilities on behalf of all.
- → Different economies have different types of vulnerability; hazards in HICs have relatively small loss of life but high economic costs, whereas in LICs the economic costs are low but the death toll is high.

19. Describe the different types of economic losses incurred in HICs as a result of a hazardous event.

Human responses to hazards are possible when risk is perceived

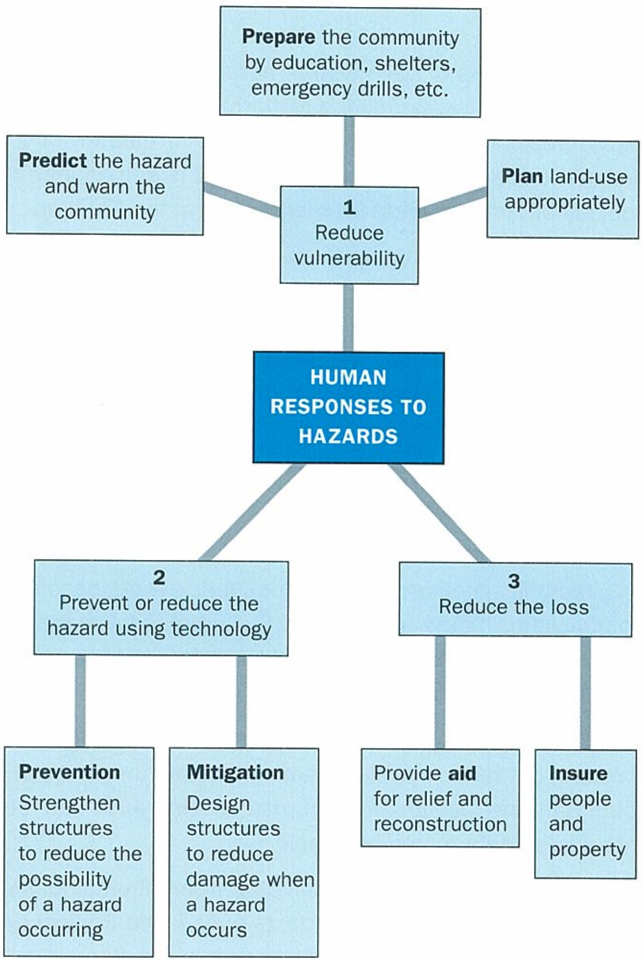

Fig. 9.55 Types of human response to hazards

20. Explain, with reasons, which of these responses to hazards are likely to be most useful in LICs.

Risk perception leads to improved hazard management

Sustainable development is possible in high-risk areas if the public and private sectors act to mitigate or prevent future hazardous events. Risk assessments help decisions about whether or not redevelopment should take place.

- Construction measures and land-use zoning save lives and prevent damage.
- Hazard mitigation is improving. Loss of life during hurricanes has been reduced in the Caribbean by early warning systems. Flood damage in some HICs is reduced by prohibiting building on floodplains, enforced by insurance conditions.
- Hazard mitigation is now seen to be cost-effective.
- Hazard management is most effective when all sectors in the area are involved in integrated development planning.

A pronouncement by the UN in November 2015 suggested that the future is less optimistic. It stated that, worldwide, deaths from hazards caused by climate change have increased. It is true that 90% of deaths in the Philippine hazards since 1990 resulted from storms and associated floods and landslides, with only 8% from tectonic hazards, but it is taking a very simplistic view to claim these deaths are caused by climate change alone. The contributions of deforestation, which has left only 3% of the original protective forest cover and a population increase of nearly 40% since 1990 (from 62 million to 102 million in late 2015) have been ignored. At the same time, the President of the Philippines announced plans to build 23 new coal-fired power stations.

An equation of disaster risk, $R = (H \times V)/C$ maintains that hazard risk increases as people's vulnerability increases and their coping ability decreases. For the Philippines and other poorer economies this holds true, but the reasons are complex and partly economic.

Key concepts

The key concepts listed in the syllabus are set out below. For each one a summary of how it applies to this chapter is included.

