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POSTNOTE

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Resilience to Natural Hazards in Developing Nations

In the last 10 years, over 500,000 people have lost their lives and around 1.5 billion people have been adversely affected due to rapid-onset natural hazards such as earthquakes, tsunami, floods and tropical storms. This briefing discusses the potential for science and technology to enhance resilience to such hazards in developing nations.

Overview

- There are no "natural" disasters, just natural hazards. Disasters occur when people are in harm's way and preparation is insufficient.
- Science and technology can play an important role in this area. However, factors such as political will, governance and international cooperation are also crucial.
- Investment in resilience saves lives and can be more cost effective than paying for restoration.
- Effective early warning systems help to build resilience, but require extensive understanding of hazards and a bottom-up approach that focuses on local needs.
- There is a need for more scientific research into the efficacy of aid and resilience initiatives, to enable lessons to be learned.

Background

"Resilience" to natural hazards refers to the ability to protect lives, livelihoods and infrastructure from destruction, and to the capability to restore areas after natural hazard has occurred. Currently, over 95% of deaths from natural hazards take place in developing countries, but disparities also exist within the developing world. From 2002-2008 over 6000 people were killed by hurricanes in Haiti, whilst the neighbouring Dominican Republic suffered fewer than 1000 fatalities. Differences in preparedness, the effectiveness of early warning systems, the quality of governance, infrastructure and education were all contributing factors.

In many countries, unplanned and rapid urban growth, with high population densities and low construction standards, is further increasing vulnerability, particularly of the poor. Moreover a recent report by the Intergovernmental Panel on Climate Change (IPCC) has drawn attention to the impact of more frequent extreme weather events in future (page 4). Note that although this POSTnote focuses on rapid-onset natural hazards, developing nations also face chronic problems such as drought, disease and malnutrition.

The Department for International Development (DFID) spent £7.7 billion on aid in 2010/11. Of this, around £250 million[1] was spent on assistance in the wake of natural hazards; providing food, medicine, shelter and other resources. In recent years DFID has moved towards integrating Disaster Risk Reduction (DRR) and resilience initiatives across all its programme areas. Because of this it is difficult to determine exactly how much money DFID spends on reducing the potential for disaster through DRR and resilience building.

National and International Policy

The Hyogo Framework,[6] which runs from 2005-2015 as part of the UN's International Strategy for Disaster Reduction (ISDR), sets out national and international responsibilities in preparing for natural hazards. In the UK, responsibility for international DRR and resilience falls to DFID. Recent years have seen increased effort being dedicated to preparing for natural hazards rather than simply responding when they occur. DFID acknowledges that *"there is now compelling evidence that the impact of disasters can be significantly mitigated by building the resilience of nations and people, and addressing the root causes of vulnerability"*. However, cost effectiveness is hard to quantify. In line with the Hyogo Framework, two of DFID's seven policy goals are to:

- build the resilience of individuals, communities and countries to disasters and conflict;
- invest in research and innovation (see Box 1).

Box 1. Research Priorities

Total DFID expenditure on research (in the UK and internationally) in 2010/11 was £128 million. Much of this is carried out in partnership with the research councils. For example DFID and the Economic and Social Research Council (ESRC) jointly fund a £23 million scheme for research on international development. This has a focus on poverty reduction, an underlying factor that affects resilience. Since 2005 over 100 projects have been funded, including work on health security and disaster resilience in Bangladesh, and a study of new farming techniques to reduce risk vulnerability in Africa. The research councils also support a portfolio of research related to resilience. For example, the Natural Environment Research Council and the ESRC run a programme which aims to build resilience in earthquake-prone and volcanic regions. Other agencies such as NGOs, private foundations and the private sector also fund research. Various cross-sector bodies exist to help coordinate these diverse efforts. The UK Collaborative on Development Sciences works to bring together government and academia while Enhancing Learning and Research for Humanitarian Assistance (ELRHA) works to bring together NGOs and academia.

