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Increasing magnitude and frequency of natural hazard impacts – a DME

The earth is a dangerous and dynamic planet. The Asian tsunami of 2004 killed almost a quarter of a million people across a distance of 4,500 km: a truly global impact. In the following year, Hurricane Katrina caused more than 2,000 deaths and $100 bn of economic damage in the United States: richer countries are not immune from natural hazards.

The impact of natural hazards is increasing. There is an upward trend, both in the number of natural hazards reported each year and in the number of people affected by environmental disasters. There are two possible reasons for this.

First, the magnitude and frequency of some hazardous natural processes may be increasing. Global climate change and rising sea levels mean that parts of the world may suffer more frequent or severe environmental catastrophes – for example, increased hurricane frequency and the 2009 Australian bush fires both have a direct climatic link. However, there is no reason to expect an increase in events such as earthquakes and volcanic eruptions.

A second reason is connected with human activity. Increasingly, impacts are caused by dramatic changes in the human, rather than the physical, environment. Rapid population increase is concentrated in the world's poorest countries, where people are least able to protect themselves from harm. Rapid rural to urban migration in poorer countries means that large numbers of people live in vulnerable areas: floodplains, volcanic slopes, gorges; and in overcrowded conditions and with inadequate infrastructure.

This **Geofile** examines hazard trends on a global scale. It then looks at examples of mass movement hazards in two countries (Iceland and the Philippines), one higher-income and one lower-income, to investigate the ways in which risk and vulnerability are driven by combinations of human and physical factors.

Figure 1: Natural disasters in 2008 – summary from the EM-DAT database

	2008	2000-2007 yearly average
Number of disasters recorded	354	397
Number of countries affected	120	118
Number of people killed	235,264	66,813
Number of people affected	214 million	231 million
Economic damages (US$)	190 bn	81.8 bn

Source: CRED newsletter 2009

Global trends: EM-DAT

The Centre for Research on the Epidemiology of Disasters (CRED) records global health and natural hazards. Their searchable, public database includes information on more than 17,000 hazards since 1900. This data makes it clear that the number of people vulnerable to or affected by natural hazards is increasing.

Their Emergency Events Database (EM-DAT) is found at http://www.emdat.be/. It lists information on events which fulfil one or more of the following criteria:

- 10 or more people reported killed (or missing and presumed dead)
- 100 people reported affected (injured, made homeless, or evacuated)
- declaration of a state of emergency
- call for international assistance.

Figure 1 summarises the EM-DAT estimates for 2008, a year which included several major catastrophes. The death toll was three times higher than the annual average, due to Cyclone Nargis (Myanmar) and the Sichuan earthquake in central China. Disaster costs were more than twice the average for the previous eight years, due to the Sichuan earthquake ($85 bn) and Hurricane Ike in the United States ($30 bn).

Figure 2 shows some of the overall trends from EM-DAT between 1974 and 2003. The raw data (thinner lines) indicates considerable variability from year to year. However, the smoothed data (bold lines) clearly shows that both the number of disasters and the number of people affected increased dramatically over that 30-year period. In 2003, 1 in 25 people worldwide was affected by a natural disaster.

