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EARLY WARNINGS FOR NATURAL DISASTERS

Sudden natural disasters, such as hurricanes, floods, and earthquakes, can strike in minutes. Although they cannot be prevented, some can be forecast. Their effects can be reduced if communities are warned and prepared. Although the UK does experience natural disasters, this note addresses its role in Early Warnings (EWs) in developing countries, where sophisticated EW systems may be difficult to implement and maintain[1]. The UK Department for International Development (DFID) and others, emphasise that EWs should be integrated in a wider disaster risk reduction strategy, rather than be a 'stand alone' solution.

Background

Rapid onset natural hazards affecting human populations are listed in Box 1. Weather-related events are more frequent than geophysical events, and affect more people.[2] Slow onset natural disasters (such as drought, famine, or extreme temperatures), which affect even more people,[2] are not covered in this note, as their longer timescales do not demand such rapid communication of warnings and mobilisation of humanitarian aid resources. Rapid onset disasters have a high impact in a very short amount of time. For example, both the 1970 tropical cyclone in Bangladesh and the 2004 Indian Ocean tsunami killed more than 300,000 people in just hours to days.

Early warning systems

For an early warning of a natural disaster to reach vulnerable populations, there must be bodies responsible for the following tasks:

- scientific monitoring, data processing, and event forecasting (see Box 2). Local knowledge can ensure that these activities are appropriately focused;
- translation of scientific information into public warnings that are meaningful to their targets;
- the widest possible dissemination of warnings to those who could be affected by the hazard.

Box 1. Natural hazards

Weather related hazards

- Tropical cyclones - violent rotating windstorms with torrential rains originating over tropical oceans, with wind speeds up to 300kmph, circulating over 100s to 1,000s of km. They are also called tropical depressions, tropical storms, hurricanes, or typhoons, depending on their size and location. Other windstorms are less severe, or on a smaller scale.
- Tornadoes – localised, violently rotating funnel shaped windstorms that extend from a cloud to the ground.
- Storm surges – extremely high sea levels, caused by strong winds and low pressures, producing severe coastal flooding, especially if coinciding with high tides.
- Floods – inundations of normally dry land, caused by heavy rain, dam failure, snow melt, glacial lake outburst or a combination of these factors. The impact and speed of onset of flooding will vary according to its cause and the local topography and rock types.

Geophysical hazards

- Landslides – downward movements of a large volume of rocks, earth, or debris. They are usually triggered by heavy rainfall, but can also result from earthquakes, volcanic activity, and erosion. They are more likely to occur on weakened or steep slopes.
- Earthquakes – sudden movements of the earth's crust due to release of stress built up along geologic faults.
- Volcanic eruptions - ranging from the quiet flow of liquid rock to the violent expulsion of hot gas, ash and rocks.
- Tsunamis – huge destructive waves triggered by an underwater earthquake, volcano, or landslide. They travel across the deep ocean at 100s of kmph, and slow down, gaining height as they reach coasts.

Box 2 Costs of scientific monitoring and forecasts

Weather hazards

Meteorological data can be obtained from ground based observations, weather balloons, satellites, weather radars, and aircraft. This information is fed into computer models to forecast weather patterns. Most of these observations and forecasts are shared globally through the Global Telecommunication System (GTS),coordinated by the World Meteorological Organisation (WMO). Weather forecasts must be combined with local risk knowledge to assess flood and landslide hazards. Sophisticated National Meteorological Services (NMS) in developed countries have annual running costs of £100s of millions. NMSs in developing countries, where only ground based and weather balloon observations are made and computing is limited, have annual costs of £100s of thousands.

Geophysical hazards

- Volcanoes - monitoring systems vary from rudimentary visual observations to sophisticated networks of monitoring equipment. The minimum instrumentation for a quiet volcano that starts showing signs of unrest is basic equipment to monitor earthquakes, ground deformation and gas emissions; and a computer to integrate the data. This would cost ~£100,000 to set up, and £20,000 a year to run, plus staffing costs.
- Earthquakes – a large earthquake occurring anywhere in the world will be recorded on hundreds of instruments, and its size and location determined within minutes. Although it is possible to identify regions at risk of earthquakes, specific predictions of the time, location and size of occurrence are not possible. Therefore earthquake risk reduction must focus on preparedness rather than reliance on warnings.
- Tsunamis - their triggers are usually located within minutes of occurring. If ocean depths are also known, tsunami arrival times can be calculated. However, it is more difficult to determine the size of the tsunami. This requires sea level monitoring to detect and measure the wave, and computer modelling of ocean depth and coastal data to calculate how different coasts will be affected. There are many tide gauges already operational in the world's oceans, whose primary function is tide monitoring. Some of these could be upgraded for use in tsunami warnings. The monitoring system for the Indian Ocean proposed by the UN would cost £15M plus £1M per year to run.[3]

For rapid onset events, warnings must reach people within minutes to hours of the event or its precursor being detected. It is thus important that all responsible agencies are on call 24 hours a day and that each task is carried out as quickly as possible. In particular, communication of data and warnings between agencies must be rapid. This requires established and regularly tested protocols for each stage of data transfer.