The Role of Science and Technology

Science and technology can assist in building resilience, by furthering understanding of:

- what can be done to prepare against the threat of natural hazards in developing nations;
- how to protect vulnerable people and critical infrastructure in the event of a disaster;
- the range of issues that still need to be resolved in order for effective resilience building to occur.

Preparing For Disaster

Forecasting Hazards

Research can help identify when and where natural hazards will occur and what their impacts might be, so that early warning systems can be set up. Forecasting accuracy depends on the type of hazard. Forecasting of geological hazards such as earthquakes (using networks of ground based sensors) is still at an early stage although progress is being made. General probabilistic forecasts for earthquakes can be obtained – for example the US Geological Survey forecasts a 62% chance of at least one earthquake of magnitude 6.7 or greater in the San Francisco Bay region from 2003-2032. However, more specific forecasts are not currently possible. For volcanoes, progress is being made in predicting when certain eruptions may occur, although predicting the evolution of an eruption is not yet possible.

Atmospheric hazards can be detected through well-established national and international meteorological satellite and ground station networks – although many developing nations still need to build their capability to access and use the available data. Met Office monitoring suggests the accuracy of weather forecasting has improved fourfold in the last 50 years, largely through the increasing availability of satellite data. However, in most cases it is still reliable only around four days in advance.

Identifying Vulnerabilities and Planning

Improving resilience does not completely eliminate vulnerability to natural hazards. For example, constructing a wall to prevent flooding provides some resilience, but the people behind the wall will still be vulnerable to a particularly large flood that overwhelms the defences. Alternatively the wall may 'move' flooding to areas further downstream. Careful consideration is required to identify schemes that do not create a false sense of safety, and take into account the needs and capabilities of local people.

Community buildings (such as hospitals, schools and religious centres) are useful as shelters because local communities already know where they are, although one disadvantage of this is that they cannot be returned quickly to their normal purpose. Taking these considerations into account at the planning stage (e.g. building on high ground to avoid flooding and/or building to withstand wind damage) is an effective way of protecting people and major assets within existing settlements.

Without effective infrastructure in place following a natural hazard, there is a risk of secondary disasters, such as disease. For example cholera outbreaks can occur if clean drinking water is not available. This can even arise as a result of the humanitarian assistance effort (see Box 2).

Box 2. Disease as a Secondary Disaster

Cholera in Haiti

Following the 2010 earthquake the supply of clean drinking water in Haiti was severely disrupted. The first cases of cholera were reported in late 2010. By the 12th September 2011 over 450,000 cases had been reported with over 240,000 hospitalisations and 6,000 fatalities.[2] A lack of clean drinking water and proper sanitation can be a problem for those arriving to assist in the wake of a disaster as well as for locals. Disease can also be 'imported' into disaster zones by those trying to assist, and may spread quickly amongst weakened locals.

The Resilience of Buildings

There is a substantial body of research into how to make buildings more resilient to earthquakes. This does not necessarily require sophisticated technology. 'Fachwerkhaus' timber buildings are an 18th century German design, which are highly resilient to seismic hazards. They can be many storeys high and constructed from locally sourced timber by local workers. This technique has been applied in places such as Iran. Many nations still rely on adobe buildings (constructed from mud and clay bricks). Interlacing vines and sinew within adobe brick walls can enhance resilience to earthquakes. During earthquakes, buildings often collapse because of failure to adhere to basic building codes, due to weak governance or corruption.

Planning for Resilience

Effective planning is just as important as technology. Ensuring that development occurs in lower-risk areas, such as away from flood-plains, can reduce the potential impacts of natural disasters. In addition, some natural environments provide a low cost way of mitigating disasters. For example, research has shown that coastal mangroves can provide significant protection against tsunami, by providing a natural buffer zone that reduces the intensity of incoming waves before they reach inhabited areas. However, many have been destroyed and replaced by prawn fisheries as economic demands on developing nations have intensified.[3]

Once the underlying scientific processes are understood, risk assessments can identify who or what would be at risk if a natural hazard were to occur. It is important that such assessments take the local context into account. Models can then be used to investigate potential damage to infrastructure, and help to inform decisions on where investment is most needed. However, modelling is not yet in wide use in the developing world as it requires levels of skills and infrastructure that many nations do not yet have.