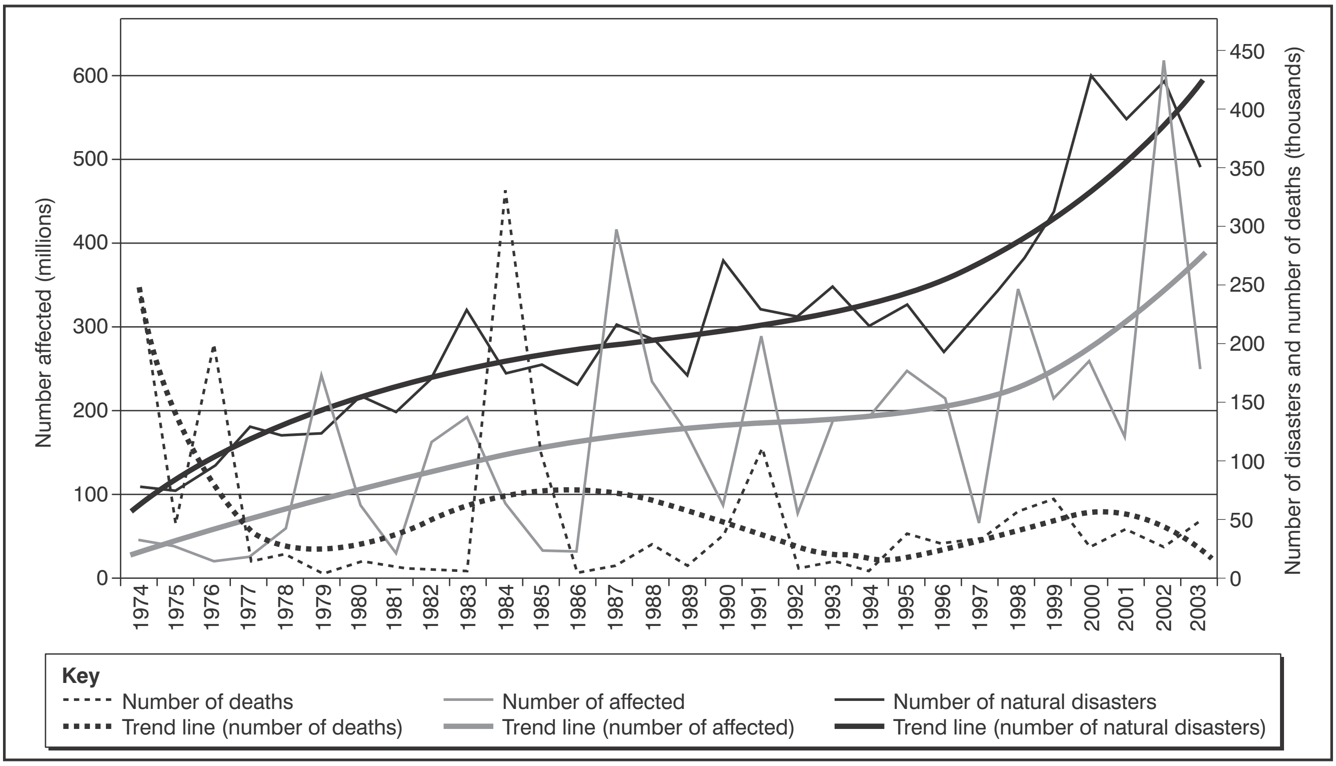
The total number of fatalities does not follow the same upward trend. This is partly because improvements in international relief have allowed more effective emergency interventions. (Far more aid is spent on disaster relief than on prediction or prevention.) There is considerable inter-annual variation, however. In the following year (2004), close to a quarter of a million people died in the Asian tsunami.

EM-DAT also shows clear contrasts between the impacts of natural hazards in high- and low-income countries.

The largest numbers of people affected are in poorer countries. Of the world's 10 richest countries, Japan had the highest natural disaster death rate over this period – an average of 182 victims per 100,000 of the population per year. In a list of the world's 10 poorest countries, the equivalent figure for Eritrea is 6,402, and for Malawi 8,748.

The economic impact of natural hazards is greatest in high-income countries, because of the financial value of property in those countries. As a proportion of GDP, however, low-income countries suffer the largest economic impact. In 1988, the value of the wind, flood and landslide damage which Hurricane Mitch caused in St Lucia was estimated at more than four times the island's total annual GDP.

Figure 2: Trends in the number of natural disasters, people affected and fatalities, 1974-2003.



Source: EM-DAT.

Hazard vulnerability

Low-income countries, and disadvantaged groups within all countries, are more vulnerable to the impact of natural hazards. This results from an overlapping set of causes, including:

- physical vulnerability – exposure to potential hazards, such as living on steep slopes or floodplains
- social vulnerability – factors which affect a population's resilience to cope with disasters, such as population growth and war
- economic vulnerability – including the diversity of a country's economic base, availability of insurance and social security, quality of infrastructure
- environmental vulnerability – such as deforestation, soil erosion, and water pollution.