UK natural disaster policies

Several recent natural disasters have focused attention on the need to improve planning for these events, and on the possible role of early warning systems. They include:

- a devastating hurricane season in the Caribbean in August and September 2004, causing thousands of deaths in Grenada and Haiti. This led to questions in Parliament as to why Grenada was not warned in time, and what could be done to warn politically unstable states such as Haiti;[4]
- the Indian Ocean Tsunami on 26 December 2004. The Prime Minister, the UK Parliament (as well as other national Parliaments), and the UN have all called for a tsunami warning system in the Indian Ocean.[5] Further discussions have noted the need for tsunami warnings in other oceans, as well as integrated warnings for other natural disasters. In January 2005, the Government Chief Scientific Adviser convened a group of experts to advise the Prime Minister on detection and early warning of global natural hazards. This has debated the need for an intergovernmental panel on natural disasters.

The UN International Strategy for Disaster Reduction (ISDR) recommends national advisory bodies for natural disasters known as National Platforms.[6] The UK is one of the few developed countries without such a body. DFID attributes this to a lack of clarity from the UN on whether these bodies should focus on national issues or on issues affecting developing countries. Other EU countries have taken their own initiatives, resulting in National Platforms with widely differing roles. Nevertheless, many UK bodies are involved in disaster risk reduction (DRR) activities in developing countries. DFID currently provides £5 million a year to multilateral and bilateral DRR schemes, in addition to £100s of millions a year on humanitarian aid channelled through civil society and UN organisations. DFID is now committed to spending 10% of its funding in response to each natural disaster on preparation for and mitigation of future natural disasters, and is working towards integrating DRR into development programmes for individual countries.

British Overseas Territories (BOTs)

Most BOTs are too small to be viable independent states and rely on Britain for defence, external affairs and other support. Many are small islands, which are particularly vulnerable to weather-related hazards, and some are also volcanic. In terms of disaster mitigation, the UK government's powers vary between territories. Generally, the UK takes responsibility for natural disaster recovery, but has limited influence in risk reduction strategies. For example, the government of Montserrat (a BOT) stopped monitoring volcanic activity on the island in 1990 whilst recovering and redeveloping after Hurricane Hugo. Yet the volcano has been intermittently erupting since 1995, resulting in evacuation of the southern half of the Island. By the end of March 2007, DFID will have spent £246 million on aid to Montserrat since eruptions began. It is likely that less aid would have been required if volcanic hazards had been considered during redevelopment.

Issues

Public response to early warnings

EWs for rapid onset events do little to protect livelihoods and property. Furthermore, they save lives only if people respond to them. This is more likely if:

- there is an established response procedure, familiar to both the community and the body issuing warnings. This requires regular testing or use of the EW system;
- the community is aware of the effects of the hazard, and understand the warning and forecast information;
- the body issuing warnings is trusted. If a community is unfamiliar with EWs or those issuing them, it may be difficult to gain its trust. False alarms or inaccurate

warnings may reduce credibility, so that warnings are not heeded.

Even with all these factors in place, some people will not respond to warnings due to other priorities, such as protecting their livelihoods. Many authorities are reluctant to issue warnings because of the potential loss of trust and the unpopularity of evacuations.

EW capabilities and development

Although a country's level of development does not influence its likelihood of encountering a natural hazard, it can influence the scale of the disaster that results and its capacity for maintaining EW systems. Even if a scientific monitoring and warning service is supported by donor nations and organisations there can be problems with:

- warnings reaching remote or marginalised people. Few of these own phones, radios, or televisions, or have consistent power for these facilities;
- unclear institutional responsibilities. This can also be a problem in developed countries, but is often exacerbated by unstable governments in developing countries. Box 3 gives an example of how this affected the early warning process for Caribbean hurricanes;
- People displaced due to conflict or food shortages. Evacuations to avoid such hazards may leave people exposed to another less familiar one.

