# 5.13 Tōhoku – a multi-hazard environment

In this section you will learn about a recent seismic event – the 2011 Tōhoku earthquake and tsunami, Japan

**Some natural disasters change history. Japan's tsunami could be one...**

(*The Economist*, 19 March 2011)

## The Tōhoku earthquake and tsunami, Japan, March 2011

On average Japan records 1500 earthquakes every year – around one-third of the world's total! So the biggest earthquake ever recorded in Japan had world-changing significance. And not just historical significance, it had immediate global impacts on the Earth. The Tōhoku earthquake and tsunami:

- moved the entire island of Honshu 2.4 metres closer to North America
- shifted the Earth's axis at least 10 cm
- made Earth days shorter by 1.8 microseconds
- calved 125 square kilometres of icebergs from the Antarctic coast
- caused visible waves in Norwegian fiords.

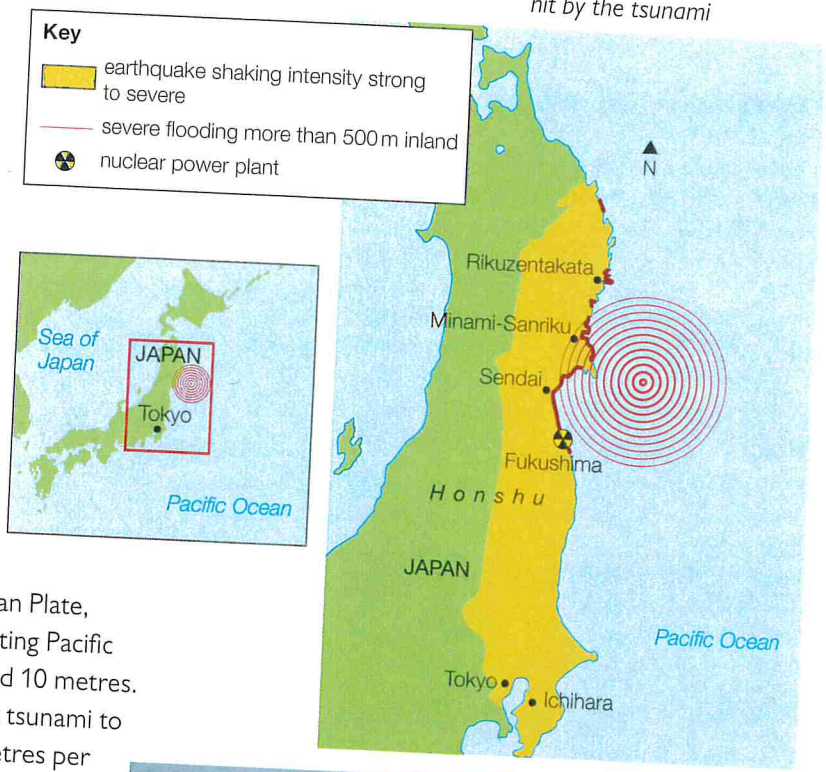


**Figure 1** *The epicentre of the earthquake and the area hit by the tsunami*

At 2.46 p.m. Tokyo time, on Friday 11 March, a magnitude 9.0 earthquake occurred under the Pacific Ocean, 100 km due east of Sendai on northern Honshu's eastern coast (Figure **1**).

A 400–500 km segment of the North American Plate, which was being dragged down by the subducting Pacific Plate, suddenly slipped upwards between 5 and 10 metres. The resulting sea water displacement caused a tsunami to spread in all directions – at hundreds of kilometres per hour.

Japan's tsunami warning system kicked in, but people along a 3000 km stretch of coastline had just minutes to escape. The first wave hit the north-east coast only 30 minutes after the earthquake.

There were ten waves, each about 1 km apart as they reached the shallower coastal water. Here they slowed and piled up, reaching a staggering 10 m in height.

They overwhelmed tsunami defence walls and surged up to 10 km inland (Figure **2**).