Early Warning Systems

Understanding the potential impact of a hazard, and being able to inform people who are likely to be exposed to it in an accessible and credible way, is crucial. This can be achieved by using many different communication channels, from radio and mobile phone networks to religious and community leaders. There is increasing emphasis on employing a "bottom-up" approach to use the knowledge and input of local people to design warning systems. An example of what happens when knowledge and warning are not linked is provided in Box 3.

Box 3. The Importance of International Coordination

Pacific Tsunami Warning Centre (PTWC)

The PTWC was established in 1968 to provide an early warning of tsunami to Pacific Ocean nations. In 2004 its remit did not extend to issuing warnings to Indian Ocean nations. When the 2004 Boxing Day earthquake occurred in the Indian Ocean there was no process in place for the PTWC to issue a tsunami warning. Over 200,000 people were killed by the tsunami in Indian Ocean nations. It is likely that many of these lives could have been saved if effective early warning systems had been in place and following the 2004 tsunami the Indian Ocean was included in an expanded warning system monitored by the PTWC.

Bangladesh is an example of a country where the spread of mobile phones and improved scientific understanding of natural hazards has helped reduce the number of deaths caused by annual flooding and more extreme hazards, such as cyclones. These advances have been exploited effectively through enhanced contingency planning and early warning systems. The mobile phone network does not reach everyone, but once the message is out, other solutions, like cyclists with megaphones, can be used.

Warning and response activities (such as search and rescue, and providing aid and shelter) can be improved by carrying out simulations and training drills and allowing participants to familiarise themselves with the actions required of them. An overview of early warning systems for natural hazards was provided in POSTnote 239.

Disaster Response

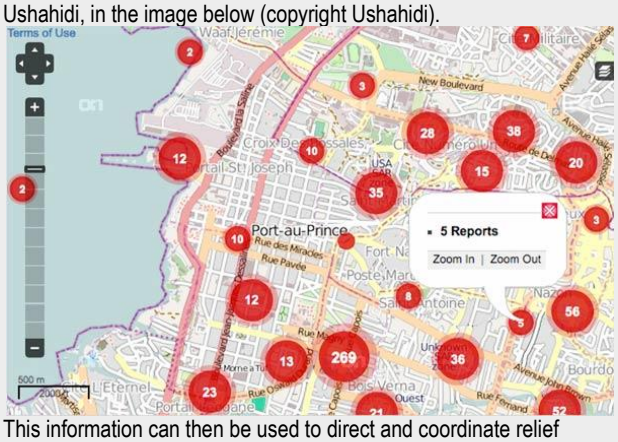
When disaster strikes the immediate concern is saving lives. Over the longer term, it is important for response efforts to help build to resilience for the future and not just recreate the same conditions that existed prior to the disaster. The aftermath of a natural hazard can be very chaotic; often power, communications and transport networks are disrupted making coordination of relief difficult. Technology can play a pivotal role in assisting in, for example:

- **search and rescue**: the UK has its own team, UK - International Search and Rescue (ISAR), along with NGO teams who can be deployed around the world to assist in the search for survivors. UK-ISAR use techniques such as special probe cameras and sniffer dogs to locate survivors buried under wreckage.
- **getting the message out**: the use of mobile phones has become widespread in many developing nations. It is often possible for people to call or SMS their location to relief aid organisations, if they know the number to use. An example of this can be found in Box 4. Satellite imaging is also increasingly assisting with understanding areas affected in the wake of a hazard.
- **reuniting communities:** online registration and SMS are increasingly being used in efforts to reunite people with their loved ones following a disaster. For example, missing people can be cross-checked against those found in shelters or hospitals.

