

## THE JAPANESE EARTHQUAKE AND TSUNAMI, 2011

THE MAGNITUDE of the earthquake that occurred off the east coast of Japan on Friday 11 March 2011, registering 9.0 on the Richter scale, not only caused ground shaking on the mainland but also triggered a massive tsunami which devastated much of the coastal strip in the Tohoku region of northern Honshu, the main island of Japan. Figures 1 and 2 show map evidence and factual data relating to this massive earthquake.

<b>Date</b>	Friday 11 March 2011
<b>Time</b>	14:46 Japanese time
<b>Magnitude</b>	9.0 (Richter scale)
<b>Depth</b>	30 km
<b>Epicentre</b>	129 km east of Sendai
<b>Cause</b>	Movement along a thrust fault on or near the subduction zone between the Pacific and North American plates

Figure 2: Earthquake fact file

Source: USGS

### Physical effects of the earthquake

#### Primary effects

The initial effects of the earthquake – the **primary effects** – were as follows:

- **Ground shaking:** parts of Japan were shifted 2.4 metres further east.
- **Ground subsidence:** a 400 km stretch of coastline dropped vertically by 0.6 metres, which allowed the tsunami to overtop defences and travel further and faster inland.

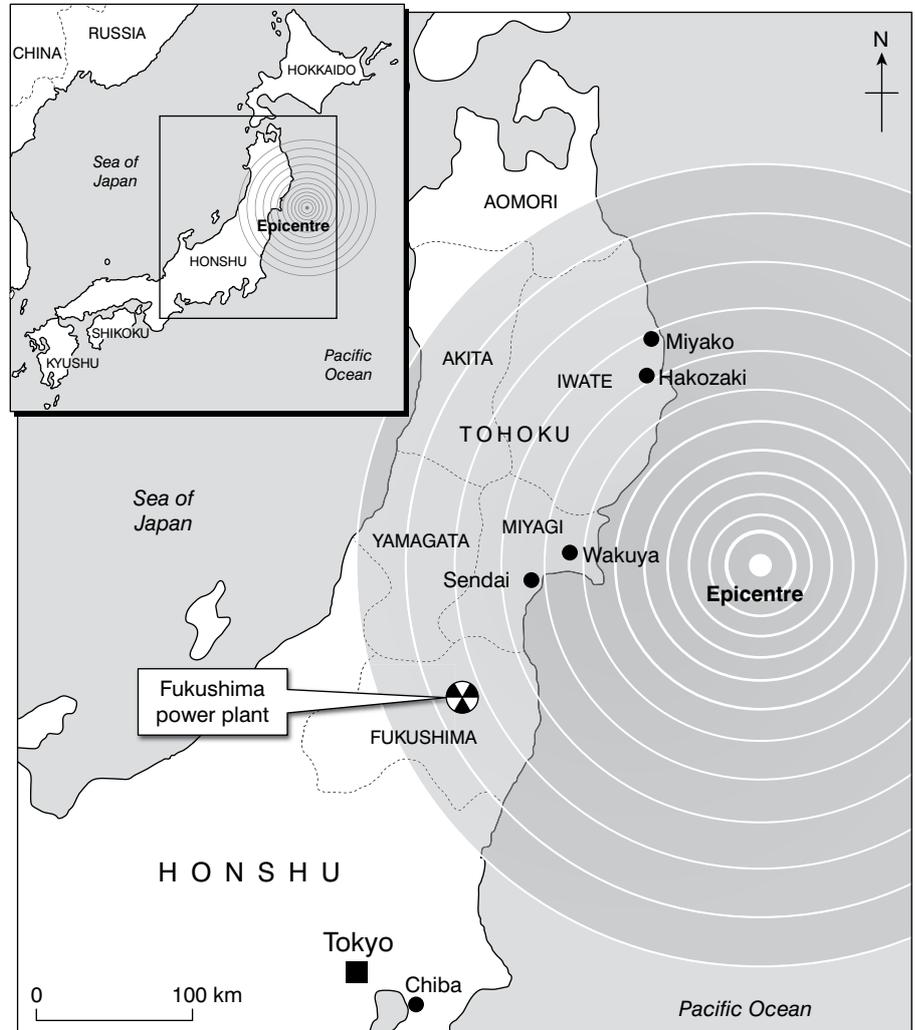


Figure 1: The Japan earthquake and tsunami

- **Soil liquefaction:** this was found to have occurred in areas of reclaimed land around Tokyo, damaging more than a thousand buildings. (You can see a video of liquefaction and ground movement in Chiba city if you follow this link: [www.youtube.com/watch?v=rn3oAvmZY8k](http://www.youtube.com/watch?v=rn3oAvmZY8k).)

