AS Geography

Unit 1: World at Risk
Global hazards Revision Guide

Keywords

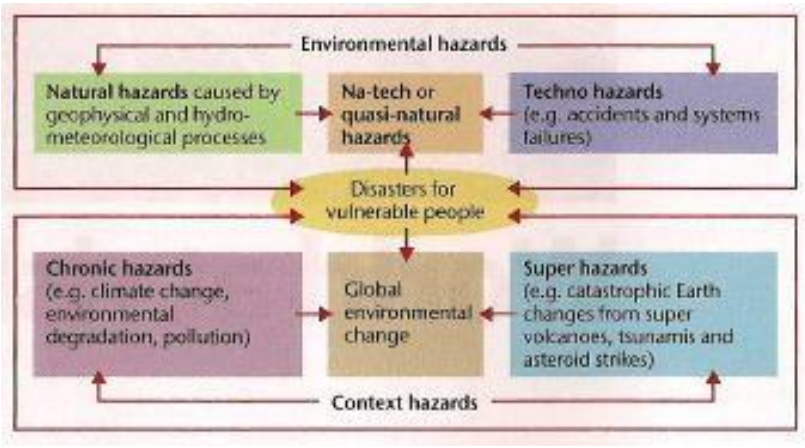
Context hazard: Widespread (global) threat due to environmental factors such as climate change
Geophysical hazard: A hazard formed by tectonic/geological processes (earthquakes, volcanoes and tsunamis)
Hazard: A perceived natural event which has the potential to threaten both life and property
Hydro-meteorological hazard: A hazard formed by hydrological (floods) and atmospheric (storms and droughts) processes
Vulnerability: A high risk combined with an inability of individuals and communities of cope
Disaster: A hazard becoming reality in an event that causes deaths and damage to goods/property and the environment
Risk: The probability of a hazard event occurring and creating loss of lives and livelihoods
Albedo: How much solar radiation a surface reflects
Climate change: Any long term trend or shift in climate (average weather over 30 years) detected by a sustained shift in the average value for any climatic element (e.g. rainfall, drought, storminess)
Enhanced greenhouse effect: This occurs when the levels of greenhouse gases in the atmosphere increase owing to human activity.
Fossil fuels: Energy sources that are rich in carbon and which release carbon dioxide when burnt (e.g. coal)
Global warming: A recently measured rise in the average surface temperature of the planet
Greenhouse effect: The warming of the Earth's atmosphere due to the trapping of heat that would otherwise be radiated back into space – it enabled the survival of life on Earth.
Tipping point: The point at which a system switches from one state to another
Feedback mechanism: Where the output of a system acts to amplify (positive) or reduce (negative) further output (e.g. the melting of Arctic permafrost leads to the release of trapped methane which leads to further global warming)
Frequency: How often an event of a certain size (magnitude) occurs.
Magnitude: The size of the event (e.g. size of an earthquake on the Richter scale)
Asthenosphere: A semi-molten zone of rock underlying the Earth's crust
Conservative boundary: A boundary between plates where the movement of the plates is parallel to the plate margin and the plates slide past each other.
Constructive boundary: A boundary between plates where the plates are diverging or moving apart
Destructive boundary: A boundary between plates where the plates are converging (moving together)
Lithosphere: The crust of the Earth, around 80-90km thick
Magma: Molten material that rises towards the Earth's surface when hotspots within the asthenosphere generate convection currents
Natural hazard: a natural event or process which affects people e.g. causing loss of life or injury, economic damage, disruption to people's lives or environmental degradation
Plates: Rigid, less dense 'slabs' of rock floating on the asthenosphere
Hotspot: A localised area of the Earth's crust with an unusually high temperature
Plume: An upwelling of abnormally hot rock within the Earth's mantle
Inter-tropical convergence zone: A zone of low atmospheric pressure near the equator. This migrates seasonally.

The nature of hazard

A natural event such as a tsunami only becomes a hazard if it threatens humans. There are many different types of hazard. Environmental hazards are specific events like earthquakes or floods, usually classified into

- **Natural processes:** where the hazard results from an extreme geophysical or hydro-meteorological event, such as a flood or volcanic eruption
- **Natural-technological disasters:** where natural hazards trigger technological disaster (e.g. flooding causes a dam to burst)
- **Technological accidents:** such as Chernobyl nuclear power plant exploding

Chronic hazards such as global warming and the El Nino-La Nina cycle may increase the threat from environmental hazards; for example, a sea level rise increases the risk of coastal floods.



Some key features of environmental hazards make them a huge threat:

- The warning time is normally short and onset is rapid (apart from droughts)
- Humans are exposed to hazards because people live in hazardous areas through perceived economic advantage or over-confidence about safety.
- Most direct losses to life or property occur within days or weeks of the event, unless there is a secondary hazard.
- The resulting disaster often justifies an emergency response, sometimes on the scale of international humanitarian aid.

Some socioeconomic characteristics, such as a high population density, high poverty level or corrupt and inefficient government increase people's vulnerability and amplify the risks, particularly of death, from environmental hazards.

Types of natural hazard

- Geophysical hazards result from geological or geomorphological processes (e.g. volcanoes, earthquakes and tsunamis). These are of two types, internal earth processes of tectonic origin (e.g. earthquakes, tsunami and volcanic activity) and external earth processes of geomorphological origin involving mass movements (e.g. landslides, rockslides, rock falls)
- Hydro-meteorological hazards result from atmospheric or

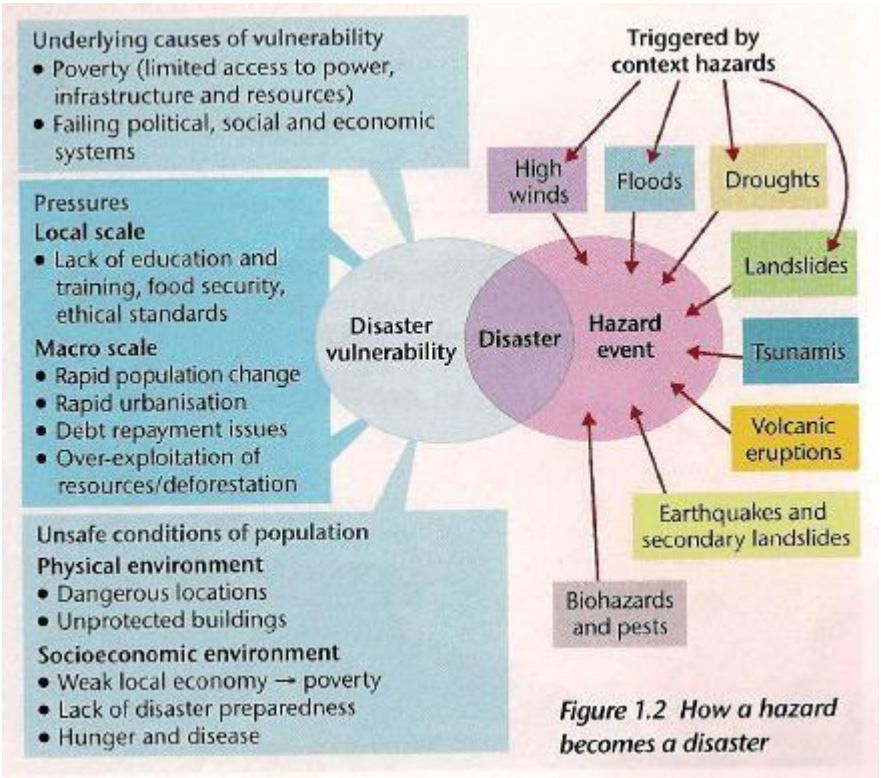
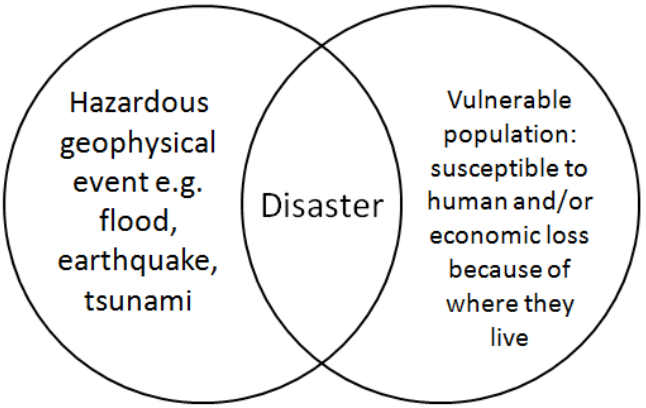


Figure 1.2 How a hazard becomes a disaster

hydrological processes (e.g. floods, storms and droughts). Hydro-meteorological hazards are those caused by running water and its processes (hydro) and those associated with or caused by weather patterns (meteorological). They include floods, debris and mud flows, hurricanes, coastal storm surges, thunder and hailstorms, rain and wind storms (including tornadoes), blizzards and other severe storms, drought, bushfires, temperature extremes, sand and dust storms.

What are disasters?



When does a **natural hazard** become a **disaster?**
A disaster is a matter of scale; it is simply bigger than a natural hazard. However, it is difficult to define precisely. Insurance companies – who do a lot of research into global hazards – attempt to define disasters. In 1990, Swiss Re defined a disaster as an event in which at least 20 people died, or insured damage of over US$16 million value was caused.

Disasters and vulnerable populations

Whether a hazard becomes a disaster or not can depend on how vulnerable the people who are exposed to it are. An increasing proportion of the world's population lives in areas which are exposed to hazards. Examples include:

- People in Bangladesh who are threatened by floods and cyclones
- People who live on steep slopes where landslides may be common, such as the favelas (shanty towns) in many Brazilian cities.

Which hazards have the worst impacts?

Floods and windstorms may be greatest in number, but do they cause the most deaths or create the most damage? The data are complex but patterns do stand out:

- Earthquakes cause occasional major damage, but there is no upward trend.
- Damaging floods are increasing, but not consistently so
- Damaging windstorms are also increasing, though again not always consistently.

Why are floods and windstorms increasing?

The media almost always say that it is due to global warming. The theory is that the

- Increased warming of the earth causes warm air to rise, creating convection cells – which form hurricanes
- Increasing temperatures increase evaporation, which in turn leads to increasing rainfall – and therefore greater flooding.
-

How significant are natural hazards?

There are no data for deaths from hazard events globally, only for those events which are large enough to be called disasters. Although numbers vary considerably from year to year, on average fewer than 100 000 deaths are recorded each year from natural disasters worldwide. This is:

- 30 times fewer than the number who die from HIV/AIDS
- 35 times fewer than the number of road deaths
- 50 times fewer than the number of smoking-related deaths

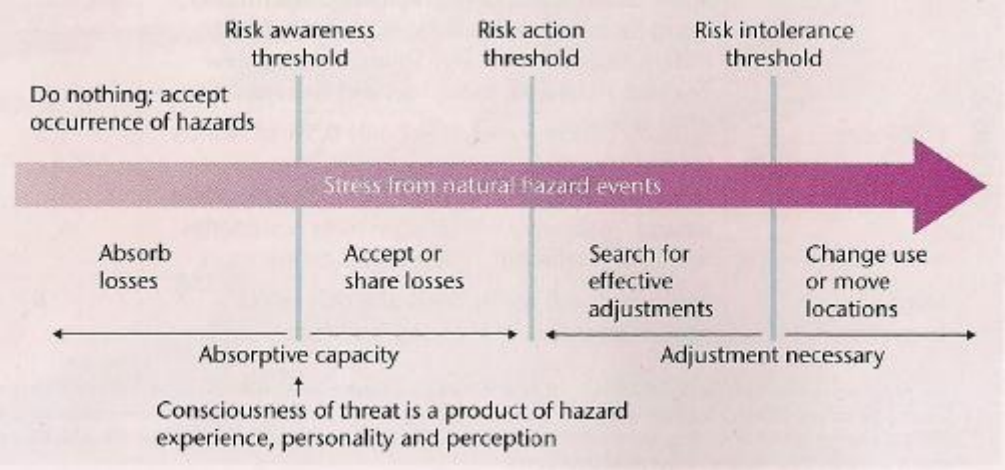
Why do people remain exposed to hazards?

Changing risks: Natural hazards vary in space as well as time because of changing human activities and changing physical factors, such as tectonic plate movements. The rise in sea level means that low-lying coastal plains that were once safe places to live are now more prone to storm surge and flood.

Lack of alternatives: Often the world's poorest; most vulnerable people are forced to live in unsafe locations such as hillsides or floodplains, or regions subject to drought, owing to shortage of land or lack of knowledge or better alternatives.

Benefits versus costs: People may subconsciously weigh up the benefits versus the costs of living in high risk areas. The benefits of fertile farming land on the flanks of a volcano, for example, may outweigh the risk from eruptions.

Risk perception: People tend to be optimistic about the risk of hazards occurring. They are comforted by statistics which show that the risk of death from hazard events is far lower than that from influenza or car accidents. They also believe that if a high magnitude event has occurred, they may be safe for the next few years, although this is not true.



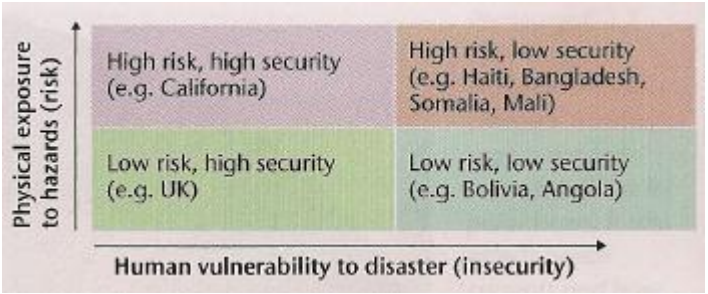
Measuring risk – the risk equation

The risk equation measures the level of hazard risk for an area:

$$\text{Risk} = \frac{\text{Frequency or magnitude of hazard} \times \text{level of vulnerability}}{\text{Capacity of population to cope}}$$

$$R = \frac{H \times V}{C}$$

Where: H = Type of hazard
V = Vulnerability to hazard
C = Capacity to cope/recover



The concept of vulnerability is quite easy to extend to other hazards; if you do not live in close proximity to a volcano, then you are not likely to be threatened by lava flows.

Capacity (C) refers to the ability of a community to absorb, and ultimately recover from, the effects of a natural hazard.

Changing patterns

Frequency or magnitude of hazard is increasing

Use of fossil fuels is warming the planet. The resulting change in climate is increasing the frequency and severity of weather-related hazards (e.g. floods, droughts, windstorms) and expanding the range of disease carriers.

It is clear that the number of reported natural disasters is increasing with each passing year. Some argue that this is due to improvements in technology that allow even the smaller-scale and more isolated disasters to be recorded. Others suggest that with international monitoring agencies like the Belgium-based Centre for Research on the Epidemiology of Disasters (CRED) in operation, people are encouraged to report the occurrence of natural hazards more than in the past thus the numbers go up because of better recording rather than any other trend.

Decreasing numbers of deaths

What is interesting about the increase in the reported number of natural disasters is the fact that there has been a decrease in the number of reported deaths due to these disasters. During the period from 1900 to 1940, approximately 500,000 people were reported to have been killed by natural disasters each year. After 1940, however, this annual death toll rapidly decreased, to the point where in the early part of this century, the number of people killed by natural disasters each year is less than 50,000.

Increasing numbers of people affected and economic costs

While fewer people die each year as a result of natural hazards, these events are affecting more people than ever before. At the same time, they are taking a greater economic toll than in the past. Since 1980, the average annual economic cost of natural hazards has risen from less than $20 billion to more than $160 billion. In the same period, the number of people reported as being affected has risen from an annual average of 100 million to more than 200 million.