**Figure 2** *The Japanese tsunami, 2011*

## Primary effects

- Ground shaking caused buildings to collapse. Some were set ablaze by broken gas and petrol pipes.
- The tsunami swept inland, mainly along the north-east coast, causing devastation to everything in its path – boats, buildings, vehicles, trees.
- It flooded an area of almost 500 square kilometres.
- When the waters receded, whole cities were in ruins. Trains had vanished. Ships and boats lay tossed like toys.
- In Tokyo, skyscrapers had 'started shaking like trees'. But their earthquake-proof design meant damage was limited. In Ichihara, a commuter town of Tokyo, an oil refinery was engulfed in flames as fuel tanks exploded.
- In Sendai, areas near the sea were badly damaged, but the city centre, just inland, was largely unscathed. Rikuzentakata was almost completely submerged and was almost totally destroyed. In Minami-Sanriku, half the population of 17 000 died, and few buildings were left standing (Figure **3**).
- Over 18 000 were dead or missing, mainly due to the tsunami, although Japan's tsunami warning system saved many lives.

***Figure 3*** *The destroyed town of Minami-Sanriku*

## Secondary effects

- Half a million people were homeless. For weeks, 150 000 people lived in temporary shelters.
- Over 1 million homes were left without running water and almost 6 million homes lost their electricity supply.
- There were shortages of food, water, petrol and medical supplies.
- In the two weeks after the earthquake, there were more than 700 aftershocks, causing concern and further damage.
- Explosions and radiation leaks at the Fukushima Daiichi nuclear power plant in the days after the earthquake spread fear around the world. The earthquake severed the power supply to the cooling system; the tsunami then destroyed the back-up generators. Workers struggled to prevent a meltdown (Figure **4**).
- Fears of a nuclear disaster caused panic-selling across global stock markets.

### Did you know?

Mobile phones and news helicopters mean it was the best recorded tsunami in history. Amateur footage of the disaster spread worldwide via social networking sites.

***Figure 4*** *The Fukushima Daiichi nuclear power plant after the earthquake and tsunami. Reactors 1 to 4 are from right to left. Three of these reactors overheated, causing meltdowns that eventually led to explosions releasing large amounts of radioactive material into the air.*

## Immediate responses

- In freezing temperatures, survivors huddled in shelters and hoarded supplies as rescue workers searched the mangled coastline of submerged homes.
- Helicopter crews plucked survivors from rooftops and flooded farmland.
- 100 000 soldiers were mobilised to establish order, organise rescue work and distribute blankets, bottled water, food and petrol.
- Offers of aid poured in from other countries, including the USA and China.
- The UK sent 63 search and rescue specialists, two rescue dogs, and a medical support team. People were rescued after being trapped for several days (Figure **5**).
- An exclusion zone was set up around the Fukushima Daiichi nuclear plant. Homes were evacuated and iodine tablets, to prevent radiation sickness, were distributed (Figure **6**).
- The Fukushima Daiichi explosions prompted a government-ordered shutdown of the majority of Japanese nuclear power plants.
- There were no reports of looting or violence.

***Figure 5*** *Japanese rescue workers in Ishiimaki carry a survivor who had been being buried alive for five days*

## Long-term responses

- Japan coped well with the earthquake. But the tsunami defences were inadequate against the extraordinary height and force of the water. Future contingency planning must consider whether defences should be built to defend the coast against a similar high magnitude, low frequency event.
- In 2013 Japan unveiled a new, upgraded tsunami warning system because many people had underestimated their personal risk and/or assumed that the tsunami would be as small as others previously experienced.
- The Japanese government set up an advisory body called the Reconstruction Design Council to plan a long-term growth in the Tōhoku region. Special Zones for Reconstruction were designated with relaxed planning regulations to encourage rapid rebuilding and tax incentives offered to promote new investment in industry and commerce.
- Prior to 2011, nuclear power provided 30 per cent of Japan's electricity – the shortfall was met through increasing its dependence on fossil fuels, particularly imports of oil and gas. Court orders brought about by anti-nuclear groups have meant that it was only in 2016 that reactors were issued licenses to restart.