Space: this is seen in the different distributions of each type of hazard, ranging from the generally linear patterns of the tectonic hazards that results from their location along plate margins, to the more haphazard pattern of mass movements with a variety of causes. Tropical atmospheric disturbances fortunately only occur in certain well-defined locations. They form only in atmospheric space over warm tropical oceans and usually affect the east coast of continents in tropical and sub-tropical latitudes at least five degrees from the Equator.

Scale: none of the hazards occur on a global or continental scale, although tectonic hazards occur in belts that circle the world and ash clouds from major eruptions stream round the world in the atmosphere. Spatial scale is also demonstrated by atmospheric hazards in that the effects of tropical cyclones are felt over a much larger area than those of tornadoes which are extremely localised. The development of hazard warning maps uses present day indicators, but also evidence from a wide timescale, as clues to the occurrence of landslips and lahars in the past are invaluable for predicting their location in the future.

Place: places that are endangered by hazards have physical characteristics that make them vulnerable: plate boundaries for tectonic hazards, low lying coasts on estuaries for tsunamis and cyclones and steep slopes for mass movements.

Environment: localities affected by tectonic, geomorphic or atmospheric events become challenging hazardous environments when they are also populated. Some human activities need to be managed if they are to be sustainable. Large-scale deforestation has increased both river flooding and landslides while the removal of mangrove forests from some coastal areas has increased the vulnerability of people to tsunamis.

Interdependence: the links between physical and human processes are two way – physical processes result in hazards that affect human lives and processes, but human processes can intensify the physical processes. The danger from storm surges is increased by global warming resulting from human activity which has raised sea levels and the choice of low lying coasts for settlements is also determined by people.

Diversity: tectonic hazards affect a variety of different environments from mountainous destructive plate margins to the oceanic ridges of constructive plate margins, while tropical coasts experience tropical cyclones, but tornadoes strike temperate continental interiors. People and cultures affected by hazards are also diverse; some live in high income countries while others in low income economies have less ability to take adequate precautions. Responses of local people to the known hazard also vary between different economies and even cultures, as a few can have a fatalistic outlook.

Change: hazards are extremely dynamic, as they can dramatically alter landscapes and lives in a matter of seconds. The impact of earthquakes is instant, as are landslides and rock falls. Tornado systems move extremely quickly over the surface, often touching down and rising from the surface in a matter of seconds. Cyclones are slower but are nonetheless dynamic in the destruction they cause.

Exam-style questions

1

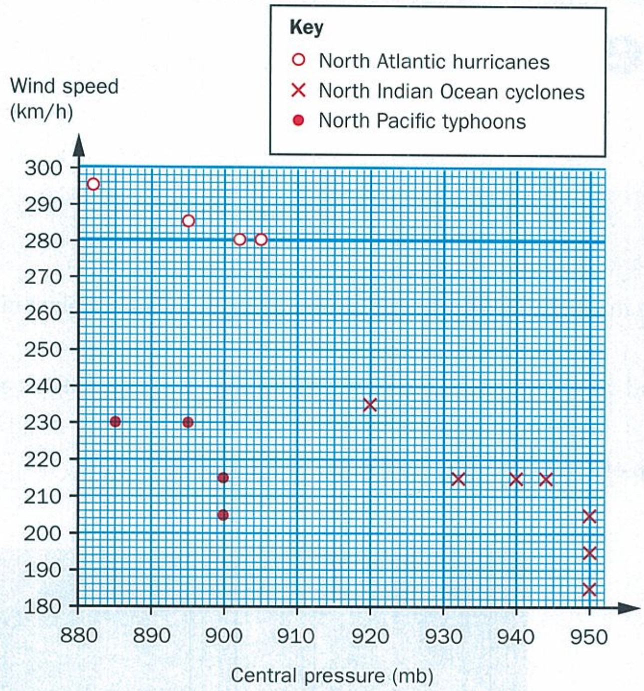

Fig. 9.56 Major tropical storms (cyclones) that have occurred in the northern hemisphere oceans since 2000

(a) Describe how the major cyclones that have occurred since 2000 in each of the North Atlantic, North Pacific and North Indian Oceans are different from those in the other two oceans. [4]

(b) Describe and explain any relationship between central pressure and wind speed for the tropical storms in the North Atlantic and North Indian Oceans. [6]

2 To what extent do you agree that hazards are made worse by human activity? Use examples to support your argument. [20]