Level of vulnerability is increasing

Hazards become disasters only when people get in the way. Unsustainable development involves poor land use (e.g. building on floodplains, unstable slopes and coasts) and environmental degradation (e.g. bleaching of coral reefs, destruction of coastal mangroves, and deforestation of water catchments). This is increasing the vulnerability of millions of people.

Capacity to cope is decreasing

Communities need skills, tools and money to cope with the effects of climate change. However, debt repayments, unfair trade arrangements, selective foreign investment, and rich countries directing aid funds towards politically strategic regions rather than the neediest mean that the poorest and most vulnerable communities lack these resources. Rural-urban migration is also undermining traditional coping strategies.

The future

The most affected areas will be the poorest countries and communities in the world, particularly in sub-Saharan Africa, parts of south-east Asia, and many of the small island developing states. The future risk equation emphasises how the development gap between rich and poor countries is actually widening.

How good are disaster statistics?

Disaster statistics are reported by governments to UN agencies. There are several reasons to question the data obtained:

- There is no universally agreed numerical threshold for designating an event as a disaster, such as 25 or 100 deaths, or 1% of the population affected, or 1% of annual GDP lost, or a combination of these.
- Reporting of disaster death numbers depends on whether direct (primary) deaths only or indirect (secondary) deaths from subsequent hazards or associated diseases are counted.
- Location is significant. Events in remote places away from the media spotlight are frequently under-recorded. Around 10% of all data from the last 10 years are missing.
- Declaration of disaster deaths and casualties may be subject to political influences. The impact of the 2004 tsunami in Myanmar (Burma) was ignored by its government, but in Thailand, where many foreign tourists were killed, the impact was initially overstated and then played down to conserve the Thai tourist industry.

Magnitude and frequency

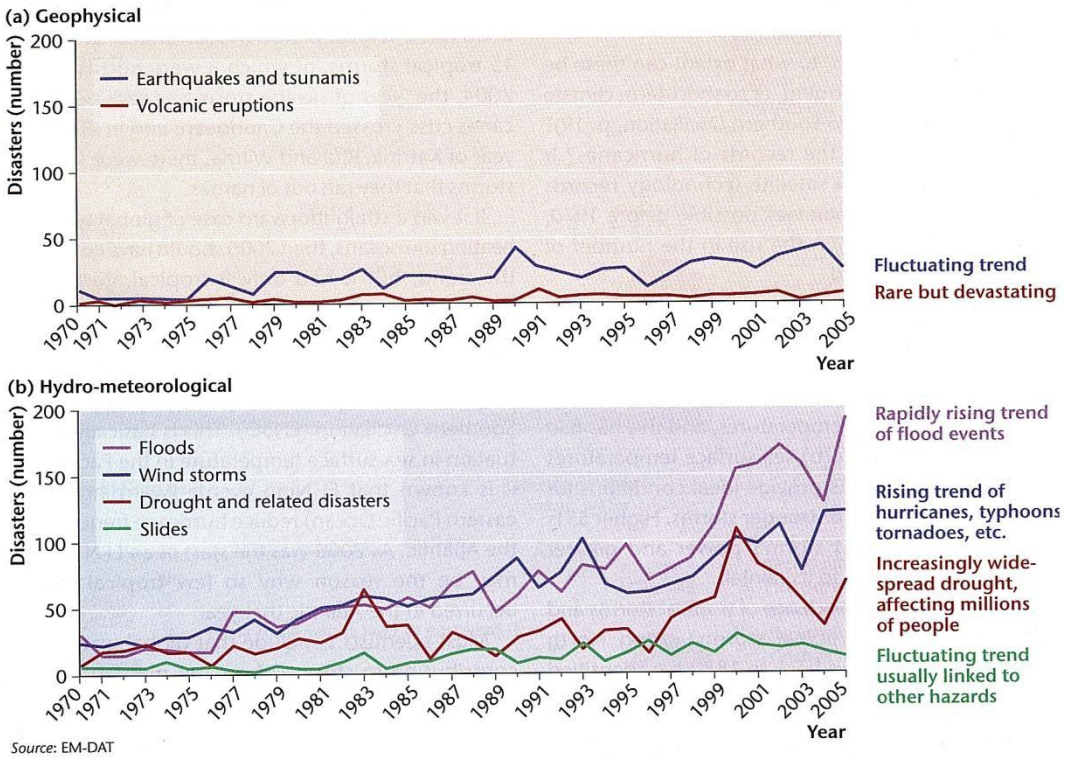
Magnitude is the size of a natural hazard event so represents the amount of work done (e.g. the energy given off during a volcanic eruption).

Lower magnitude events, such as an earth tremor of Richter Scale 2.5, have less impact on people than high-magnitude events, such as the earthquake which caused the 2004 south Asia tsunami, measuring 9.1 on the Richter scale.

Frequency is the number of events of a given magnitude that occur over a period of time. Low magnitude events are likely to have a more frequency recurrence level and therefore to present more frequent but less devastating risks.

Contrasting trends

For geophysical hazards, the variations over time can be accounted for by the clustering of events along mobile (usually destructive) plate boundaries. However, there is no solid evidence that the frequency or magnitude of earthquakes or volcanic eruptions is increasing. Nevertheless, geophysical activity remains a huge killer.

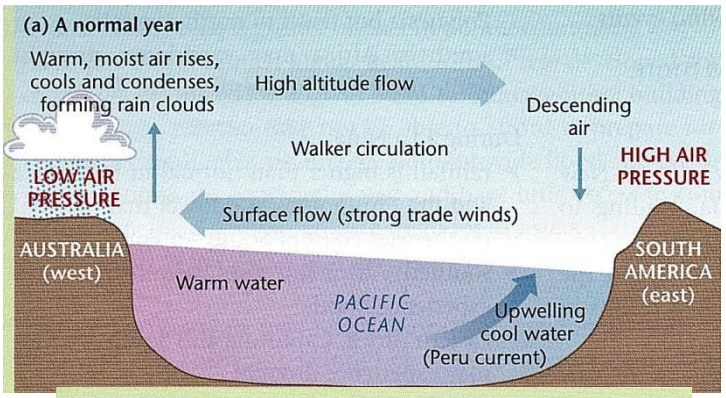


In contrast, the number of reported hydro-meteorological events is definitely on the increase. This is likely to be associated with climate change. It is predicted that global warming will increase the frequency, magnitude and impact of hydro-meteorological disasters. Another explanation of the increased frequency of such disasters lies in the context hazard of increased environmental degradation caused by population pressure

What is El Niño?

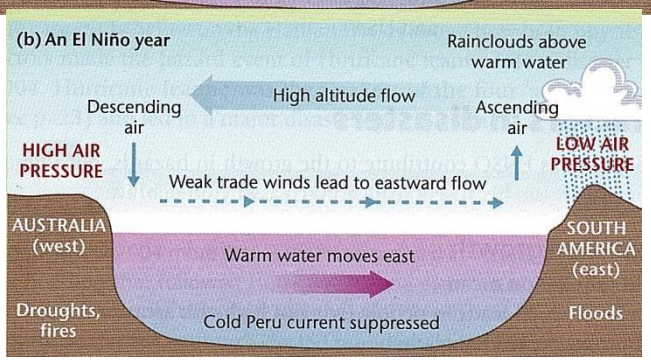
Normal Year

- The trade winds move warm surface water towards the western Pacific
- Cold water wells up along the west coast of South America (near Peru)
- Upwelling important for fish stocks in Peru



El Nino Year

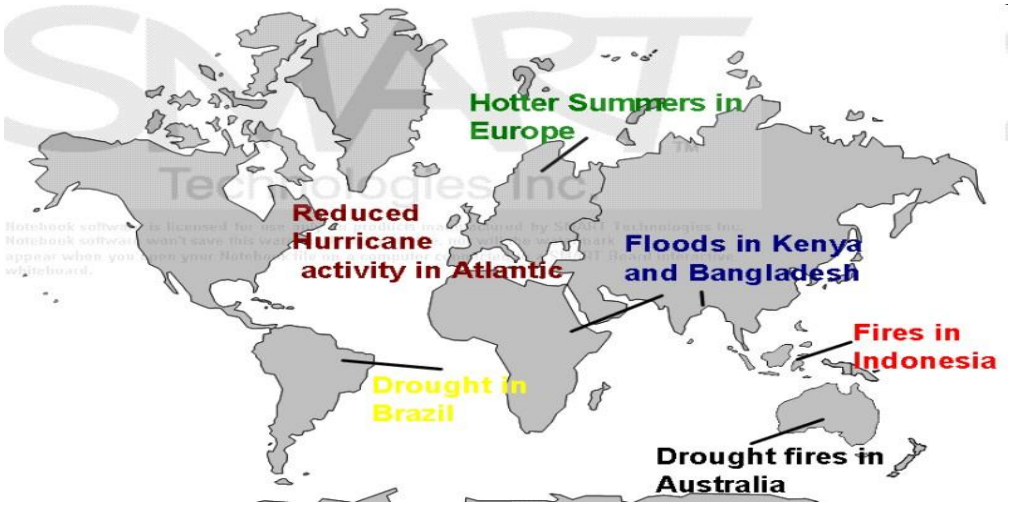
- Air pressure over West coast of S. America becomes low and air over west Australia high pressure
- The normal east to west trade winds over pacific are disrupted and warm water 'sloshes' eastwards
- No upwelling on South American coast



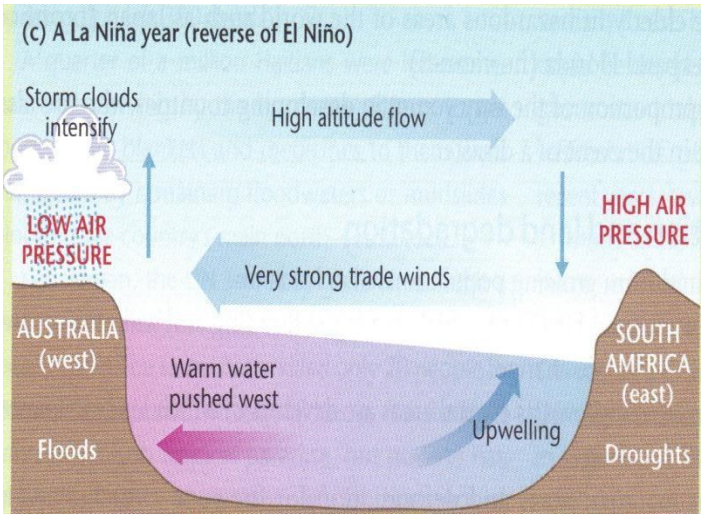
THEORIES ON THE CAUSE OF EL NINO

- **Rossby wave** – wave lowers thermocline in W. Pacific reducing the upwelling of water. Winds then blow towards warmer water and event starts.
- **Random occurrence**
- **Tropical storms** – if storms are strong enough they can blow water eastwards and start the event.
- **Heat from sea floor** – warming by sea floor volcanoes (no evidence)

Due to the **teleconnections** of the earth's climate problems are caused elsewhere! El-Niño can disrupt passage of jet streams



La Nina



- Air pressure is unusually high over the west coast of South America and low over eastern Australia
- As warm water is pushed westwards sea levels rise by up to 1m
- Around Indonesia and Philippines. Strong uplift of air leads to heavy Rain!

Human factors in disasters

Rapid population growth

Growing world population means

- Pressure on land which leads to people living in high risk areas, such as low-lying flood-prone land in Bangladesh
- Growing numbers of very elderly people, e.g. there are concerns about the vulnerable elderly in hazardous areas of the world such as Japan (prone to earthquakes) and Florida (hurricanes)
- A growing proportion of the very young in developing countries who are also vulnerable in the event of a disaster

Deforestation and land degradation

Pressure on land from growing populations also leads to:

- Pressure on land to gain farmland, which can cause flooding and soil erosion and contributes to climate change.
- Destruction of mangroves as coastal areas are developed, which leads to coastal erosion and flooding
- Farming in marginal areas and deforestation for firewood, which leads to desertification

Urbanisation

Rural-urban migration and rapid uncontrolled growth of cities lead to:

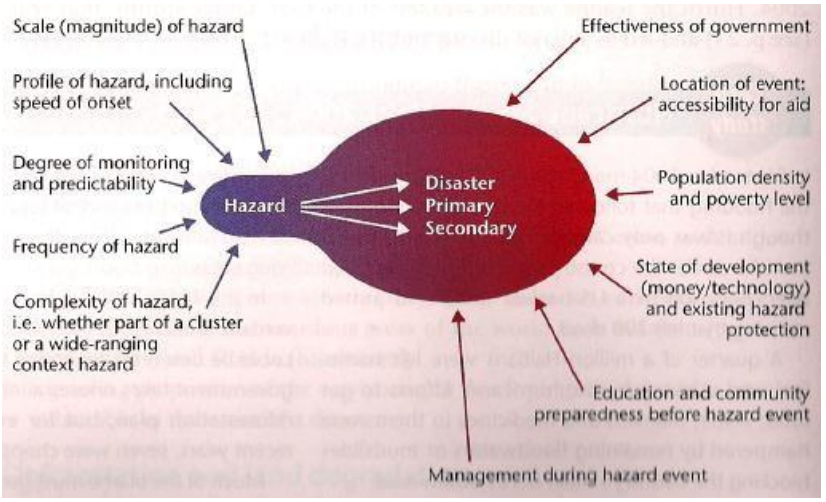
- The development of squatter settlements on areas at risk of landslides or flooding

Poverty and politics

Disasters tend to have a greater impact in poorer countries:

- Earthquakes have much higher death tolls in less developed countries which cannot afford the technology to build earthquake proof buildings
- Developing countries may not be able to afford to prepare for emergencies (e.g. Bangladesh relies on foreign aid to provide flood and cyclone shelters)
- If populations are poorly educated and have little access to communications technology it is harder to prepare them for disasters
- It is difficult to get aid to remote areas with poor infrastructure such as roads and bridges

- Corrupt governments may misuse resources, making disasters worse or prevent international aid reaching their populations



The distribution of geophysical hazards

The three main geophysical hazards are earthquakes, volcanoes and tsunamis. Knowledge of plate tectonics is fundamental to understanding the occurrence of geophysical hazards.

Earthquakes

The main earthquake zones are clustered along plate boundaries. The most powerful earthquakes are associated with destructive and conservative boundaries.