The consequences of these primary effects (the immediate effects of an event, caused directly by it) were:

- 15,845 killed
- 3,375 missing
- 5,894 injured

- 128,479 properties totally destroyed
- 3,918 roads damaged
- 78 bridges damaged.

#### Secondary effects

Geographers also explore the after-effects of natural hazards such as earthquakes. These are called **secondary effects**.

- **Tsunami:** this was caused by a 5–8 metre upthrust along a 180 km long section of the seabed 60 km off the east coast of the Tohoku region of Japan. It reached a maximum height of 39 metres at Miyako city in Iwate prefecture

and travelled up to 10 km inland. Tsunami waves up to 2 metres high hit the coast of Chile on the other side of the Pacific Ocean.

- **Flooding:** there was massive coastal flooding as a consequence of the tsunami flowing inland, such as in Wakuya (see Figure 6). The earthquake also caused localised flooding problems.

The consequences of these secondary effects were as follows:

- **Shipping** was disrupted due to closure and destruction of ports.
- **Commuting and travel** was affected due to damage to transport links. The main Tohoku Expressway was closed until 24 March and 20,000 people were stranded at stations in Tokyo alone.
- **Agriculture** in the Tohoku region was devastated. It accounts for 3–4% of Japan's rice production, and seawater contamination of the soil could affect rice crops for years.
- **Nuclear power plants were damaged.** In the Fukushima region over 200,000 residents were evacuated and are still unable to return to the area. Radiation levels are well above normal and radioactive elements have been detected in local water supplies and soils. The meltdown led to an energy crisis in many areas of Japan, with regular blackouts, leading to further disruption.
- The **economic impact** on the region and on Japan as a whole is severe. The Japanese government estimated that the damage alone could cost US\$300 billion, and Japan's gross domestic product (GDP) shrank by 3.7% between January and March 2011. By June that year, 209 companies in Japan had been forced into bankruptcy by the disaster.

## Response and recovery

The responses can be categorised into **immediate responses** and **long-term responses**. Immediate responses are those that are necessary during or directly after the disaster occurs, such as rescuing trapped people, providing food and shelter and caring for the injured. Long-term responses are those that seek to rebuild damaged areas, improve

defences and restore affected people's quality of life.

### Immediate responses

As a developed country, Japan invests a significant amount of time and money into earthquake preparedness. The country is regularly struck by earthquakes and has had frequent experience of tsunamis (itself a Japanese word meaning 'harbour wave'). In 2008, the Japan Self-Defence Force (JSDF – the name of the Japanese army) carried out a massive earthquake emergency training drill called 'Michinoku ALERT 2008'. The drill was based around an earthquake of magnitude 6 occurring off the coast of Sendai accompanied by a tsunami. It involved 18,000 participants in 22 towns throughout the Tohoku region. The drill highlighted the danger of communities being isolated by the tsunami. When the real earthquake and tsunami struck on 11 March 2011, one priority was to get aircraft in the air to survey the devastation and identify priority areas for emergency aid (see Figure 6). Within 30 minutes of the earthquake, 11 military aircraft had responded and identified communities such as Hakoziaki as being completely cut off. The JSDF moved in on the ground and within two days all debris had been cleared and emergency goods could be delivered twice a day.

Since 2004, the regional train operator in the Tohoku area, Japanese Railway East (JR East), has invested £500 million in upgrading the earthquake measurement equipment along its routes. This has reduced the time between early earthquake detection and electricity cut-off to the lines and trains, from 3 to 2 seconds. In 2009 all Shinkansen (bullet) trains were fitted with an early earthquake warning system. So within 2 seconds of the earthquake being detected on 11 March 2011,

and a full 1 minute 20 seconds before the main tremors hit, all 27 Shinkansen trains in the area had stopped without derailment, and with no injuries or deaths.

