

Five ways to trigger a natural disaster

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Few people still doubt that human emissions are causing long-term climate change, which is predicted to increase storm surges, drought and possibly hurricanes. So there's little doubt that humans influence natural disasters over the long term. But can we also trigger sudden "natural" catastrophes?

The answer is yes. From mud volcanoes to disappearing lakes, human actions can have all sorts of unforeseen environmental consequences.

Here we review five disasters with a human cause. We focus on sudden, short-term events rather than protracted environmental catastrophes.

Mud volcanoes

On 28 May, steaming mud erupted from a gas well near Surabaya, East Java. Since then, each day between 7000 and 15,000 cubic metres of mud have poured out of what is now known as the Lusi Mud Volcano. Eleven villages have been displaced by the flow.

Lapindo Brantas, which operates a nearby mine, claims that the original eruption was caused by a large earthquake with an epicentre near the ancient city of Yogyakarta some 250 km from the gas drilling site 40 hours earlier.

But this has been discounted by several independent geological studies. "We suggest that a blowout in the Banjar Panji-1 well was the most likely mechanism for triggering the Lusi eruption," write Mark Tingay of the University of Adelaide, Australia, and colleagues in the latest such study, published this month in the journal *Geology*.

Earthquakes

Lusi produced mud rather than molten lava, and geologists agree that humans cannot trigger real volcanoes. But we can certainly make the ground shake with great fury. Tremors in the crust beneath the North Sea have become more frequent since oil drilling operations began there, and mining operations are also known to increase the frequency of tremors.

Both drilling and mining redistribute the normal stresses present in rocks, but they are not the biggest cause of man-made earthquakes.

"Dams are the most dangerous man-made structure likely to cause quake," says David Booth of the British Geological Survey.

By artificially holding a large volume of water in one place, dams increase pressure on fractures beneath the surface of the earth. What's more, water has a lubricating effect, making it easier for the fractures – or faults – to slip.

Booth says the largest dam-induced earthquake occurred in Koyna, India on 11 December 1967. The region was previously considered nearly non-seismic but, shortly after a large dam was built and its reservoir filled, a magnitude 7.5 quake struck the area killing 200 people and injuring thousands more. Since then, the region has experienced frequent earthquakes.

"People often ask whether nuclear testing can generate earthquakes," says Booth. "The answer is no." This is because, unlike dams, nuclear explosions produce instantaneous and short-lived geological stresses. As the wave of pressure moves through the rocks, the particles inside them shake but quickly go back to their original position.

Disappearing lakes

In addition to erupting and furiously shaking, the earth can be made to consume entire lakes.

On 20 November 1980, Lake Peigneur in Louisiana was sucked into the ground in an enormous whirlpool. Although the exact cause of the incident is difficult to ascertain as the evidence was washed away, it is generally believed that the lake's plug was pulled when a Texaco oil rig drilled into a salt mine directly beneath the lake.

This caused water to pour into the mine, filling the shafts and dissolving the salt, as the oil rig and eleven barges were sucked down. The event is said to have looked like a giant bathtub emptying down a drain.

Incredibly, no-one was hurt. But the lake's ecosystem was permanently altered. Just days after the event, water flowed backwards from the Gulf of Mexico into Lake Peigneur, turning the freshwater lake into a brackish, saltwater one.

Flooding

Cloud-seeding is an increasingly common form of weather modification – but is it possible to push the method one step too far and bring on a biblical flood?

On June 9, 1972, more than 35 centimetres of water – nearly a year's worth of rain – fell in six hours over the Black Hills of Western South Dakota. The rainfall caused Rapid Creek to overflow and the Canyon Lake Dam to burst, resulting in huge floods in downstream Rapid City.

More than 200 people died and 3000 were injured. About 1300 houses were destroyed, some simply lifted by the water and carried away. In all, the floods caused over \$160 million in damage to the city.

On the day of the storm, scientists had been carrying out cloud-seeding experiments nearby, and were later blamed for the floods.

The principle of cloud seeding is relatively simple. The skies are peppered with a chemical – usually silver iodide – which draws the moisture out of clouds by providing something for water to condense on. But it is difficult, if not impossible, to establish how much rainfall is a direct result of cloud seeding.

Don Griffith, of North American Weather Consultants, says it is highly unlikely that cloud seeding could trigger a flood on the scale of the one that devastated Rapid City in 1972.

"In truth it was probably a bad idea for the scientists to be cloud seeding while a storm was building," says Griffith. "But man's ability to modify the weather in some small measure can in no way match power of nature."

Kerry Emanuel of Massachusetts Institute of Technology agrees that humans probably cannot influence such a large storm. "Cloud seeders often have the opposite problem: they don't know whether they've had an effect at all," he says.

Hurricanes

Worryingly, hurricanes can also be seeded. In the 1960s, US scientists involved in a project called Stormfury sought to demonstrate that they could disrupt the structure and energy of a hurricane by seeding the atmosphere.

After two decades, some scientists suggested that Stormfury had failed to induce any change and the project was cancelled. But hurricane expert Kerry Emanuel says controlling the path of a hurricane is something that "we know how to do theoretically".

Emanuel explains that two-thirds of the hurricanes on course to make landfall in the US are knocked off course by another weather system. So scientists know what temperature and pressure disturbances in the atmosphere will help divert a raging hurricane. "The evolution of the atmosphere is very sensitive to small perturbations," Emanuel adds.

One way to create the necessary disturbances would be to release a trail of black carbon – tiny soot particles – into the sky. This should absorb enough of the Sun's energy to create a temperature disturbance.

But rerouting a hurricane would be an incredibly risky job that could result in international conflict and countless lawsuits. "If there is an 80% chance a storm is going to hit Miami, and if diverting it creates a 10% chance it will hit Bermuda – what do you do?" Emanuel wonders.

Partly for these reasons, government agencies have so far steered clear of steering hurricanes. However, the prospect could become too appealing not to test.

"For now, it is just an idea. But if we get a few more Katrinas and it becomes widely known that scientists have a technique to shift hurricane paths, it could become less taboo," says Emanuel. "In my view it is inevitable that it will be tried, but that may not be in our lifetime."