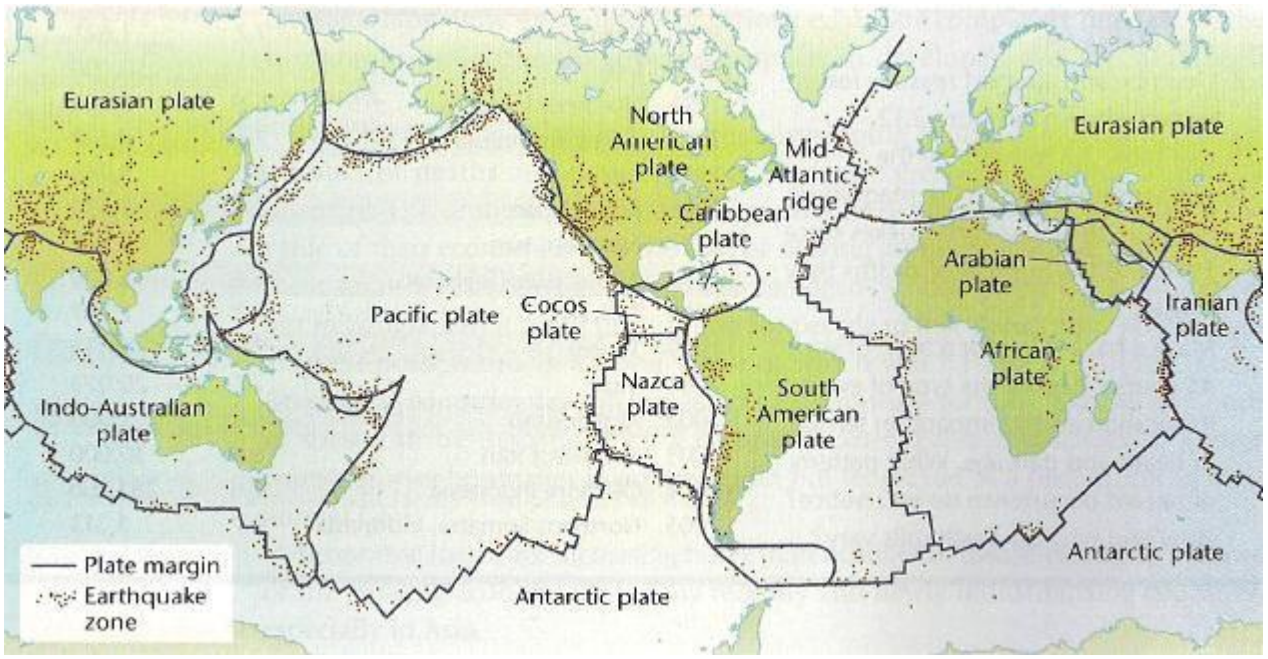


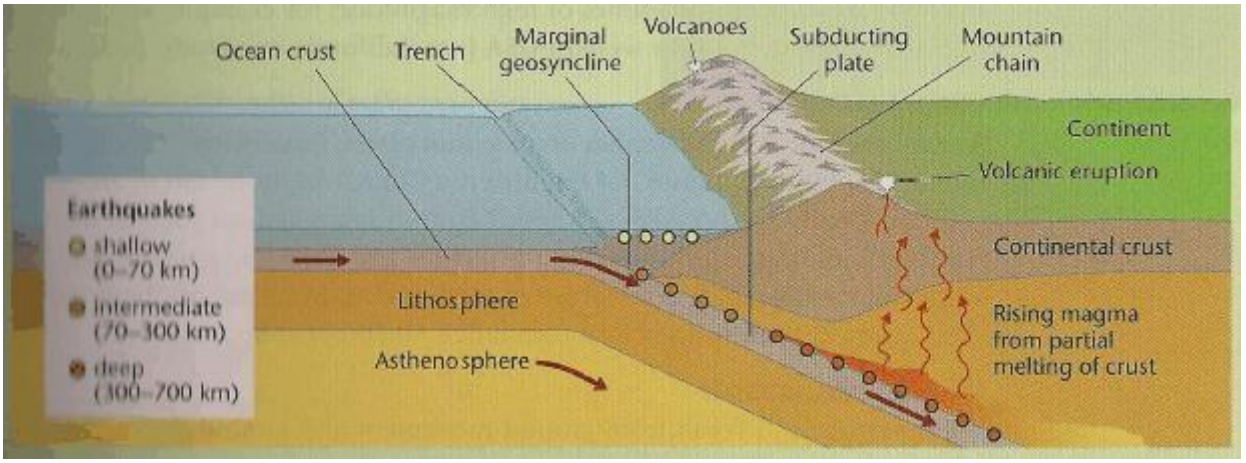
Plate tectonics

- According to plate tectonics theory the lithosphere or Earth's crust is divided into seven major sections or plates, and a number of smaller ones. Some plates are oceanic (e.g. the Pacific plate), others continental. These plates float on the underlying semi-molten mantle known as the asthenosphere.
- Hotspots from within the asthenosphere generate thermal convection currents which cause magma (molten material) to ruse towards the Earth's surface. This continuous process forms new crust along the line of constructive boundaries, where the plates are diverging.

- At the same time, older crust being destroyed at destructive boundaries, where plates converge. The type of activity here depends on whether both plates are continental, both plates are oceanic or an oceanic plate is being subducted or dragged down beneath a lighter continental plate.
- At conservative boundaries, two plates slide past each other and there is no creation or destruction of crust.
- The type of movement and the degree of activity at the plate margins almost totally controls the distribution, frequency and magnitude of earthquakes and volcanic eruptions.

Destructive plate boundaries

- Destructive boundaries where oceanic crust is being subducted beneath a continental plate, or where two oceanic plates collide, produce a full range of earthquake types (shallow, intermediate and deep). The force of compression as the plates meet causes stresses in the crust, and when the pressure is suddenly released, the ground surface immediately above shakes violently.
- The point at which pressure release occurs within the crust is known as the earthquake focus, and the point immediately above that at the Earth's surface is the epicentre.
- At the destructive boundaries where two continental plates are colliding to produce Fold Mountains shallow, highly damaging earthquakes occur.



Constructive plate boundaries

Constructive plate boundaries (where oceanic plates are moving apart) are associated with large numbers of shallow, low magnitude earthquakes as magma rises. Most are submarine so pose little hazard to people.

Conservative plate boundaries

Conservative boundaries, where there is lateral crust movement, produce frequent shallow earthquakes, sometimes of high magnitude: for example, San Andreas fault system

Other earthquakes

Occasionally, earthquakes can result from human actions such as dam and reservoir building, which increase the weight and therefore stress on the land. These occur where there is no record of earthquakes.

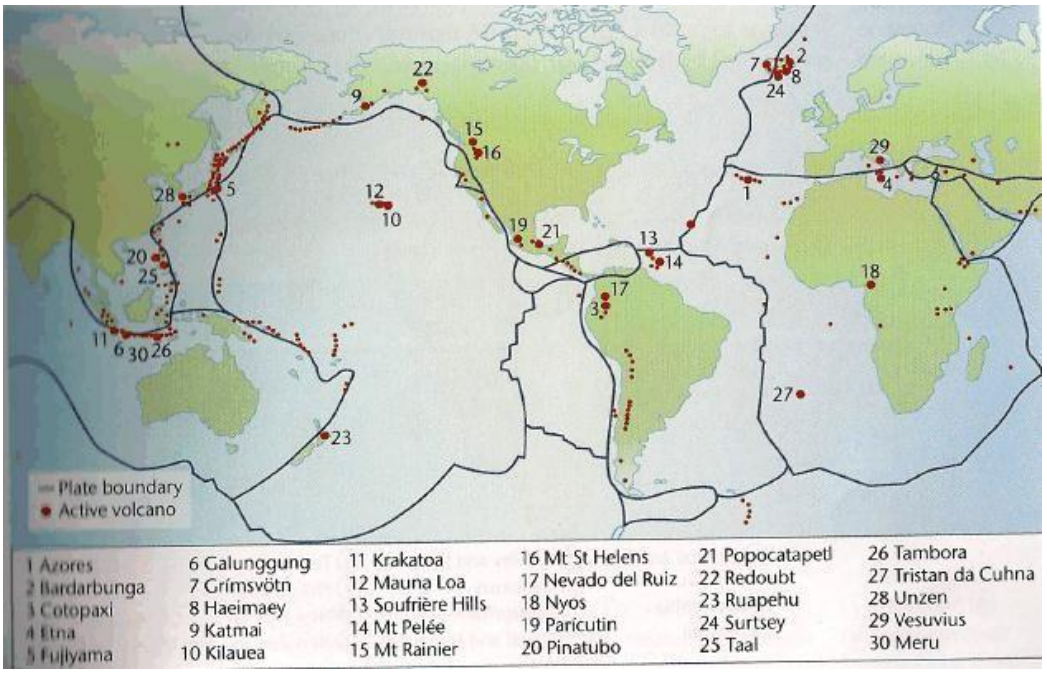
Earthquake hazards

- Primary hazards result from ground movement and ground shaking. Surface seismic waves can cause buildings and other infrastructure (e.g. pipes for water and gas supply) to collapse.
- Secondary hazards include soil liquefaction, landslides, avalanches, tsunamis and exposure to adverse weather. These can add significantly to the death toll.

Most of the injuries and deaths that occur in an earthquake are a result of people being hit by falling roofs or being trapped in collapsed buildings. In the more developed world, and especially those parts that are prone to earthquakes, buildings may be designed and engineered to withstand the vibrations of an earthquake. Sadly, in less developed parts of the world, where buildings may be less rigidly constructed or made from cheaper, readily available materials (including mud, bricks or stone), the death toll from earthquakes can be significantly higher.

Volcanic eruptions

The world's active volcanoes are found in three tectonics situations: at constructive and destructive plate boundaries, and at hotspots. The type of tectonic situation determines the composition of the magma and therefore the degree of explosivity of the eruption, which is a key factor in the degree of hazard risk.



The materials ejected from volcanoes can include magma (molten rock, which when exposed above ground, is referred to as 'lava'), volcanic gases (such as hydrogen sulphide), ash and dust. An 'active' volcano is one which is in the process of erupting or showing signs that an eruption is imminent.

Constructive plate boundaries

Most of the magma that reaches the Earth's surface wells up at oceanic ridges such as the mid-Atlantic. These volcanoes are mostly on the sea floor and do not represent a major hazard to people except where they emerge above sea level to form islands such as Iceland. Rift valleys occur where the continental crust is being 'stretched'.

Destructive plate boundaries

Some 80% of the world's active volcanoes occur along destructive boundaries. Soufriere Hills in Montserrat, West Indies is an example of a volcano formed where two ocean plates collide. The 'ring of fire' around the Pacific has many such volcanoes.

Hotspots

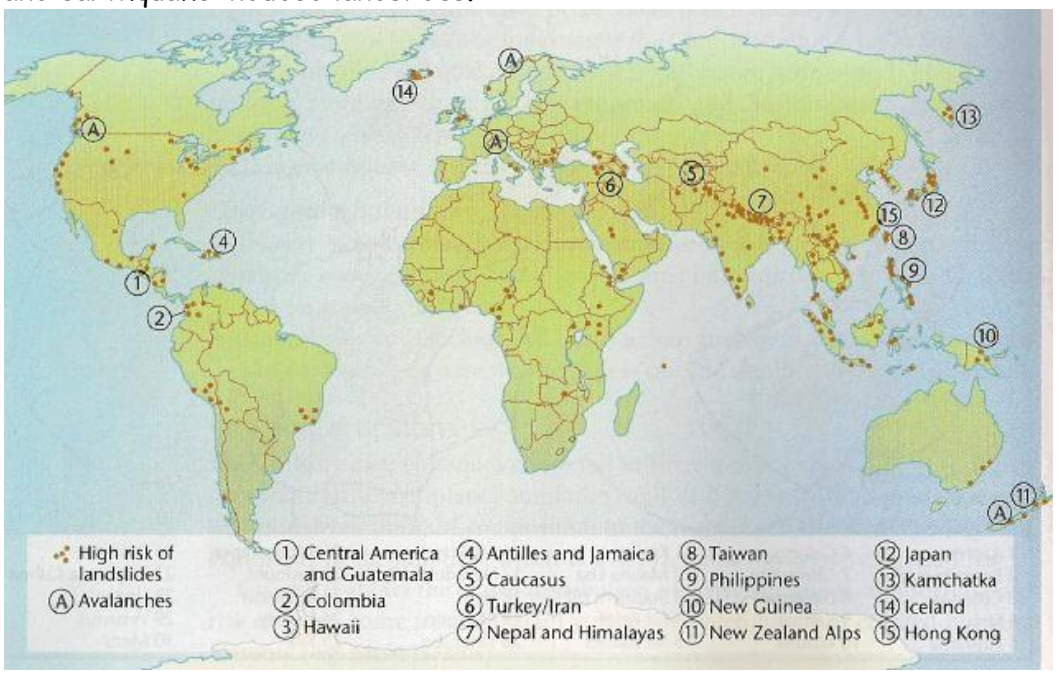
Hotspots are localised areas of the lithosphere which have an unusually high heat flow, and where magma rises to the surface as a plume. Hawaii is an example.

Volcanic hazards

Apart from the local impacts of lava flows the most catastrophic impacts of volcanoes are pyroclastic flows, ash falls, tsunamis and mudflows.

The distribution of slides

Slides include a variety of rapid mass movements, such as rock slides, debris flows, snow avalanches, and rainfall, and earthquake induced landslides.



Landslides

- Landslides are the seventh biggest killer with over 1,400 deaths per year, ranking above both volcanoes and drought. Most areas affected are mountainous, and experience landslides after abnormally heavy rain and/or seismic activity.
- Human factors also play a part. Deforestation of hillsides in Southeast Asia and building on hill slopes in Hong Kong has both led to widespread slides following rain.
- We associate landslides with high rainfall areas such as those located within the earth's tropics. Here, where hurricanes and monsoons can dump large amounts of rainfall in a matter of hours, soil can very quickly become saturated.

Snow avalanches

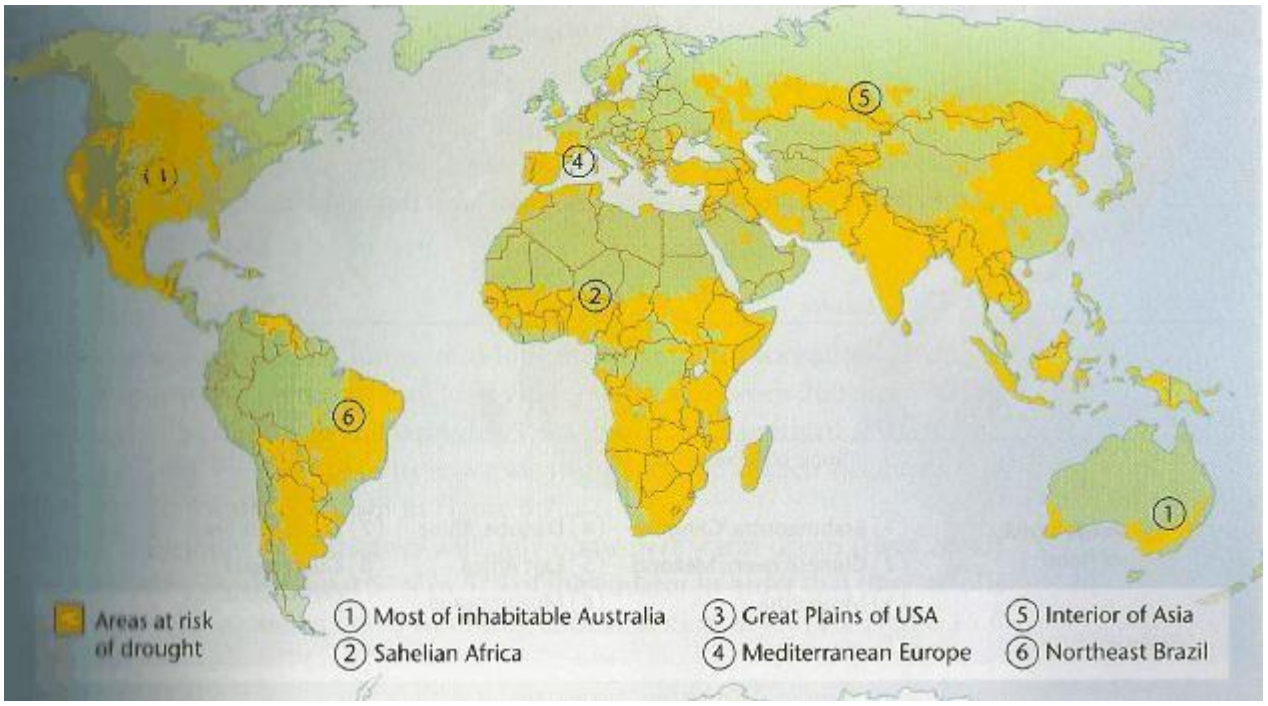
- Snow avalanches are concentrated in high mountainous areas such as the Southern Alps of New Zealand or the Rockies of North America. Avalanches tend to occur on slopes steeper than 35°.

- An average of 40 deaths a year in Europe and over 100 in North America are caused by avalanches. Recent research has suggested that global warming may be increasing avalanche occurrence, although trends in deaths have slowed because of effective management.