Box 3. 2004 Atlantic and Caribbean hurricanes

Haiti, tropical storm Jeanne (wind speeds up to 117km/h), 17th September

Impact: 3,000 dead, 300,000 affected, due to heavy rain in deforested areas resulting in severe flooding.

Warnings: Following a coup in February 2004, the civil protection office and other agencies involved in emergency planning were disbanded. Therefore there was no warning or evacuation, and the floods hit at night time, surprising the population as they slept.

Cuba, category 3 hurricane Charley (wind speeds up to 210km/h), 13th August

Impact: 4 dead, 215,500 evacuated, 70,000 homes damaged, >US$1 billion damage

Warnings: Timely warnings and evacuations meant there were few deaths despite extensive damage to buildings. This is due, in part, to Cuba having a stable government with very clear operational responsibilities for warnings and evacuations.

Community involvement in early warning systems

Community-based early warning systems, which involve the local community in creating hazard maps, scientific monitoring and contingency planning, are often more effective than high tech systems.[7] This involvement increases awareness and understanding of the impacts of natural hazards, but these systems offer shorter warning times than high tech systems. Integration of both types of system may allow warnings with a longer timescale to reach more communities in a form they understand.

Weather warnings

WMO Regional Specialised Meteorological Centres (RSMCs) are responsible for the detection, monitoring, tracking and intensity forecasting of tropical cyclones in their area. When a cyclone approaches, many nations will refine these forecasts for their own locality, before issuing official warnings (see Box 4). Risk assessments and local monitoring may then be used to issue local flood warnings. Although the standard of RSMCs varies, many NMSs know that ensuring that forecasts reach vulnerable communities is as important as improving the accuracy of the forecasts.

Box 4. Cyclone preparedness in Bangladesh

Cyclone Preparedness Programme[8]

This scheme involves 32,000 trained volunteers organised into teams of 12 in 3,500 villages. They are responsible for raising public awareness, disseminating warnings and for evacuation procedures. They are supplied with radios to monitor weather bulletins and megaphones and sirens to disseminate warnings. The Bangladesh Meteorological Department issues warnings over the radio, using information from the WMO RSMC. The number of deaths in cyclones of similar magnitude has dropped since this scheme began in 1973. Similar tropical cyclones killed about 300,000 people in 1970, compared with 140,000 in 1991.[1]

Issues

- Ignored warnings – some communities have lost trust in warnings, after false alarms have been issued through a process in which they have no involvement in and do not understand.
- Gender – Bangladeshi women are reluctant to move to shelters without male protection, increasing their mortality during cyclones.
- Permanence of funding - the Bangladeshi government covers only 20% of the cost of this scheme. The rest comes from international civil society organisations.
- Cyclone shelters – many rural coastal communities do not have accessible shelters and do not seek shelter until it is too late to reach them.

Volcano warnings

Volcanoes differ from many other natural hazards in that their location is fixed and usually known before they erupt. Public warnings are extended to cover larger regions around the volcano as the perceived hazard increases. To issue meaningful and informative public warnings, assessments and forecasts of volcanic behaviour are combined with knowledge about:

- how topography and winds will affect flows, ash clouds, and fallout;
- how rainfall, unstable slopes, and water or ice bodies may cause secondary disasters.

The quality and completeness of this knowledge varies in different countries and at different volcanoes.

Tsunami warnings

The Pacific is the ocean most prone to tsunamis, due to the major geological faults and volcanoes around its rim. It is the only ocean with an established tsunami warning system (TWS), coordinated by the Pacific Tsunami Warning Center (PTWC). When a large underwater earthquake is detected, nearby national agencies issue a local tsunami warning, while the PTWC issues a 'regional tsunami watch'. As these watches are based on earthquake information without sea level data, only 25% of them actually involve a tsunami. The timeline of the

Indian Ocean tsunami in Box 5 shows that even such a local warning would have been too late for communities in the Andaman and Nicobar Islands, had a similar system been in place. Once the PTWC receives tsunami height information from ocean sensors, it either cancels the watch, or upgrades it to a regional or Pacific wide warning. This takes ~30 minutes, which in the Indian Ocean could have saved communities in Thailand, Sri Lanka, India, and further away. Although Thailand and Indonesia are part of the PTWS, they had no mechanisms for warning their Indian Ocean coasts. Coastal communities aware that earthquakes and receding seas are precursors of a tsunami may evacuate before an official warning is issued. This knowledge saved a few communities in the December 2004 Indian Ocean tsunami, and could have saved many more, if such basic geophysical knowledge were more widely appreciated.