There is a vicious cycle of poverty and vulnerability to natural disaster. The most exposed populations live in high-risk or environmentally degraded areas, have least access to social safety nets and have few savings or available credit.

Rapid urbanisation is also a major social reason for low- and middle-income countries' increasing vulnerability to natural hazards.

In southern Iran, for example, the ancient city of Bam had experienced rapid growth due to rural-urban migration, and hastily constructed buildings did not meet legal building standards. Three-quarters of the city's mud-brick houses were destroyed in the 2003 Bam earthquake, which killed more than 25,000 people.

The growth of mega-cities magnifies the likelihood of major catastrophes. The Iranian capital, Tehran, has been destroyed four times by an active fault system. When Tehran was a small provincial town, this had a limited impact. Tehran today has 12 million inhabitants, and a future seismic event would be devastating.

Avalanche deaths in Iceland

Examining one type of natural hazard in a single country shows these changing risk factors in more detail.

Iceland's record of avalanche fatalities is one of the world's longest and most complete data series on natural disasters. It provides an excellent case study of the ways in which danger results from the interaction of physical and social processes.

Snow avalanches have been a major hazard to life and property in Iceland over the thousand-year history of settlement on the island. The first report dates from AD 1118, when five people were killed in a snow avalanche in western Iceland. More recently, avalanche protection has been a renewed focus of Icelandic government policy. Thirty-four people died in 1995 in two catastrophic events in the coastal villages of Flateyri and Suðavik in north-west Iceland.

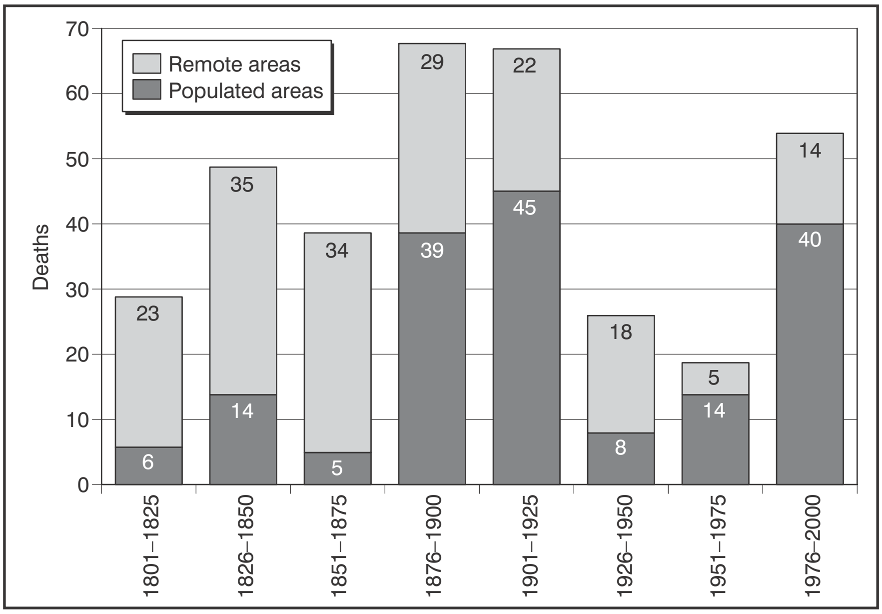
Figure 3 shows deaths in the period 1801–2000, during which some 351 people died in snow avalanches. Figure 4 shows the very clear spatial pattern of these fatal accidents.

Trends in Icelandic avalanche fatalities result from a combination of physical and human factors. Variations in the total number of avalanche deaths have occurred partly in response to climatic fluctuations. Peak fatalities corresponded with a period of relatively harsh winters (1880–1920), and deteriorating climate since 1965. Death rates were lower in the period of lower snowfall total in the middle of the twentieth century.

Changes in settlement pattern and economic activity have also led to marked shifts in the number of deaths occurring in different types of areas. Before the middle of the 19th century, Iceland's population lived almost exclusively in isolated farms.