The distribution of hydro-meteorological hazards

Drought

Drought has a dispersed pattern – over one-third of the world's land surface has some level of drought exposure. This includes 70% of the world's people and agricultural value, which means that drought, has an effect on global food security.



A drought is an extended period of lower than average precipitation which causes water shortage. Droughts can extend for as little as one year, during which the rainfall that is received is noticeably lower than in average years. More often, however, a drought is a dry period that extends over two or more growing seasons for years. Droughts can be localised, occurring in relatively small regions (approximately the size of a country or state), or they can be much larger, affecting, at their worst, entire continents. Includes large parts of Northern Africa, Central Asia and most of Australia.

Causes of drought

The causes of drought include the following:

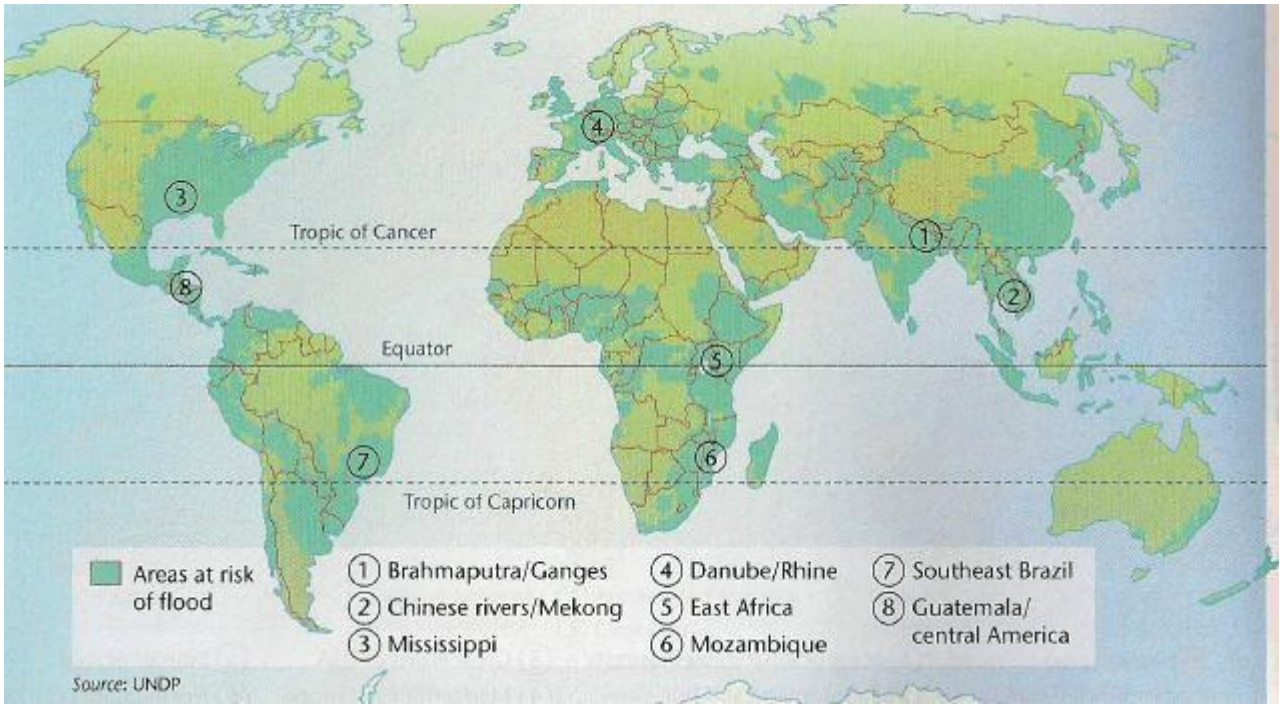
- Variations in the movement of the inter-tropical convergence zone (ITCZ). As the ITCZ moves north and south through Africa, it brings a band of seasonal rain. In some years, high pressure zones expand and block the rain-bearing winds. In southern Ethiopia and Somalia, where farmers depend for food on rain-fed agriculture, famines may result if the summer rains never arrive.
- El Nino can bring major changes to rainfall patterns. In particular, it can bring drought conditions to Indonesia and Australia.
- Changes in mid-latitude depression tracks. In temperate regions, depressions bring large amounts of rainfall. However, if blocking anticyclones form and persist, depressions are forced to track further north, leading to very dry conditions.

Drought hazards

Drought leads to failure of crops and loss of livestock, wildfires, dust storms and famine. It has economic impacts on agriculture and water-related businesses in developed countries.

Flooding

Flooding is a frequent hazard and is evident in some 33% of the world's area, which is inhabited by over 80% of its population. Regional scale, high magnitude floods are frequent events in India/Bangladesh and China.



A flood occurs when land that is usually dry becomes inundated. In most cases, floods occur after a prolonged period of rainfall, which causes water course to burst their banks and overflow. Sometimes, floods occur because the systems that have been designed to cope with average levels of rainfall, such as storm water drains and levee banks, simply fail to work properly because of a blockage or a structural weakness. Floods can even occur in regions that have experienced no recent rainfall themselves.

Some areas are more prone to flooding than others. For example, the relatively low-lying nation of Bangladesh is regularly inundated by melt waters that originate in the mountainous regions of its neighbours India and Nepal.

Causes of flooding

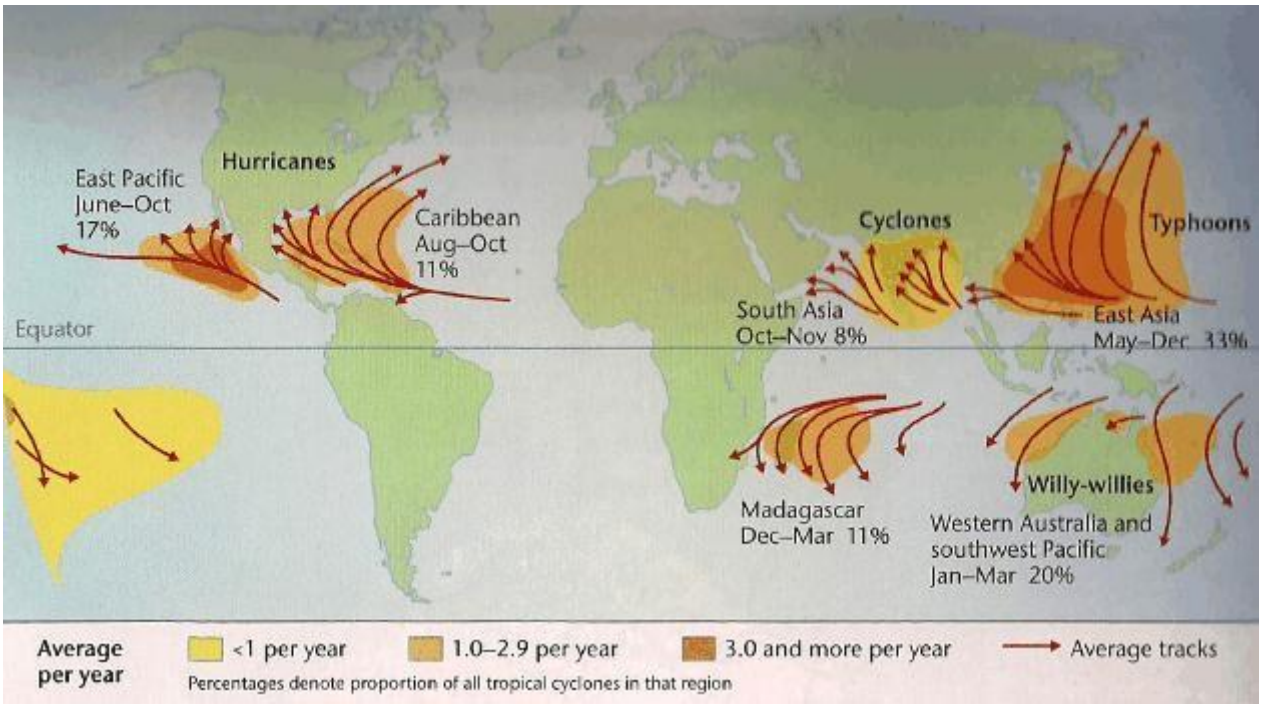
- By far the most common cause is excessive rainfall related to atmospheric processes, including monsoon rainfall and cyclones. In temperate climates, a series of depressions sometimes brings prolonged high rainfall.
- Intense rainfall sometimes associated with thunderstorms can lead to localised flash flooding. These sudden floods can have a devastating impact.
- The El Nino Southern Oscillation can bring devastating floods, as in Mozambique in 1997 and 2006.
- Rapid snowmelt can add water to an already swollen river system.

Flooding hazards

In developing countries flooding may lead to deaths by drowning and disease, destruction of food crops and infrastructure and loss of homes. In developed countries it disrupts transport and infrastructure, damages livelihoods and creates high insurance costs.

Storms

- Storms include tropical cyclones, mid-latitude storms and tornadoes. Tropical cyclones are violent storms between 200 and 700km in diameter. They occur in the latitudes 5-20° north and south of the equator. Once generated, cyclones tend to move westward and are at their height of destruction.
- Tropical cyclones or hurricanes will only occur over warm ocean (over 26°C) of at least 70m depth at least 5°N or 5°S of the equator in order that the Coriolis effect (very weak at the equator) can bring about rotation of air.



Cyclones

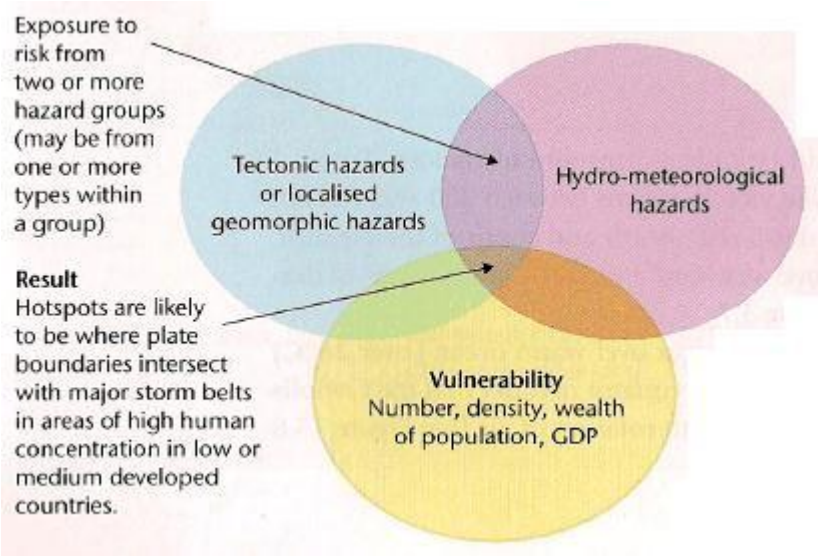
The term 'cyclone' can be applied to any area of low atmospheric pressure that is created when air rises from the surface of the earth. As the air rises into the atmosphere, it is cooled and condensation occurs. This may result in the formation of clouds and eventually precipitation, both of which often characterise low pressure systems. As the rising air is relatively unstable, cyclone can also bring windy conditions and are often associated with storms. Tropical cyclones, also commonly known as hurricanes and typhoons, are fuelled and formed by warm ocean water. Temperate cyclones are formed when air of different characteristics converges and rises, drawn upwards by an accelerating jet stream.

The most intense cyclones are those that develop over the warm waters of the earth's tropics. Here, the warmth of the tropical ocean rapidly heats the air lying just above its surface. As the air rises into the atmosphere, condensation is rapid and cloud formation occurs quickly. The tropical cyclones that result from this process are often very large, and their behaviour can be extremely hard to predict. Tropical cyclones that begin life in the Atlantic Ocean are often referred to as 'hurricanes'. Those that begin in the Pacific Ocean are sometimes called 'typhoons' (Asia) or 'cyclones' (Australia).

Tropical storm hazards

Storms cause damage in several ways, including heavy rain (leading to floods and mudslides), high wind velocity and very low central pressure (leading to storm surges and coastal flooding). They can be devastating (e.g. Hurricane Katrina).

Disaster hotspots - Identifying and defining hazard hotspots



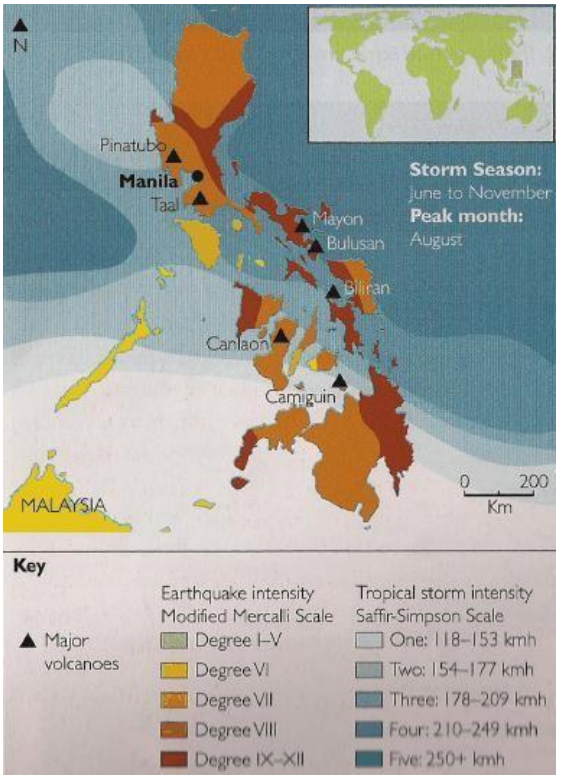
These hotspots are multiple hazard zones. The project assessed the risk of death and damage. The level of risk was estimated by combining exposure to the six major natural hazards (earthquakes, volcanoes, landslides, floods, drought and storms). Historical vulnerability (from data from the last 30 years) was combined with potential vulnerability based on size, density and poverty of the population (as measures of mortality) and GDP per unit area (as a measure of potential economic damage).

Managing a hazard hotspot

The identification of multiple hazard zones has major implications for development and investment planning, and for disaster preparedness and loss prevention. However, many hazard-prone areas have long lists of priorities more immediate than risk management, such as poverty reduction, or fighting HIV/AIDS, and may be unable to afford the technology required to cope with multiple hazards. Most countries face some kind of hazard, but six countries stand out as being the most hazard-prone in the world: the Philippines, Japan, India, Bangladesh, China and Indonesia.

COMPULSORY CASE STUDY: DISASTER HOTSPOTS: THE PHILIPPINES

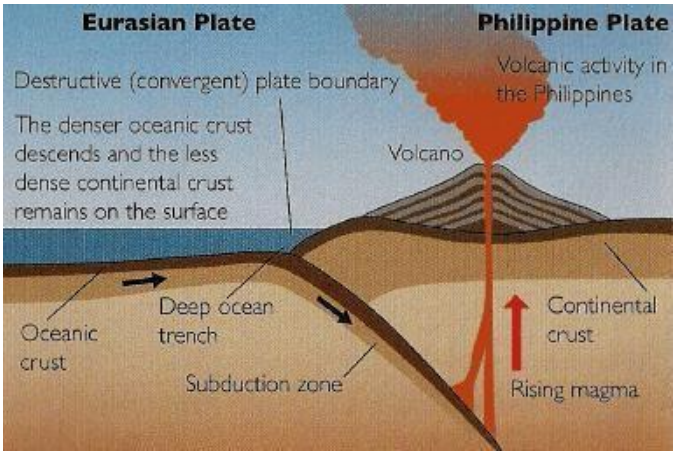
Area: the Philippines consists of about 7000 islands, and is 25% bigger than the UK
Population: 91 million in 2007
Wealth: GDP in 2006 was US$5000 per capita; a middle income country according to the World Bank



Main problems faced:

- It sits across a major plate boundary, so risks from volcanoes and earthquakes
- Its northern and eastern coasts face the Pacific, the world's most tsunami-prone ocean.
- It lies within south-east Asia's major typhoon belts. In most years, it is affected by 15 typhoons and struck by 5 or 6 of them.
- Landslides are common in mountain districts due to deforestation of many hillsides
- Lower middle-income country → rapidly growing population → high population densities → especially coastal regions
- Droughts → these occur when the wet season (may-Oct) hasn't brought enough rain to last the dry season. In 2005 the reduction in rainfall decreased the water flow in rivers, which affected power production from HEP plants.
- Flooding → during the wet season floods can be caused by typhoons and heavy rain.