However, the sheer scale of the disaster meant that emergency response teams were overstretched and inadequately supplied and trained. Electricity supplies and phone systems were damaged, so co-ordination of rescue teams was difficult. Due to the destruction of homes, an estimated 452,000 people were in evacuation shelters within days of the disaster. However, many of these were inadequate in terms of comfort and provision of blankets and food. The power had been lost to many of the buildings being used, so heating was a problem. With temperatures falling to  $-4^{\circ}\text{C}$  at night, and many shelters being damp due to the flooding, hypothermia and respiratory diseases (such as bronchitis and pneumonia) were a real threat – especially to the very young, the elderly and the sick.

### Long-term responses

Japan's economic growth after the Second World War was the envy of the world. However, over the last 20 years the economy has stagnated and been in and out of recession. The 11 March earthquake wiped 5–10% off the value of Japanese stock markets, and there has been global concern over Japan's ability to recover from the disaster. The priority for Japan's long-term response is to rebuild the infrastructure in the affected regions and hence restore and improve the health of the economy as a whole.

After the rescue and treatment of survivors, the priority was the repair and re-opening of transport links. About half – 347 km out of 675 km – of the Tohoku Expressway which links the region to Tokyo was damaged. By 24 March this had been repaired and re-opened. Sendai Airport had been badly damaged but, through

a joint effort by the JSDF and the US Army, the runway was restored and re-usable by 29 March. By November 2011, 100% of expressway, the Shinkansen and airport facilities had been restored. However, the port was operating at only 68% capacity.

Other important areas of reconstruction include the energy, water supply and telecommunications infrastructure. As of November 2011, 96% of the electricity supply had been restored, 98% of the water supply and 99% of the landline network.

### The Fukushima nuclear plant

The Fukushima nuclear reactor went into meltdown when supplies of cold water were blocked by tsunami debris (Figure 3). Of the six reactors, four were badly damaged. The nuclear fuel rods in reactors 1, 2 and 3 melted down due to a failure of the cooling systems, causing damage to their containment structures. There were also explosions caused by the build-up of hydrogen gas.

The immediate response was to declare a 20 km evacuation zone around the plant to reduce the threat of radiation exposure to local residents. The next priority was to get the stricken reactors into ‘cold shutdown condition’ where temperatures inside the reactors are below 100°C, so that water can be collected and re-used rather than boil over and spread radioactive material. By November 2011 the reactors had been cooled and stabilised. However, the long-term challenges remain: to remove the radioactive contamination of the surrounding air, water and land, and to monitor the reactors to ensure that there is no more leakage.

### The New Growth Strategy

The magnitude of the event has had a profound impact on the long-term development strategy of Japan as a whole. The Japanese described the earthquake and tsunami as ‘a crisis in the



Figure 3: The damaged power plant at Fukushima

Source: Wikimedia Commons; Daisuke Tsuda

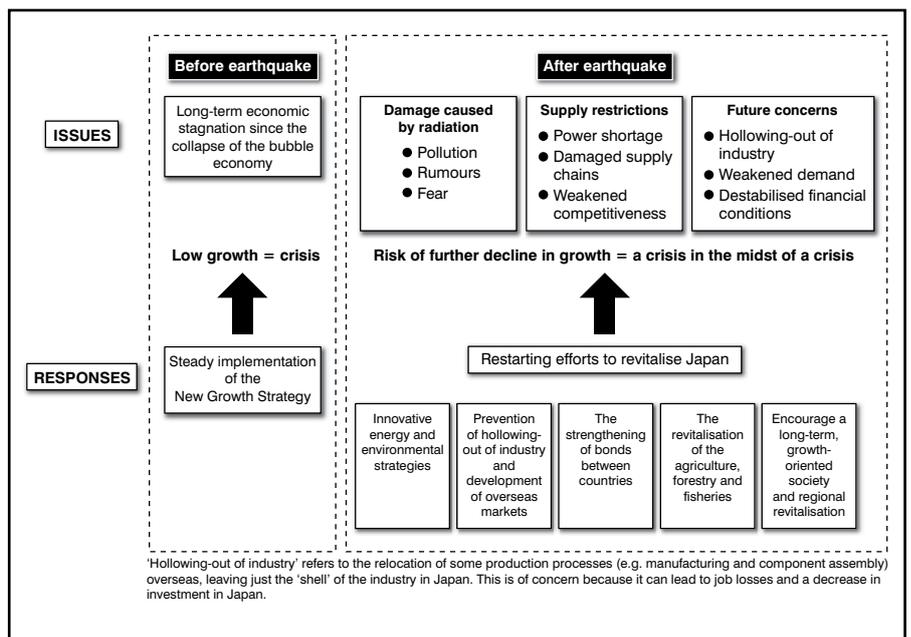


Figure 4: The New Growth Strategy

midst of a crisis’, referring to the stagnation of the economy and decline of traditional social values that had preceded the disaster for many years. A month after the earthquake, the Japanese government set up an expert advisory body called the Reconstruction Design Council to plan a long-term strategy to ensure the development of a stronger economy and society (Figure 4).