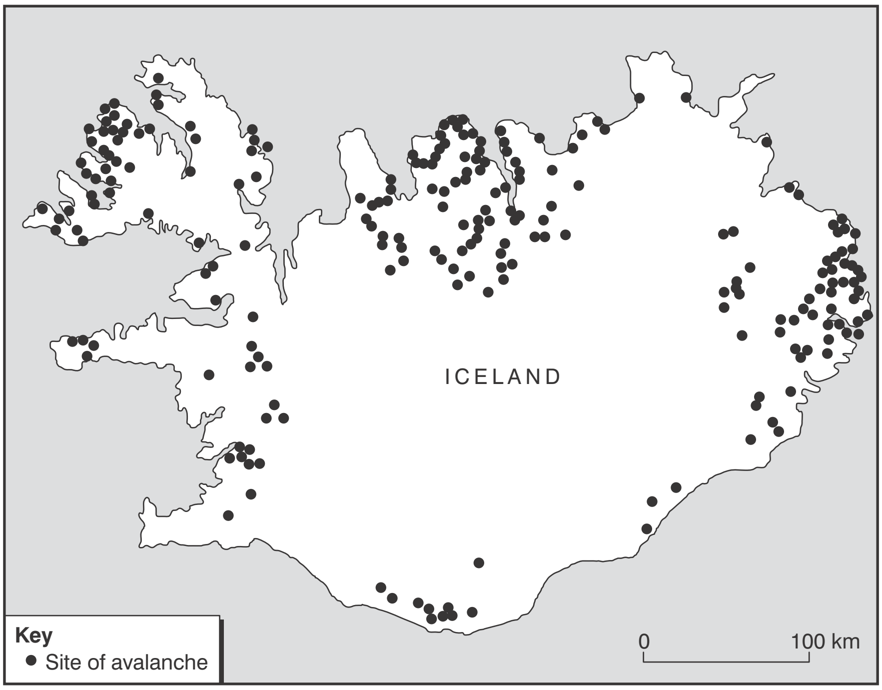
After that time, a number of fishing towns developed in deep coastal fjords, and continued to grow through the 20th century. The growth of towns did not result in increased security,

Figure 3: Avalanche deaths in populated and remote areas of Iceland since 1801



Source: Jóhannesson and Arnalds (2001), based on Björnsson (1980)

Figure 4: Location of all known avalanches causing damage or death in Iceland, from the 9th century to the present day



Source: Jóhannesson and Arnalds (2001), based on Björnsson (1980)

however. Many of these settlements were unfortunately located at the base of steep slopes which provided ideal topographic conditions for avalanche initiation. Figure 4 shows the clear spatial patterns in the locations of Icelandic landslides and avalanches.

The data in Figure 3 also reflects these societal trends. The number of deaths in isolated areas has decreased significantly over time, as rural to urban migration has taken place. As the size and number of towns has grown, so has their vulnerability to avalanche hazards. The increase in fatal accidents in unpopulated areas since 1975 reflects a growth in remote winter travel and tourism. The high death toll in populated areas in that period is almost entirely due to the accidents at the two West Fjord villages in 1995.

Human or physical causation? 2006 landslide at Guinsaugon, Philippines

The EM-DAT database shows that over the past 35 years, 75% of all deaths from natural disasters have occurred in Asia. This final section examines one example in more detail: the landslide at Guinsaugon, on Leyte Island in the southern Philippines, which killed more than 1,300 people in February 2006.

The landslide caused great controversy. The key question was the extent to which the slide was the result of deforestation. Was it simply a natural disaster? Or had the actions of landowners – or the inaction of policy makers – played a significant role in the devastation?

A single mass movement event has a variety of causes. Several aspects of an area's physical geography affect its susceptibility to slope failure – for example, topography, rock type, vegetation, hydrology and antecedent rainfall conditions. Slope failure only becomes a human hazard where it affects people's lives or economic activities, and so an understanding of land-use and settlement is also vital.