Tectonic Risks: The Philippines lies on the boundary between two tectonic plates, the Philippine and Eurasian. The Eurasian Plate is forced beneath the Philippine, creating the deep Manila Ocean Trench, to the west. The plates move in a series of 'jerks', producing an earthquake each time they do so.



Mount Pinatubo's volcanic eruption in June 1991

Mount Pinatubo's eruption was the biggest the world had seen for over 50 years. The volcano showed signs of eruption in April 1991, with steam explosions and minor earthquakes. A 10km exclusion zone was set up around Pinatubo by government advisers, who eventually extended the zone to 30km – evacuating more people each time it was extended. By 9 June 1991, 58 000 had been evacuated

reaching 200 000 by 12 June (when the first eruption sent a cloud of ash 20km into the atmosphere, spreading over South-East Asia within three days). The second eruption, on 15 June, was cataclysmic, a dome on the side of the volcano collapsed, creating a pyroclastic blast and causing huge lahars. However, effective monitoring and management reduced Pinatubo's death and injury toll to just over 4300 people.

- 350 people died, including 77 in the lahars that occurred.
- Some evacuees died in camps, where they were exposed to disease
- 80 000 hectares of farmland were buried beneath ash, disrupting the livelihoods of 500 000 farmers and their family members
- Economic losses were US$710 million mainly agriculture and property.

Landslides:

The Guinsaugon landslide

Guinsaugon was a village in the central Philippines. In February 2006, a mudslide completely engulfed the village and its land, covering 3km^2 and killing about 1150 people. It was not unusual – a series of storms in December 2004 killed 1800 people in the north-eastern Philippines. In 2003, 200 people were killed in landslides. Typhoons and storms kill several thousand people there every decade.

The physical causes were:

- There was unseasonable torrential rain; 2000mm of rain fell in 10 days in February – normally the dry season
- La Nina – a cyclic ocean and wind current affecting South East Asia – was probably the cause of the rainfall.
- A 2.6 magnitude earthquake struck just before the slide and may have triggered it

The human causes included:

- Deforestation of native forest cover protecting the soil. In 50 years, logging has reduced several million hectares of forest to about 600 000 today
- Replacement of native forest by shallow rooted trees, such as coconuts, further reducing soil protection.

Other hazard risks

Some hazard risks in the Philippines are complex because they have multiple effects. One earthquake in 2006:

- Killed 15 people, injured 100 and damaged or destroyed 800 buildings
- Generated a local tsunami 3 metres high
- Triggered landslides which breached the crater wall of Parker Volcano, and then fell into Maughan Lake…
- …creating a flood which washed away houses

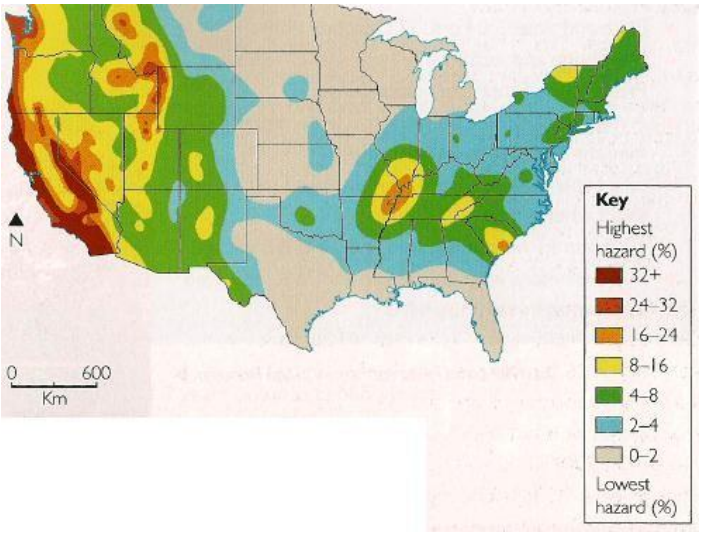
Government Responses:

In response, the government has established several organisations to carry out forecasting, warning, hazard risk assessment, disaster training and education. These include the National Disaster Co-ordinating Council; Philippine Atmospheric, Geophysical and Astronomical Services; and the Philippine Institute of Volcanology and Seismology, Land use planning and building regulation, and structural programmes of defences help people to survive the huge range of hazards facing them.

Sample Question: Using specific examples compare and contrast the Philippines with California as a disaster hotspot (15)

COMPULSORY CASE STUDY: DISASTER HOTSPOTS: THE CALIFORNIA COAST

Area: the Philippines consists of about 7000 islands, and is 25% bigger than the UK
Population: 40 million
Wealth: economy is the world's sixth largest, bigger than France or Italy



Main problems faced:

1) Earthquakes – The San Andreas Fault runs the length of California – Conservative plate boundary. Has 2 or 3 earthquakes each year
2) Population – much of the coastline is overcrowded - +70% live within 50km of a fault line. Although a wealthy state around 20% of the residents live below the poverty line so have limited capacity to cope
3) Droughts – these can be caused by anticyclones (long-lasting periods of high air pressure with sinking, dry air) or by La Nina events. Often leads to wildfires and in October 2007 22 people were killed and 1300 homes destroyed by wildfires in Southern California
4) Tsunami – earthquakes under the Pacific ocean could cause a tsunami along the California coastline
5) Landslides – occur on unstable steep land. The risk of landslides is high in California because of building on and around steep slopes, as well as building on coastal land overlooking the ocean

Plate tectonics and California

San Francisco seems like a city living on the brink of disaster. Its residents know that it lies along the San Andreas Fault, where the Pacific Plate moves north-westwards past the North American Plate. The two plates move in the same direction but the Pacific Plate moves move more quickly, thus creating friction. This is called a conservative plate boundary. The San Andreas Fault is the fracture – or fault line – between them. It runs along the Californian coast from Los Angeles north to San Francisco. Other fault lines run parallel to the major fault; San Francisco is built over two of them.

These faults move regularly, causing earthquakes. In 1906, San Francisco was destroyed in an earthquake measuring 8.2 on the Richter scale. It fractured gas pipes (which caused explosions and fires) and water mains (which could have prevented the spread of the fires). A further earthquake, of magnitude 7.1, occurred in 1989. With is epicentre at Loma Prieta, it caused major damage and deaths. Some buildings collapsed, while others were badly shaken. Five years later, a further earthquake shook Northridge in Los Angeles.

The 1989 Loma Prieta earthquake in San Francisco

- Date and time: 5.04pm, 17 October 1989
- Magnitude and location: 7.1; epicentre Loma Prieta in the Santa Cruz mountains
- A magnitude 5.2 aftershock struck the region 37 minutes after the main earthquake
- 63 people died and 13 757 were injured (most were killed when a freeway collapsed)
- 1018 homes were destroyed and 23 408 damaged
- 366 businesses were destroyed and 3530 damaged
- The damage cost US$6 billion

The 1994 Northridge earthquake in Los Angeles

- Date and time: 4.31am, 17 January 1994
- Magnitude and location: 6.7; striking the densely populated San Fernando Valley in northern Los Angeles
- There were many thousands of aftershocks (mostly in magnitude 4.0-5.0) during the following weeks, causing further damage
- 57 people died and over 1500 were seriously injured
- 12 500 buildings were damaged; 25% suffered severe-to-moderate damage
- 9000 homes and businesses were without electricity for several days (20 000 without gas), and 48 500 people were without water
- There was damage to several freeways serving Los Angeles – choking traffic for 30km.

Dealing with earthquake threats

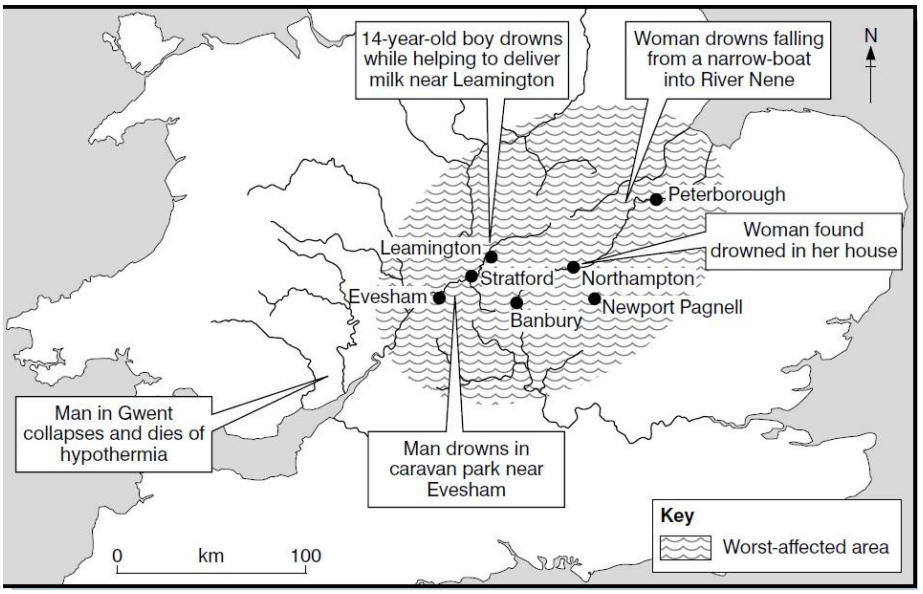
What if there was another major earthquake? The panels above show that in wealthier countries the economic damage can be great, whereas the impacts in developing economies tend to affect people. To protect themselves, most Californians insure their property against earthquake damage. After the Loma Prieta and Northridge earthquakes, demand for insurance rose sharply. But, by 1996, it had dropped to below 1989 levels, and has declined further since. Many people avoid the cost of taking out insurance.

Climatic patterns and California

California has a reputation as a state where the weather is always perfect, but it suffers periodic changes which can be hazardous. Sometimes drought occurs and forest fires threaten, while at other times floods and landslides provide headline news. Flood risks in California vary, but they coincide with El Nino; forest fires and drought coincide with La Nina.

Practice Question: Using specific examples, explain why California is considered to be a disaster hotspot (15)

Named Case Study: Hazard risk in your local area → Northampton Floods 1998



Location: Northampton lies 13 km east of Daventry and 17 km west of Milton Keynes, at the confluence of the River Nene's main tributaries, the Brampton Branch and the Kislingbury.

Background: The majority of the Far Cotton and St James areas of Northampton were developed in the 19th century, and these areas had a history of flooding. There had been no major flooding in Northampton since 1939, and the core elements of the flood defences in 1998 dated from this time.

Physical Causes:

- → With up to 3.2 times the average monthly rainfall totals over much of England and Wales.
- → Tuesday 7 April, an area of low pressure formed near Iceland. On 8 April this depression moved southwards across the UK.
- → 9 April, thunderstorms broke out ahead of it resulting in the ground reaching saturation point in many areas.
- → Most of the rain fell in a band about 300 km long and between 50 and 100 km wide, stretching from the Black Mountains in South Wales to the north of Cambridgeshire.
- → Many of the areas affected received more than 75 mm of rain – equivalent to 6 weeks of average rainfall – in a 36-hour period.

Human Causes:

• Flood forecasting was handicapped by insufficient rainfall information which masked the severity of the event.
• Flow measuring stations were poorly placed for flood monitoring and quickly became overwhelmed or were by-passed altogether.
• Forecasting did not take into account that reservoirs upstream of the town were full prior to the storm.
• River channels were poorly maintained in some places, with trees and debris reducing the storage capacity of the channel.
• Flood defences were poorly maintained and funded – some defences had 4 metre gaps in them.
• Arrangements for direct warnings to the public were not in place, as the Environment Agency did not see Northampton as being a high-risk area.

Consequences:

- During the night of 9/10 April 1998 more than 2,400 properties in Northampton were affected.
- Power supplies were cut off, and as most people were asleep in their beds, there was little time to take action to reduce damage
- Water polluted with sewage, heavy metals and mercury had swept through 2,500 properties.
- One in three households in St James was uninsured; 5,000 cars in the area were written off.
- The Borough Council estimates its own expenses as a result of the flood to be somewhere in the region of £6 million.
- The Northampton Flood Relief Fund was established and over £160,000 was collected to help flood victims.

The future

The Borough Council argued that all developments had been subject to planning permission and that adequate flood protection measures had been taken. Now, the Borough Council will not grant planning permission for any new Greenfield development on the floodplain, but admits that it finds it far more difficult to refuse planning permission on existing Brownfield sites. Northampton is the sixth fastest-growing town in the UK, with an average of 2,000 new inhabitants arriving each year, and the Council must balance the risk of another severe flood against the need to continue to encourage new industrial and residential developments in the town. Environment Agency has placed four flood warning sirens – two in Far Cotton and two in St James – to alert residents to the risk of flooding as early as possible.

NAMED CASE STUDY: Boxing Day tsunami, 2004

Tsunamis occur where:

- Earthquakes measure more than 6.5 on the Richter Scale
- The earthquake's focus is shallow beneath the Earth's surface
- The focus is also beneath the ocean

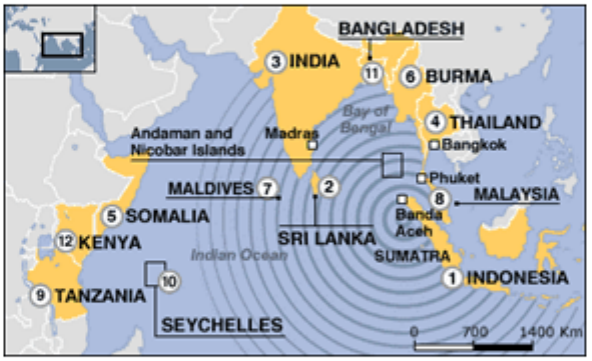
The earthquake that caused the Boxing Day tsunami was estimated at between 9.0 and 9.3 on the Richter scale, and was over 100 times stronger than the one which caused the Kobe earthquake in 1995. The thrust heaved the floor of the Indian Ocean towards Indonesia by about 15 metres, and, in so doing, sent out shock waves. Once started, these radiated out in a series of 'ripples', moving almost unnoticed across oceans until they hit land. The longer and shallower the costal approach, the more the ripples built up in height. The waves that struck the shallow coastline near Banda Aceh (only 15 minutes from their origin), and parts of Sri Lanka were nearly 17 metres high on impact.

The Boxing Day tsunami, 2004

Maldives
Of the 199 inhabited islands, 20 were destroyed. The shallowness of the water limited the tsunami's destructive power but flooding was extensive. A sea wall protecting the capital Male prevented half the city being destroyed. Many luxury tourist resorts were badly damaged – affecting the economy of the country, which depends on tourism. 82 dead or missing.

Somalia
This was the worst-hit African country, with damage concentrated in the top of the Horn of Africa. Homes and boats were destroyed and freshwater wells and reservoirs were contaminated. Up to 30 000 people were displaced and 150 people dead or missing.

India
The south east coast of the mainland, especially Tamil Nadu, was worst affected. Up to 140 000 people were displaced. In the Andaman and Nicobar Islands, salt water contaminated freshwater sources and destroyed arable land. Most of the Island's jetties were also destroyed. 16 513 dead or missing.