In order to fund this grand strategy the Japanese government has approved a budget of 23 trillion yen (approximately £190 billion) to be spent over a period of 10 years. Central to the New Growth Strategy is the creation of a system of ‘Special Zones for

Reconstruction’. The aim of these is to provide incentives in order to attract investment, both in terms of business and reconstruction, into the Tohoku region. The incentives to attract investment include:

- special deregulation of planning permission and bureaucracy to enable rapid rebuilding of housing, industry, medical services, nursing homes etc.
- tax incentives to promote employment and industrial activities
- interest substitutes for loan-lenders.

To further increase the chances of its success, the scheme is open to involvement from foreign governments and businesses.

# Activities

1 Copy the following paragraph and fill in the blanks:

The Tohoku earthquake occurred on \_\_\_\_\_ at \_\_\_\_\_. It measured \_\_\_\_\_ on the Richter scale at a depth of \_\_\_\_\_ and its epicentre was located \_\_\_\_\_ from the coast of Sendai. It occurred along the \_\_\_\_\_ zone between the \_\_\_\_\_ plate and the \_\_\_\_\_ plate.

2 With reference to Figure 1 and your knowledge of destructive plate boundaries, draw a diagram to explain how and why the earthquake and tsunami occurred.

3 Using information from the text, draw a table describing the primary and secondary effects of the earthquake and tsunami. Categorise the effects into social, economic and environmental.

4 Draw an annotated field sketch of Figure 6, focusing on the main issues for delivery of aid, clean-up and reconstruction. You might want to consider the type of debris, the port, accessibility to the area and the needs of the local people. Make sure you leave enough space around your sketch to enable detailed annotations.

Here are some tips for drawing a field sketch:

- You do not need to be a good artist to draw a field sketch.
- Your aim is to identify and draw the key features of the scene that you wish to show. Do not try to show everything – the value of a field sketch is its simplicity and ability to show clearly the relevant information.
- You can use tracing paper to help sketch the basic outline.
- Don't just focus on the foreground – there may be features of interest in the background too.



Figure 6: Damage to the Wakuya coastal area

Source: Wikimedia Commons; US Navy photo by Mass Communication Specialist 3rd Class Alexander Tidd

Figure 7: Key information about the Haiti earthquake in 2010

<b>Date</b>	Wednesday 13 January
<b>Time</b>	16:53 local time
<b>Magnitude</b>	7.0 (Richter scale)
<b>Epicentre</b>	25 km west of the capital city Port-au-Prince
<b>Death toll</b>	316,000 (government estimate)
<b>Injured</b>	300,000
<b>Homeless</b>	1 million
<b>Buildings destroyed</b>	280,000
<b>Cost</b>	Up to \$13.2 billion

5 Using the internet, conduct an image search under 'Japan earthquake infographics' or 'Japan tsunami infographics'. An infographic is a method to clearly and attractively describe and explain a complex event, issue or process. Look at the various online examples for guidance. Then, on a sheet of A3 paper or on a computer, design your own infographic to illustrate the Tohoku earthquake and tsunami. You could just focus on the causes and effects or the responses, or you could try to summarise everything. This could be done either individually or in pairs.

6 Look at Figure 7, which shows information about the earthquake that struck Haiti in January 2010.

(a) Create a table comparing the characteristics and the effects of the Tohoku and Haiti earthquakes.  
 (b) Conduct further research on the Haiti earthquake. You could search online for information, refer to recent textbooks, or read GeoActive Unit 465 'Haiti Earthquake 2010'. Write a comparison of the two earthquakes. This could be in the form of an essay, a table, an information poster or infographic (see question 5) or a computer presentation. Consider the following:

- Haiti's earthquake was weaker, yet had a greater social impact. Why?
- How do Japan and Haiti compare in terms of their socio-economic development?
- How well prepared was Haiti for an earthquake in comparison to Japan?
- How do the long-term secondary effects compare?
- Why is the expected cost of Japan's earthquake greater?
- How do Japan and Haiti compare in terms of their responses to the earthquakes?