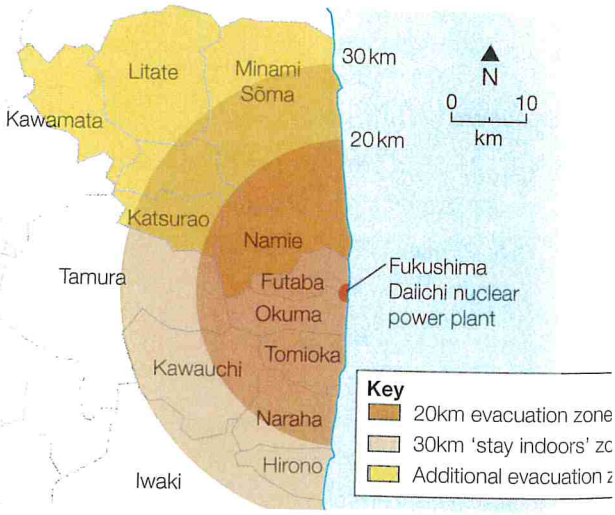


***Figure 6*** *Fukushima Daiichi evacuation (20 km) and stay indoors orders (30 km) were repeatedly revised and extended in the immediate aftermath of the explosions*

***Figure 7*** *200 000 children now suffer from precancerous thyroid abnormalities, primarily nodules and cysts*

- Following the Chernobyl nuclear accident of 1986, the number of thyroid cancer cases among children started to increase rapidly after four to five years had passed. Some are of the opinion that, because of the Fukushima Daiichi disaster, a similar increase in the incidence of juvenile thyroid cancer may occur (Figure **7**).
- Five years after the Fukushima Daiichi explosions, 100 000 residents had still not returned home. Subject to radiation tests, the national government aims to withdraw evacuation orders of the Fukushima prefecture (regional government) by March 2017.
- Radioactive rubble and refuse was still awaiting permanent disposal (Figure **8**). No Japanese prefecture was prepared to accept it.
- The total damages from the earthquake and tsunami are estimated at US$300 billion, making it the most costly natural disaster in history. Japan was already the most heavily indebted country in the industrialised world and the repair bill has had to be met by more government borrowing.

## ACTIVITIES

1 Study Figure **6**.
   - **a** Assess the effectiveness of the mapping technique adopted on this map. (Refer to 'distance decay' in your answer.)
   - **b** Describe the pattern shown.
   - **c** Suggest a reason that might explain extensions to the evacuation and stay indoors orders to the north and west.

2 The nature of tsunami damage varies considerably between areas. With reference to both the 2004 Indian Ocean (5.11) and 2011 Japanese tsunamis, discuss the human and physical factors that may be responsible for this variation.

3 For both HICs and LICs, which should come first – prediction or contingency planning? Explain your answer with reference to tsunamis or any other seismic hazard.

## STRETCH YOURSELF

'Those with least suffer most.' Critically evaluate this contention with reference to named seismic events studied.

## Think about

### Challenges facing Japan

Japan is an island nation in the north-western Pacific Ocean. It is densely populated and arguably the most geographically hazardous nation on Earth – subject to the full range of tectonic hazards, in addition to late summer typhoons. Climatically varied, extensively forested, but chronically short of good agricultural land, its energy and mineral resources are scarce. Yet it transformed itself from a poor agricultural nation in the nineteenth century into a first-rank global power. Furthermore, out of the ashes of the Second World War, Japan has built one of the richest and most successful democracies in history.

But although outsiders may view the Japanese as diligent and disciplined and also culturally, economically and technologically sophisticated, Japan is not without its problems. The UN predicts that the country will reach an economic crisis point by 2050 when the dependent population will outnumber the economically active population. Japan's greatest resource may well be its remarkable people, but economic and social provision for this ageing, yet declining population will become ever more challenging.

***Figure 8*** *Workers haul a bag of radiation-contaminated leaves during a clean-up operation in the abandoned town of Naraha, just outside the exclusion zone surrounding the Fukushima Daiichi nuclear plant*