Thailand
The west coast was severely hit, including islands and tourist resorts near Phuket, so the death toll included 1700 foreigners from 36 countries. 5395 dead or missing.

Indonesia
Western Sumatra, the closest inhabited area to the earthquake's epicentre, was devastated by the tsunami. Up to 70% of some coastal populations were killed or missing. Up to 400 000 people were displaced. 236 169 dead or missing.

Kenya
Kenya was one of the few affected countries to be warned and to take some action, so many people were able to escape the coastal areas as a result – and only one person was killed.

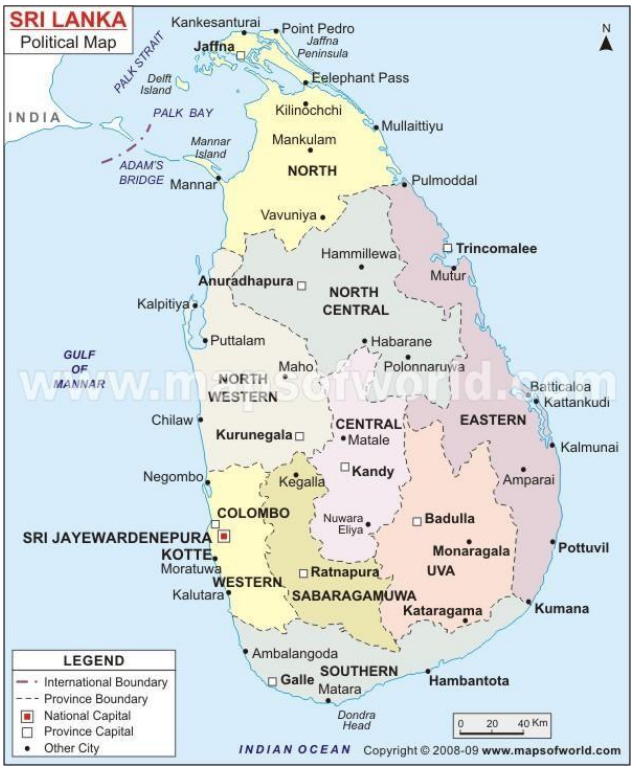
Sri Lanka
The second worst affected country – the southern and eastern coastlines were ravaged, with homes, crops and fishing boats destroyed. 400 000 people lost their jobs. 31 147 dead or missing.

Sri Lanka – who died in the 2004 tsunami?

Sri Lanka was the second most seriously affected country after Indonesia, with over 30 000 deaths, 5 700 people missing and 861 000 people displaced. One survey carried out in Ampara (an eastern coastal district of Sri Lanka) found that the most vulnerable people had suffered the most. This area had previously experienced rapid coastal urbanisation. Its economy is also based on tourism and subsistence fishing, which left it vulnerable to the tsunami.

In this part of Ampara, out of a population of 3533 (living in 859 households), 12.9% died. Of these:

- Most deaths occurred during and immediately after the disaster
- More than double the number of women died, compared to men
- 56% of victims were children
- The elderly and disabled were more likely to die than young, healthy adults; 15% of deaths were of people aged over 50



Other factors which increased people's vulnerability were:

- Whether they were indoors at the time of the tsunami (13.8% of casualties). Women and children were more likely to be inside on the morning of the tsunami. Even compared with those on the beach or in the sea, people at home were more likely to die.
- The quality of the building they were in, either in terms of its structure or its location and exposure to the full force of the waves. 14% of deaths occurred in buildings that held up well or withstood the initial impact.
- Whether they belonged to a fishing family (15% of deaths)
- Whether they had lower educational qualifications. Those with higher educational qualifications were 20% less likely to die if educated to secondary level, and 60% less likely if educated to university level. University educated people earn more and could afford to live away from high-risk locations.
- Whether they earned lower incomes. In Ampara, 15 000 rupees (US$150) per month is a high wage. Most deaths occurred in households earning 1-2999 and 3000-5999 rupees, with few deaths in the highest earnings category.

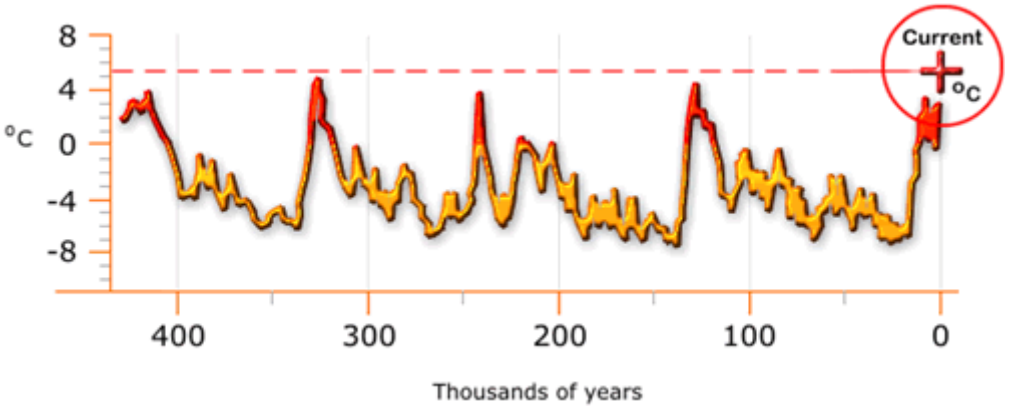
Environmental change and the tsunami

One clear factor has emerged from several countries affected by the tsunami – the countries which suffered most were those where the tourism industry has grown rapidly in recent years. Many coastal areas of Thailand and Sri Lanka have been cleared of coastal mangrove swamps to make way for hotels and resorts. Mangroves act as a natural barrier, absorbing wave power and creating a natural coastal buffer zone. Damage from the tsunami was noticeably reduced in coastal areas which had maintained their mangrove swamps, beach forest and coral reefs.

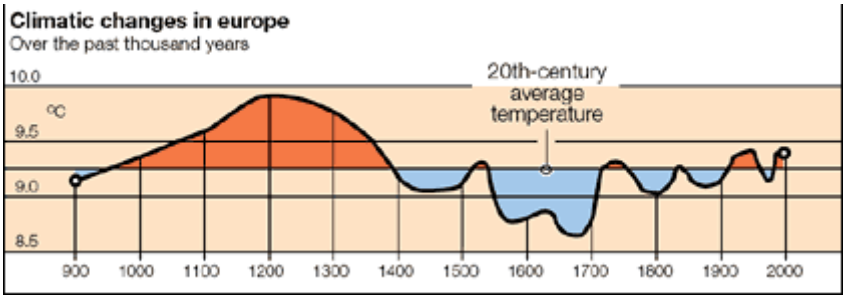
Climate change and its causes

Climate change is any significant change in the weather of a region over a period of at least several decades

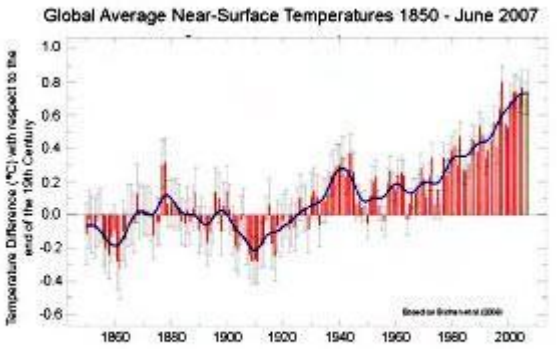
Long-term climate change → temperatures have been much higher at some points in the past than they are today. Climate has shifted between cold glacial periods that lasted around 100,000 years and warmer interglacial periods that lasted around 10,000 years.



Medium-term climate change → the last glacial period ended 18,000 years ago and the warming of the climate was fast but not always constant. Around 5,000 years ago temperatures were 1-2°c higher than today



Short-term climate change → there has been a sharp rise in temperature over the last 1000 years. Global temperatures rose steadily from early 20th century until the 1940s, and then dropped back down. Temperatures however have since risen rapid since the 1970s (global warming)



Temperature changes during the last 150 years based on instrument data
(Source: Hadley Centre for Climate Change, UK Meteorological Office)

What is the evidence?

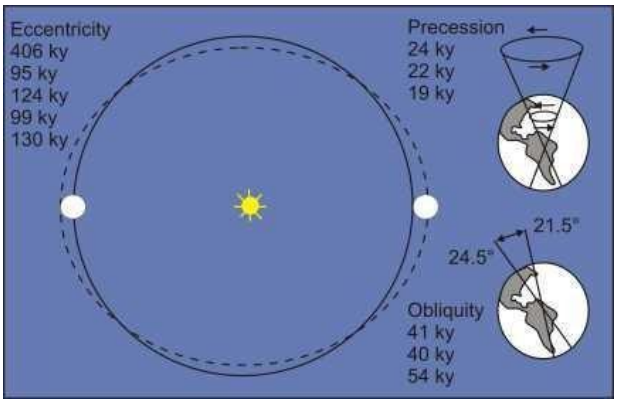
Long Term change	Ice cores – scientists can analyse the gases trapped when the ice was formed to tell what the temperature was each year. Then they can figure how temperature has changed over time.	Pollen analysis – pollen from plants is preserved in sediment and can be identified and dated so know what the conditions were like at that particular time	Sea level change – past sea levels are shown by raised beached e.g. Isle of Arran
Medium change	Historical records – indirectly indicate the conditions e.g. paintings	Tree rings – a new tree ring is formed each year as a tree grows, wide rings show good growing conditions, narrow periods of climate stress. Show climate conditions up to 10,000 years ago	Retreating glaciers – the distance from the rocks deposited by the glacier up to its current position indicate the temperature changes
Short-term change	Weather records – consistently collected since 1861 and show detailed climate changes	Polar ice melt – changes in the extent of polar ice shows changes in climatic factors affecting them	Ecosystem changes – affects the availability of food and shelter, as well as what species can live in an area

Causes of climate change

Natural:

1) Variations in the earth's orbit → Milankovitch cycles suggested 3 key factors that could have caused climate change to occur

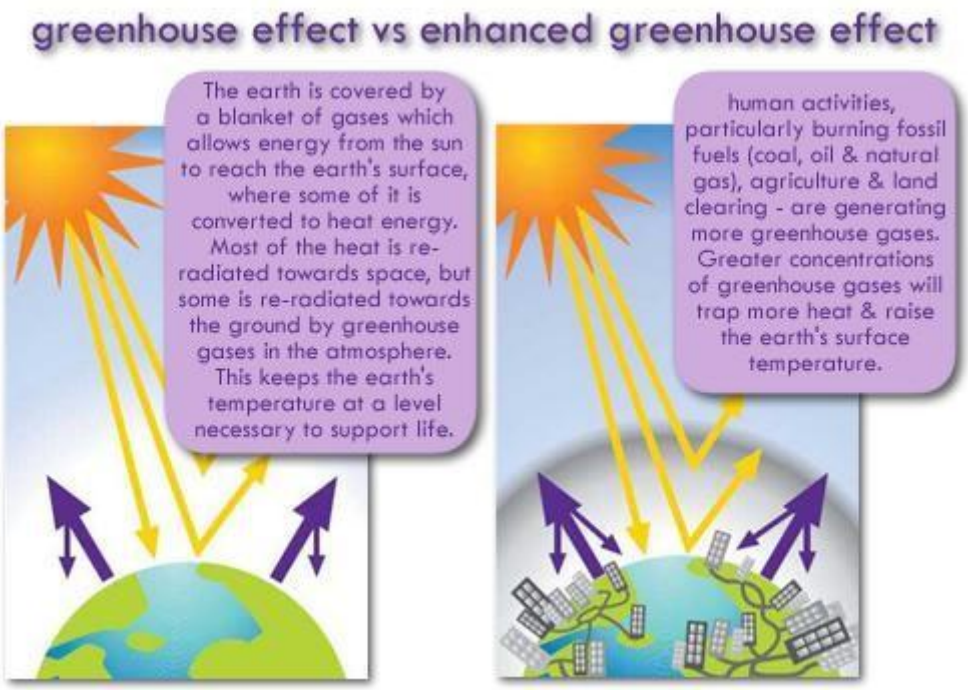
- Orbit – the path of the earth's orbit around the sun changes from a perfect circle to an ellipse every 96,000 years. This changes the distance from the earth to the sun and so the amount of energy received
- Tilt – the earth is tilted on its axis at 23.5° but this change between 21.8 - 24.4° over a 41,000 year cycle. The change in tilt changes the amount of energy different latitudes receive
- Wobble – the earth's axis wobbles on a cycle of 22,000 years



2) Variations in solar output – the presence of sunspots on the sun's surface cause an increase in solar energy output. These increases and decrease on an 11 year cycle
3) Meteor impacts – the impact of a meteor or asteroid causes huge amounts of material into the atmosphere reducing the amount of sunlight and changing the climate
4) Volcanic eruptions – major eruptions release huge amounts of material into the atmosphere blocking out sunlight which changes the climate

Human:

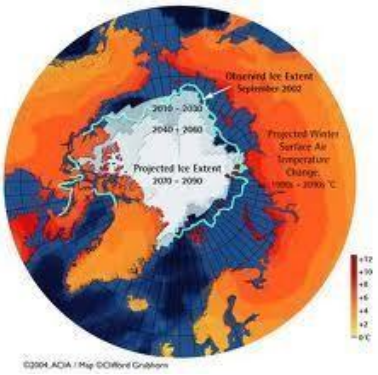
1) Enhanced greenhouse gas emissions – the greenhouse effect is a natural phenomenon and is essential for keeping the planet warm however, increased presence of greenhouse gases such as carbon dioxide, methane etc. causes too much energy to become trapped and warms up the planet



2) Destruction of natural C02 sinks – the biggest sinks are the oceans and plants. Co2 is released into the atmosphere when trees are burnt by forest fires or to make way for agriculture

Impacts of climate change

Compulsory Case Study – Impact of climate change on the Arctic Region



Facts:

- Average Artic temperatures have risen at x2 the rate of the rest of the world (3-4°c in the last 50 years)
- Over the next 100 years they are expected to rise a 3-5°c over land and 7°c over the oceans
- Suffers from positive feedback (albedo effect) – small increases in snow and ice raise the surface reflectivity so more solar energy is reflected back into space. By an increase in global temperature → snow and ice melting → less radiation is reflected → more ice melts = vicious cycle

Impacts

Natural systems	Animal species	Society
Vegetation shifts – predicted to move northwards with coniferous forests moving into ice areas → impact on food webs Warmer growing season = growth of agriculture	Northward species shift – shift north with the forests → decline in some species	Loss of hunting culture and decline of food security for indigenous population
Permafrost thawing – up to 40% expected to thaw releasing huge amounts of methane. Melting to cause new wetlands and impact on species	Marine species – those dependant on sea ice e.g. polar bears will decline/extinct. Birds to have different migration patterns	Need for herd animals e.g. reindeer to change their migration routes
Increased fires and insects – increase in insect caused tree death = loss of valuable habitats	Land species – many species that have adapted to the artic climate are at risk e.g. artic fox, vole	Decline in northern freshwater fisheries but enhanced marine fisheries e.g. cod to warmer waters
UV impacts – Increase UV reaching the surface = loss of snow and ice. Destroys phytoplankton as the base of the marine food we		Increased access for marine shipping but disruption of land-based transport due to permafrost thawing
Carbon cycle changes – replacing artic vegetation = more forests = higher primary productivity and increase carbon dioxide intake		Enhanced agriculture and forestry
Other – increased coastal erosion and waves/storm surges as protection from sea ice is lost		New land and open sea so Artic becomes more accessible = exploitation for oil, gas, fish etc.