The Leyte landslide also shows that an understanding of the causes of a landslide will affect subsequent policy. If landslide hazards are mainly caused by deforestation, then governments should focus on logging. If mass movement is an inevitable result of an area's tectonics and topography, however, then the focus must be on hazard mapping and on the protection or evacuation of vulnerable areas.

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Figure 5: Could anyone have saved Preciosa Santos?

1. Geologists described the movement as a deep-seated rockslide and debris avalanche.	2. 'It was as if the mountain had exploded,' a survivor told Radio Manilla.	3. Newspapers reported a text message sent on February 19: 'Hurry, the waters are rising.'
4. Torrential rain triggered secondary mudflows, which made rescue efforts dangerous.	5. Preciosa had dreamt of qualifying as a doctor and working abroad.	6. Shallow-rooted coconut plantations add weight to slopes without providing deep strength.
7. 15 million cubic metres of rock and soil collapsed from the slopes of Can-abag mountain.	8. The landslide was 4 km from crown to toe. It moved at 140 km/hour.	9. At 10:30 am on Friday 17 February 2006, the mountain side disintegrated.
10. Air pockets gradually filled with water.	11. 20 people were rescued alive, all in the first 48 hours.	12. Tree roots add cohesive strength to soils.
13. After the landslide, President Arroyo granted $1.5 million for geological hazard mapping.	14. A magnitude 2.6 earthquake also shook Leyte on February 17.	15. 'I don't believe tree cover could have held it in place,' said Patrick Durst from the United Nations.
16. As population grows in the lowlands, farmers are forced to clear upland tropical forest areas.	17. Guinsaugon is in Leyte Island in the Philippines. It is a poor area 420 km south of Manila.	18. 'When will illegal loggers account for their greed?', asked the Kalikasan People's Network.
19. The United States sent 3,000 troops to help with the rescue operation.	20. Greenpeace SE Asia accused politicians of failing to enforce the logging ban.	21. Preciosa was a pupil at the elementary school. Of 246 children, only one survived.
22. 133 people died in another landslide in Leyte in 2003.	23. 1,328 people remain missing, presumed dead.	24. Coconut oil is the main cash crop from steeper areas.
25. Two days before the landslide, Jorge noticed that the Himbangan River had dried up.	26. Geologists arrived with ground-penetrating radar equipment on the morning of February 21.	27. Jorge could not believe that there were no houses left standing. Guinsaugon was a sea of mud.
28. Philippines President Gloria Arroyo banned logging in December 2004.	29. Seismic cracks diverted stream water into the slope, raising pore pressures.	30. Preciosa's body was one of 122 bodies recovered. She was identified by Jejomar.
31. Exceptional rainfall every 3 to 5 years is linked to the La Niña climatic oscillation.	32. The birth rate in Leyte is 22/1000.	33. 49% of Leyte's forest cover has been removed.
34. Guinsaugon was located on a steep scarp of the Philippine Fault, part of the Pacific 'Ring of Fire'.	35. A weather station 7 km from Preciosa's house recorded 683 mm of rain from February 8 to February 17.	36. Preciosa's father Jejomar Santos farmed 4 acres of rice on level ground close to the village.
37. Land-use zoning might be more effective than logging bans.	38. Preciosa had six brothers and sisters. Jorge was the only one who survived.	39. Jorge immediately rushed down the steep track from his farm on his motorbike.

Decision-Making Exercise

1. To what extent do you agree that it is inevitable that the impact of natural hazards across the world will continue to increase?

2. Explain why both human and physical explanations are needed to understand the changing impact of avalanches over time in Iceland.

3. Outline the main reasons for the major loss of life in the 2006 Leyte landslide. What policies would you recommend to the Philippine government enforce to prevent future mass movement disasters?

4. The 'mystery' shown in Figure 5 focuses on one victim. Preciosa Santos and her family are fictional. The other pieces of information are not.

As a detective follows a series of clues, your task is to analyse the threads of data about the Leyte landslide. You might group them into categories, rank them in terms of importance, or arrange them chronologically.

Could this mass movement disaster have been prevented? What lessons should be learnt for other future hazards? Could anyone have saved Preciosa Santos?