Box 5. Indian Ocean earthquake and tsunami

On 26 December 2004, a magnitude 9.3 earthquake in the Indian Ocean, off the western coast of northern Sumatra, caused a tsunami that killed people from Sumatra to as far away as Africa. Deaths from the earthquake and tsunami were >300,000.[2]

Timeline

00:58 GMT: Magnitude 9.3 earthquake occurs
01:00 to 01:10 GMT: Tsunami hits Andaman and Nicobar Islands. Quake and tsunami leave 7,500 dead or missing.[9]
01:07 GMT: Australia contacts the PTWC with initial earthquake parameters (stating magnitude=8)
01:14 GMT: PTWC sends an earthquake information bulletin to Pacific participants (including Indonesia and Thailand), stating there is no tsunami risk in the *Pacific*
01:20 GMT: Tsunami hits Aceh province in Indonesia. 250,000 dead or missing in Indonesia.
01:28 GMT: PTWC target time for issuing Pacific-wide warnings (1/2 hour after earthquake)
02:04 GMT: PTWC revises Magnitude to 8.5
03:00 GMT: Tsunami hits Phuket, Thailand. 5,500 dead or missing in Thailand.
03:20 GMT: Tsunami hits eastern Sri Lanka, killing 31,000
03:30 GMT: Internet newswire reports of casualties in Sri Lanka provided PTWC with the first indications of the existence of a destructive tsunami.
03:50 GMT: Tsunami hits Eastern India, killing 11,000
07:30 GMT: Tsunami hits Eastern Africa, killing 200

International transfer of data and warnings

The World Meteorological Organisation (WMO) coordinates the transfer of weather data and warnings through its Global Telecommunications System (GTS). All nations can access data from each other This system allows all nations to exchange data without the need for any bilateral agreements or exchanges. Tsunami warnings for the Pacific are also transmitted through this system. This allows warnings for rare high impact events such as tsunamis to be transmitted through a system which is regularly tested with frequent weather warnings. It is planned that Indian Ocean tsunami warnings will be transmitted through the GTS.

UK participation in EW systems

As part of its core responsibilities, the UK Meteorological Office produces low resolution weather forecasts for the whole globe, and high resolution forecasts for Europe and other regions requested by the Ministry of Defence. During humanitarian crises, it will often run high resolution forecasts for the affected region, to help the aid effort. It has also been involved in many activities to improve the capabilities of National Meteorological Services (NMSs) in developing countries, including supplying equipment and training for meteorological monitoring, generating and broadcasting forecasts.

The British Geological Survey (BGS) has completed vulnerability assessments and hazard maps for many unstable slopes and volcanoes in developing countries as part of the geoscience sector of DFID's Knowledge and Research programme. BGS also runs the volcano observatory on Montserrat. It has proposed further risk assessments and training of local geologists in countries affected by the Indian Ocean tsunami and also in other developing countries if funding were available from development agencies.

Many British Universities and civil society organisations (CSOs) conduct research on risk reduction strategies and methods for forecasting natural disasters. CSOs are also involved in implementing some EW systems.

Overview

Despite activities in EWs for rapid onset natural disasters for developing countries, the UK has no specific policy on its involvement and responsibilities. Technology-based systems will have little impact in developing countries, unless they are coupled with:

- Risk reduction strategies;
- Public education programmes;
- Clear institutional responsibilities and capabilities at both national and local levels;
- Effective dissemination.

Endnotes

1 POST decided to produce this briefing in early 2004, through its collaboration with the Natural Environment Research Council. By coincidence, work began a week after the 'Asian Tsunami'.
2 http://www.em-dat.net
3 http://portal.unesco.org
4 Commons Debate on the Caribbean, Westminster Hall, 2 Dec 2004.
5 Commons Written Answers, International Development, Asian Tsunami, 8 Feb 2005. Common statement of the Special Session on the Indian Ocean Disaster: Risk Reduction for a Safer Future, UN/ ISDR, 20 Jan 2005. Statement by the Prime Minister to the House of Commons, 10 Jan 2005.
6 *Building the Resilience of Nations and Communities to Disasters: Hyogo Framework for Action 2005-2015*, UN/ISDR, 2005.
7 *Disaster Risk Reduction: A Development Concern*, DfID, 2004.
8 http://www.redcross.org
9 death tolls are estimates from the World Bank, March 2005.

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology. POST is grateful to NERC for its collaboration with POST to enable Rosanna Smith to produce this briefing note.

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