Compulsory Case Study – Impact of climate change on Africa

Due to the variety of climates in Africa global warming will have different impacts on different areas:

- Areas that are already dry e.g. arid or semi-arid will get drier
- Wetter areas e.g. tropical or sub-tropical will get wetter
- Whole continent is getting warmer – 0.5°c in the last century

Africa's population are also very **VULNERABLE** as the poor people have a reduced capacity to cope and are less able to prepare for and respond to the impacts of climate change.

Water issues:
- Demand outstrips supply for 25% of Africans
- Water stress could lead to wars, global migrations and famine

Food insecurity:
- 70% of population are subsistence farmers, who won't be able to feed themselves if water supplies dry up
- Increase in locust plagues expected

Desertification
- This is increased by unreliable or decreasing rainfall

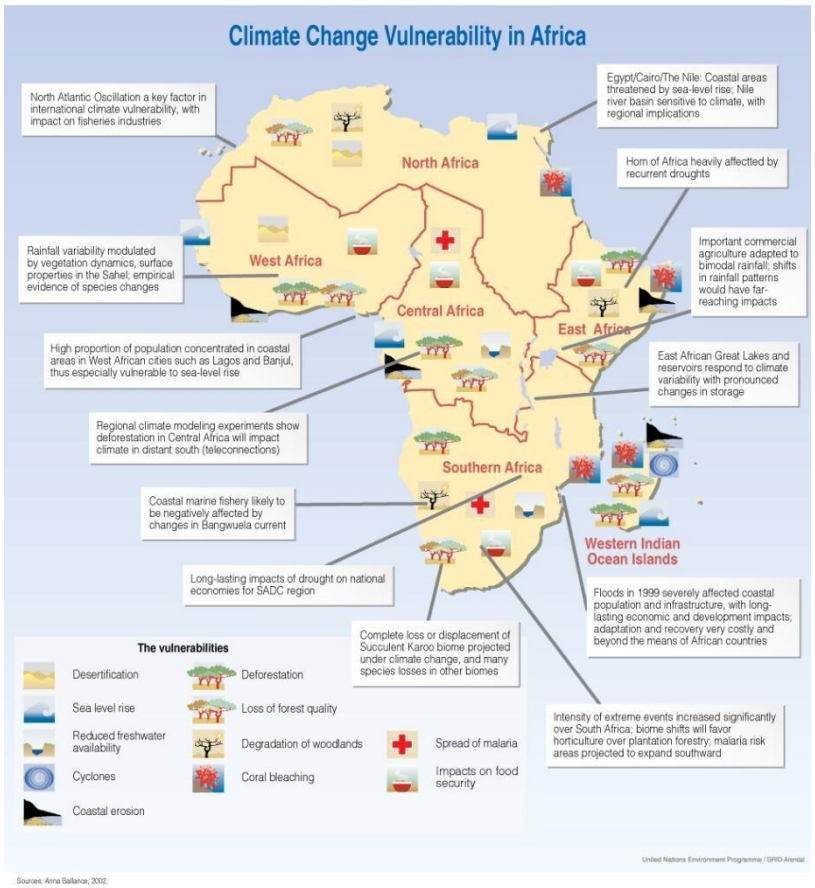
Health:
- Increase in malaria and water-borne diseases
- 80% of health services rely on wild plants for remedies which are under threat

Development of coastal zones
- Movement of environmental refugees with put pressure on coastal zones as they set up shanty towns
- 60% live in coastal zones which are at risk of coastal flooding and erosion

Natural Resources:
- Poor people rely directly on wild plants and animals
- Loss of biodiversity will threaten them

Poverty:
- 2/3rds of the least developed countries are located in Africa

Debt crisis – most African countries can only reduce their debt through the production of cash crops which has led to forest clearance for commercial farming. This combined with global warming will create drought, desertification and place Africa's food security under threat



Potential Exam Question: Explain the environmental and ecological impact of global warming in a named area of the world (10)

Indirect impacts of global warming: Rising sea levels

The worst case scenario predicts a 15m rise in sea level by 2100 which would put major cities such as London, New York and Tokyo at risk. This is because the melting of the ice on land e.g. Greenland means that water stored as ice returns to the sea. This increases the volume of water in the oceans causing the sea level to rise (EUSTATIC). Combined with thermal expansion, the volume of water contained in the oceans will also increase as the oceans get warmer.

Vulnerable areas:

Named area: Low-lying = Bangladesh

- 80% of the land area is low-lying (less than 6m above sea level)
- Could lose up to 20% of its land, displacing up to 40m people
- Threaten to reduce supplies of food and fresh drinking water and damage agricultural land (65% population are subsistence farmers)
- Multiple hazard zone = river floods, coastal floods, storm surges and typhoons)
- Vulnerable population with a low capacity to cope

Named area: low-lying but already defended: Netherlands

- One of the richest countries in the world
- Over 50% of land are is reclaimed from the sea (polders) so sits below sea level
- Densely population and heavily developed
- Complex protection system of dukes and coastal sand dunes
- A 1m rise in sea level would cost $12,000 million to defend

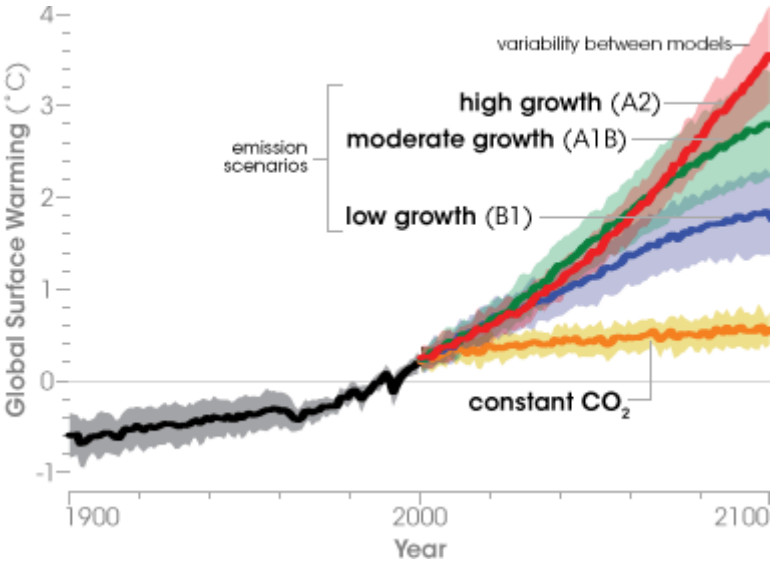
Named area: Small, low-lying island: The Maldives

- 311,000 people – dense and growing populations
- 1,196 islands, most just 2m above sea level – also small physical size means nowhere to flee
- Prone to natural disaster e.g. hurricanes –
- Vulnerability of groundwater to contamination by sea water
- A rise in sea level of 0.5m would submerge most of the country
- The economy is dependent on tourism, which would be threatened by a rise in sea level

Changing Salinity – oceans and winds help distribute heat between its warmest and coldest parts. They transport heat from the equator towards the poles. The current of warm water in the Atlantic is known as the Gulf Stream and the North Atlantic Drift ensures the UK's climate is warmer than it should be for its latitude. More freshwater is entering the oceans which lowers the salinity and decreases the density of the oceans. This affects these warm currents and some say could turn off the North Atlantic Drift

Predicting the impacts of Climate change

Scientists try to predict how emissions will change in the future, so that they can try to predict the change in climate and its impacts. The Intergovernmental Panel on Climate Change (IPCC) have produced a number of emissions scenarios. In 2007, greenhouse gas levels stood at 430ppm carbon dioxide (280ppm before Industrial revolution).



It is difficult to predict the impacts because:

1) We don't actually know how emissions will change
2) We don't know how much of the emissions will be absorbed in natural CO2 sinks
3) We don't know the exact climate changes each emission scenario will cause
4) The extent of climate change due to natural causes isn't know
5) We don't know what attempts to manage climate change there will be or how successful

A1: Converging World

- Introduction of new, energy efficient technology
- Global agreements enable social/cultural cooperation
- Rapid global eocnomic growth
- Global population reaches 9 billion by 2050 and then declines
- By 2100, global GNP is 26x that of 2007

A2: Divided World

- Reduced globalisation with countries becoming more independent
- Global population contines to increase
- Economic growth is regional with little global exchange of ideas
- Technological change is very slow!

B1: Converging world

- Similiar to A1 but reduced global income differences
- Global population rises to 9 billion by 2050, then steady decline
- Economy chnages to service and information
- Cleaner, more efficient technologies
- By 2100 there is more forest then in 1900

B2: Sustainability

- Global society attempting to achieve progress at local levels rather than through large companies
- Lower economic growth but more diverse changes in technology
- Attempts to achieve envioronmental protection and social equity
- More forest by 2100 than in 1900

Concept of a 'tipping point'

The tipping point is reached when climate change occurs irreversibly and at an increasing rate. This was originally agreed that this was at a certain level of greenhouse emissions (450ppm carbon dioxide) and a threshold temperature rise of 2°c. This may happen because of positive feedback loops – where a change in the climate is speeded up by the impacts already causes e.g. Albedo effect!

In 2006 the UK government published the **Stern Review** which focused on the impacts of global warming and the actions needed to deal with them.

Environmental impacts of global warming:

- Increasing flood risk
- Declining crop yields e.g. Africa as climate belts shift
- Rising sea levels, leaving 200m people permanently homeless
- Extinction of 40% of the earth's species

Economic impacts of global warming:

- More extreme weather could reduce global GDP by 1%
- A 2-3°c rise in temperatures could reduce global economic output by 3%
- If temperatures rise by 5°c, 10% global output could be lost

How strategies can attempt to limit the impacts of climate change at various scales

Mitigation vs. Adaptation?

Mitigation means reducing the output of greenhouse gases and increases the size of greenhouse gas sinks e.g. setting targets to reduce emissions or capturing carbon emissions from power stations

Adaptation means changing our lifestyles to cope with a new environment rather than trying to stop climate change e.g. managed retreat from vulnerable coastlines or developing drought-resistant crops

The ability for a country to adapt is linked to the level of development. Most adaptation strategies will be local in scale as they need to be tailored to local impacts of climate change. Mitigation on the other hand occurs at a range of scales from global to local e.g. international agreements to individual governments deciding how agreements should be implemented.

Adaptation ←					→ Mitigation
None ←		Reduction in greenhouse gases			→ Significant
Land use planning	Agricultural technology	Geo-engineering	Sustainable development	Carbon Capture Technology	Carbon-neutral agreement
Preventing development on floodplains and vulnerable coasts. Removal of urban scrubland to prevent the spread of fire	Drought-tolerant crops, water harvesting and use of urban waste water on fields	Orbiting solar shields to reflect incoming solar radiation	Reduced resource use, recycling, locally sourced food, alternative transport	Large-scale carbon capture technology applied to power stations and industry, deep-sea or geological burial	Offsetting all carbon emissions through afforestation, wholesale switching to renewable energy supplies
Reduced vulnerability to extreme weather events	Much of the technology already exists and can be adopted quickly	Could provide a 'one-off' solution and avoid need for lifestyle changes	Is known to work, and some aspects already accepted by the public	Technology is advanced and removes the problem at the source	Has the most impact on emissions
Costly to implement and may be opposition from local people	Costs may stop the developing world from accessing, even though they need it the most	Huge costs and untried technology, side-effects unknown	Can be opposed and the changes are slow to take effect	High costs passed to consumers. Encourages continued use of non-renewable resources	Could prevent development, public opposition to lifestyle changes

Other examples include

- Carbon tax – taxing companies or people who produce CO2 to discourage overconsumption of energy
- Energy conservation – using less energy e.g. switching off appliances when not in use
- Tree planting – creating new carbon sinks
- Community awareness – educating local people on the potential impacts of climate change

Key Players in Climate Change

Key Player	Role	Conflicts	Example
Businesses e.g. Shell	Can be responsible for contributing to climate change or can help to slow it down.	• Can lobby governments to reduce restrictions and allow them to continue producing greenhouse gases • Argue that reducing pollution costs jobs, money and profits • Have funded research to counter the warnings about global warming • Shift towards being more 'green' as pressure mounted	**Shell** Pumps C02 from an oil refinery into 500 greenhouses growing fruit in the Netherlands which: - Avoids annual emissions of 170,000 tonnes - Saves greenhouse owners from turning 95m3 of gas to get the C02 they need for heat retention
Governments	Develop strategies on an international, national and local scale	• Often public opposition to some of the proposals e.g. wind power turbines are noisy and an eye-sore	**UK** Aim: Reduce carbon dioxide emissions by 60% by 2050 - 10% of electricity to come from renewable sources by 2010 - 20% by 2020 - Tax system introduced so that choosing to drive a large car costs, more as it pollutes more **London Congestion Charge** Since 2003 drivers have been charged £8 per day to drive in the central London zone - Traffic levels down 15% - Congestion down 30% - Road traffic accidents down 5% - 12% decline in C02 and NOx in the zone - No effect on businesses - £170m income in the first 2 years
Groups e.g. EU	Work together to suggest solutions that Europe could implement	• Forces businesses to move to other areas which do not have the limits • Companies passed the cost of the credits onto the customers • Does not lead to investment in green	**European Emissions Trading Scheme (ETS)** Began in 2005 and is the world's only compulsory 'cap and trade' system. Sets a limit on the emission of a pollutant (cap) but allows companies that are within the set limit to sell credits to companies who need to pollute more (trade).

Communities/individuals	Strategies developed at a large scale are carried out at a local level	• People have no say in the strategies that are implemented e.g. 2 weekly bin collections • Conflict regarding lifestyle changes	**UK Recycling** - Government target is 30% of domestic waste to be recycled by 2010 - Funds advertising campaigns to persuade people to recycle - Local council provides recycling bins, boxes and can fine you if you refuse Individuals can also be more responsible by switching to energy efficient light-bulbs, using public transport etc.
NGOs	Use climate change as a selling point to keep climate change in the news	• Conflicting views with local governments who are looking to develop through unsustainable means e.g. China • Conflict with businesses as they place increasing pressure on them to go greener	**Greenpeace** Have produced 8 papers outlining how each sector could prevent dangerous climate change. They aim to : • Get companies to quit coal in favour of wind and solar power • Protect forests so they can continue to clean the atmosphere • Switch to natural refrigeration • Encourage IT companies who offer climate solutions and good environmental laws

International Agreements e.g. Kyoto Protocol 1997

Industrialised countries were expected to cut their overall emissions by 5% below their 1990 levels by 2008-12.

How Successful?

- ✈ Some countries delayed signing e.g. Russia signed in 2004
- ✈ Some countries never signed e.g. Australia – world's 2nd biggest per capita producer
- ✈ Industrialised countries such as UK did cut emissions by 3% below their 1990 by 2000
- ✈ UN says currently off target and expected to by 10% above 1990 by 2010
- ✈ Developing countries signed up but did not have to commit actual figures
- ✈ Many scientists believe the targets were too low and needed 60%

For the UK?

- ➢ Change from coal to gas-fired power stations has reduced emissions
- ➢ Renewable energy policy to produce 10% of electricity
- ➢ Government taxed petrol more highly to try to cut demand – protests!
- ➢ Needs to be a shift to nuclear power but huge public opposition

‘Act local, think global’

International agreements help at the largest scale, but changes need to be co-ordinated at all levels. Most people think the ‘act local, think global’ approach is the way forward, as individuals can make small changes that will help the global problem e.g. reduce their carbon footprint.

Some people believe that if everyone took steps to decrease their carbon footprint, it would make a big different, whilst others believe that individual impacts aren’t significant. However, if every light bulb in London was an energy-efficient one it would save 575,000 tonnes of carbon dioxide emissions each year.

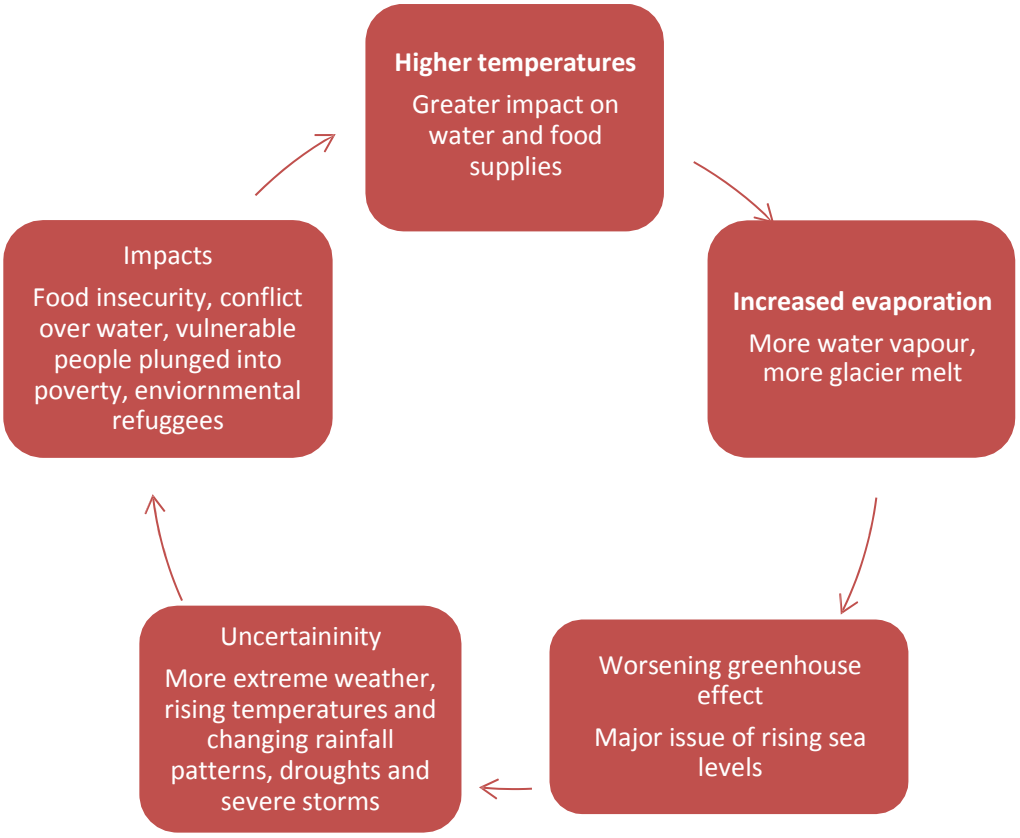
It is however likely that changes to emissions will be incremental (steps, rather than constantly) as large-scale initiatives and changes to attitudes cause sudden changes

The challenge of global hazards for the future

1) **Water Shortages**
    - Water demands estimated to rise by 50%
    - 50% of the world’s population will face severe water shortages by 2025
    - In the Andes and Himalayas the disappearance of glaciers means that people can no longer rely on glacial melt water as a water source
2) **Food insecurity**
    - Results from either a lack of available food due to physical factors such as climate, or adequate food but individuals are too poor to access it
    - Higher temperatures stress crops and reduce yields
    - Higher concentration of carbon dioxide seeds plant growth and increase resilience to water stress
    - Certain areas with have more rainfall e.g. east Africa
    - Higher temperatures can promote grow of crop pests and diseases
    - Crop yields could drop by up to 10% for every 1°c temperature rise in Asia

The problems of water shortages and food security will cause political disputes between countries and can lead to armed conflict. Examples include the River Nile, which supplies Egypt, Ethiopia and Sudan. If global warming continues to cause droughts in Sudan and Ethiopia they will be forced to take more water from the Nile, effecting Egypt’s supply. Egypt has said they will use force to protect its access to the Nile.

Conflict, famine, poverty and climate change makes managing global hazards more difficult due to the downwards cycle that occurs



Vicious cycle of climate change

Tackling the challenge of global warming

Energy Efficiency

- ✓ Reduced emissions and also cuts costs and local pollution
- ✓ Examples include – green transport using new or greener fuels or remodelling houses for greater efficiency

Named Example: India and China

- Rapid economic growth (6-10% per year) and have a critical part to play in controlling emissions
- India's greenhouse emissions could rise by 70% by 2025
- India's energy consumption rose by 280% between 1980-2201 and nearly ½ population still lacks regular access to electricity
- Most of new energy will need to come from coal – China builds 1 coal-fuelled power station every day
- They can get the international community to pay for improvements under the Kyoto agreement without limiting their own development e.g. Clean Development Mechanism (CMD) allows developed countries to sponsor gas-cutting projects in exchange for carbon credits to meet their own targets

Green Strategies

- Tree planting – in the first 10 years of its life, a growing tree releases more carbon dioxide then it stores but after this they become a carbon dioxide store. Under Kyoto countries can claim carbon credits for new planting
- Renewable energy – these range from large scale e.g. Three Gorges Dam in China, to small scale biomass cooking

Named example: Community hydropower in Kenya

- Provide lighting, radio and telecommunications to 200 households
- Saves 42 tonnes of carbon dioxide as no kerosene is needed
- Community based solutions – these are 'bottom-up' and are developed by local people for local people

Named Example: Wolvercote, Oxfordshire

- This village has created a number of schemes to lower the village's carbon footprint
- Each road has waste champions who organise rubbish swaps of unwanted items and take surplus to recycling centre
- Information circulated on the best ways to reduce carbon emissions
- Green transport strategies – car shares for work, safe cycling
- Cloth bags available to cut down on the use of plastic bags

Solutions to a hazardous world, at all scales, need to focus on the underlying issues of risk and vulnerability

Named Case Study: Tackling increasing flood risk in Bangladesh

Background:

World's most densely populated country (population 142m in 2005)
Largest system of mega-deltas in the world
Every year huge areas flood due to Himalayan snowmelt, monsoon rains and high tides in the Bay of Bengal
60% of country lies 1m above sea level

Impacts of global warming:

- ✈ Glacier melt in the Himalayas will increase flooding by 2030
- ✈ Increased water temperatures will cause increasing number of bacteria and water-borne diseases
- ✈ Coastal areas at risk from flooding and seawater contamination → destroy crops and increase risk of hunger
- ✈ Tens of millions of people could be displaced if Bangladesh was permanently lost to the sea
- ✈ Increase in numbers of intense tropical cyclones

Adapting to global warming:

- ✓ Technology → In 1990s the capital, Dhaka cleared 102km of drains and opened up 633 channels to improve drainage
- ✓ Early warming/flood prediction → enables people to be evacuated quickly and flood shelters built on raised ground (targeted at most vulnerable)

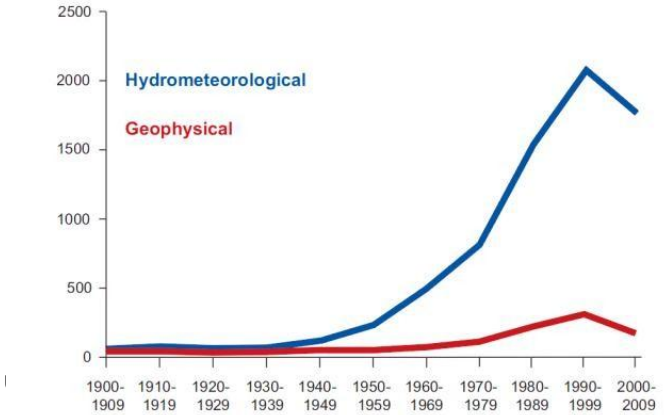
- ✓ Behavioural → changing land uses and food choices. Stopping urban growth in areas of flood risk
- ✓ Managerial → improving sanitation, waste management and slum improvement in the worst areas, so water infections from disease during floods are reduced

However, the issue Bangladesh faces in terms of adapting to climate change is in terms of funding. As well as this there population is very vulnerable and although it has some of the worlds most sophisticated flood monitoring it is not sure whether it will be able to survive.

What questions have been asked?

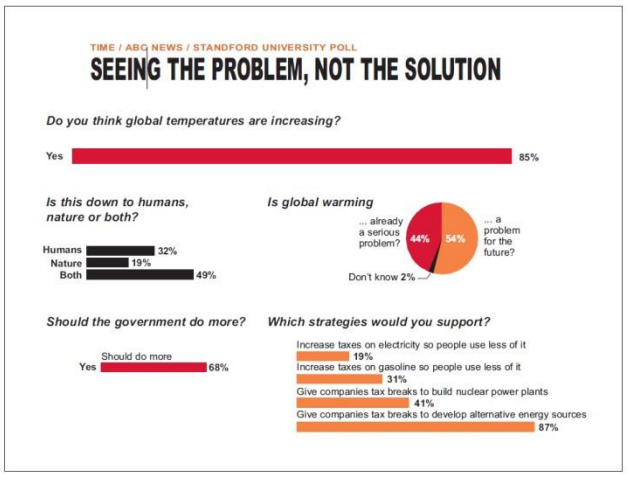
- Choose either the Philippines or California and explain why it is considered a disaster hotspot (10)
- Suggest how melting ice in the Arctic might a. bring advantages and b. create problems for people there and elsewhere (10)
- Why does climate change present potential problems for the African continent? (10)
- Explain why international agreements are essential if anything effective is to be done about global warming (15)
- Using examples, explain why hazard events sometimes bring more problems for some people and societies than other (10)
- Explain how evidence can support arguments for both a. natural and b. human causes of global warming (10)
- Explain how people are attempting to deal with the effects of global warming at either a local or a global scale (15)
- Describe and explain how the number of deaths and the amount of economic loss caused by disasters is changing (15)
- Outline the sources of evidence for long-term climate change (10)
- Describe and explain how human activity is affecting climate change (15)
- With reference to the IPCC emissions scenarios, explain why the impacts of global warming are difficult to predict (15)
- Explain the environmental and ecological impacts of global warming in a named area of the world (10)
- Using a named example, explain why global agreements on coping with climate change are complex (15)
- Explain how global warming could increase water shortages, famine and conflict (10)
- Suggest reasons for the trends in natural disasters shown in the graph.**(10)**

Figure 7 Trends in the number of global natural disasters in the 20th century



- Suggest what this survey, carried out in the USA, shows about people's views on global warming. **(10)**

Figure 8 Some results from a recent survey of American views on global warming



- Suggest why droughts, such as the one shown, have severe impacts on people and the environment. **(10)**

Figure 7 The European drought of 2003

Motorists fled forest fires in France

Impacts included:

- 25,000 wildfires, destroying 650,000 hectares of forest
- large reductions in agricultural production (the drought cost nearly £7 billion in lost production)
- record low river flows created problems for river navigation and the water cooling of power plants
- the number of tourists visiting Spain from northern Europe fell by 800,000 as people stayed home to enjoy warm and sunny local conditions
- groundwater levels reached 100-year record lows, drying up springs and wetlands
- the arid conditions resulted in 35,000 heat-related deaths.

Many tree deaths were blamed on the 2003 drought

In Greece, irrigated crops failed as rivers dried up

- Explain the increasing **frequency** of hydro-meteorological hazards (such as cyclones, storms, droughts or floods). **(15)**

- Suggest why action needs to be taken at different scales to reduce the rate of global warming. **(10)**

Figure 8 Selected carbon-reducing energy strategies and their challenges

	Strategy (Scale)	Description	Challenges
1	Kyoto Agreement (global)	A political initiative where many polluting nations agreed to targets for reducing CO^2 emissions.	• Not all big countries have signed up. • Targets may still be ignored. • Aims to cut emissions, not to stop them.
2	Greater use of nuclear power instead of oil (national)	Atomic energy (heat given off by radioactive uranium) powers turbines and generates electricity.	• Nuclear waste must be disposed of. • Possibility of terrible accidents. • Strong NIMBY* feelings aroused.
3	Greater use of wind turbines instead of oil (national)	Wind energy is used to turn giant propellers that can generate electricity.	• Propellers are a threat to bird-life. • Propellers can modify local climate. • Strong NIMBY* feelings aroused.
4	Ethical purchasing to reduce food miles (personal)	Consumers boycott products labelled as having been air-freighted very long distances.	• Not all products carry mileage labels. • Hard to monitor restaurant meals. • Many people ignore the labels.

*NIMBY = "not in my back yard" (meaning local people will object)

- Explain why some governments are more willing than others to help tackle climate change. **(15)**
- Suggest why many megacities could face increased **vulnerability** to natural disasters.**(10)**

Figure 7 Possible causes of natural disasters for some megacities

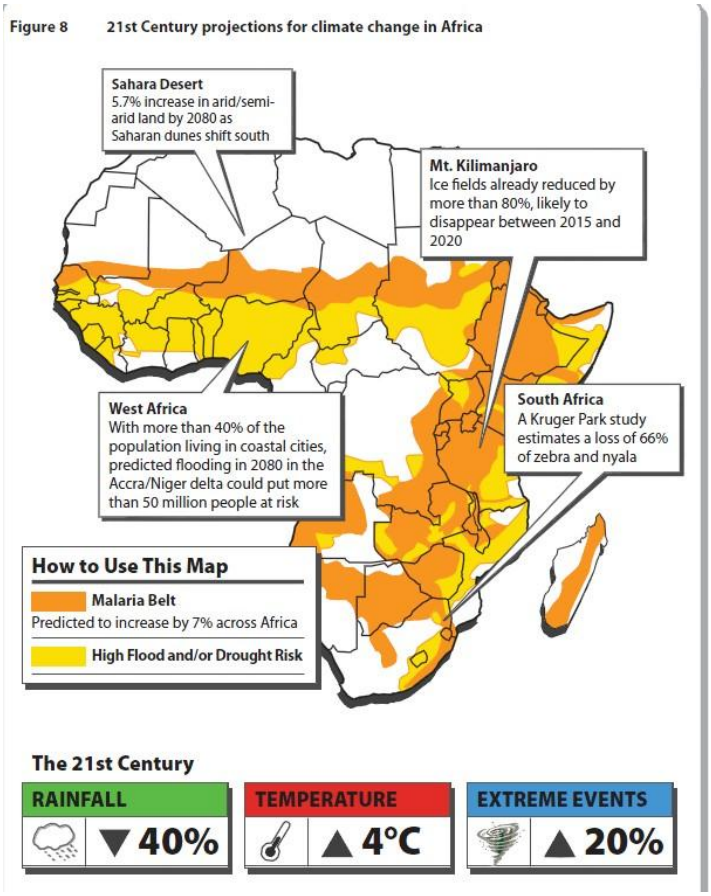
Megacity	Country	Resident population at risk (millions)		Possible causes of natural disasters				
		As at 2003	Forecast for 2015	Earthquake	Volcanic eruption	Tropical storm	Winter storm	Flood
Tokyo	Japan	35.0	36.2	High	Low	Medium	Low	Low
New York	USA	21.2	22.8	Low	None	Medium	Medium	Low
Mumbai	India	17.4	22.6	Medium	None	Low	None	Medium
Los Angeles	USA	16.4	17.6	High	None	None	Low	Medium
Manila	Philippines	13.9	16.8	High	Medium	High	None	Medium
Calcutta	India	13.8	16.8	Medium	None	High	None	High
Osaka, Kobe	Japan	13.0	13.2	High	None	Medium	None	Medium
Shanghai	China	12.8	12.7	Low	None	Medium	None	Medium
Dhaka	Bangladesh	11.6	17.9	High	None	High	None	High

Level of risk: None Low Medium High

(Source: Munich Re)

- Explain how global warming and El Niño events may lead to increasing natural hazards. **(15)**

- Suggest ways in which climate change might affect Africa's physical environment. **(10)**



- Examine the possible **economic** impacts of projected climate change for the African continent. **(15)**