Box 4. Mobile Communications, IT and Locating Survivors

Crisis Mapping in Haiti

Services now exist whereby survivors of a disaster can send an SMS message to request help or report issues. These messages can be mapped in real-time, as seen with the software provided by the NGO, Ushahidi, in the image below (copyright Ushahidi).



This information can then be used to direct and coordinate relief efforts and can be shared and updated as events progress. The private sector is also becoming involved, with organisations like Google.org providing support in the wake of crises such as the 2011 Tohoku earthquake in Japan.

Outstanding Issues

Scientific and technological developments alone are not enough to enhance resilience. Their effectiveness depends on factors such as coordination between stakeholders and consistent documentation of past successes and failures. Such factors assist in enabling lessons to be learned.

Coordination

Various studies have identified a need for different actors (both civilian and military) to coordinate before, during and after emergencies.[4] In the chaos after an event, roads may be impassable and meetings can be time-consuming to reach. Telephone and video-conferencing services can allow coordination to take place remotely, although this is often not possible because of disruption to power and communications networks. There is a need for greater

coordination between those involved in long term development, who may already be in-situ, and those involved in relief aid, who arrive after disaster has occurred. All these activities should consider what may already be in place in the local community (e.g. local suppliers).

The UN Office for the Coordination of Humanitarian Affairs is responsible for ensuring a coherent response to emergencies, while the UNISDR Secretariat attempts to facilitate international cooperation on long-term development with a focus on DRR and resilience. UNISDR produces a biennial Global Assessment Report which discusses how different governments are approaching DRR.[5]

Understanding What Works

The UNISDR noted in its midterm review of the Hyogo framework that *"much of the existing operational research related to emergencies and disasters lacks consistency, is of poor reliability and validity and is of limited use for establishing baselines, defining standards, making comparisons or tracking trends".*[6] Many lessons are not learned because only anecdotal evidence survives. This also limits the extent to which policy can be evidence based. Effective DRR reduces the impact of a hazard. However, it is difficult to conclude how effective a DRR initiative has been, as it is impossible to say what would have happened in an emergency if the initiative had not been carried out. These factors mean making DRR initiatives accountable to governments, donors and the public is a challenge.

The Role of Innovation and the Private Sector

Innovation is not just about developing new 'high-tech' solutions. Understanding how to deploy existing technology effectively in developing markets, and in new ways, is also important. The private sector plays a key role in this area (Box 5), particularly in activities such as providing communications networks or distributing food. The resilience of such services is as important as that of physical infrastructure. There can be commercial advantage in being able to continue to operate after a natural hazard.

The UK has a small 'green enterprise' sector - including some companies which have benevolent or 'not-for-profit' objectives and are focussed on international development projects. Many such organisations form as spin-outs from universities, and can be effective at quickly turning research into products and/or techniques ready for 'field' use.

Future Vulnerabilities

Poverty, unplanned and rapid urbanisation, and climate change can all influence how vulnerable people are to natural hazards.[7] Historically most hazards have occurred in rural areas but urbanisation presents new challenges:

- unplanned urbanisation can lead to low levels of resilience and high levels of vulnerability;
- high concentrations of deprived people in urban areas increases competition for resources and may enhance the spread of contagious disease following a hazard;
- urban areas are compact spaces which can make the provision of aid more complex and time consuming.

Box 5. Innovation in Action

Enabling Cash Aid

An example of innovation with a direct impact on disaster resilience and provision of aid can be seen with mobile phone banking.

- Mobile phones and text messages are increasingly used for 'online' banking in developing nations.
- Relief organisations can provide aid in the form of online bank transfers to individuals, rather than providing physical hand-outs of cash, food, shelter or other resources.
- Individuals can then buy what they need from local businesses using money transfers over the mobile phone banking system.
- This helps prevent local economies from being disrupted when external agencies arrive to provide aid in the wake of a disaster.
- After the 2010 Haiti earthquake, USAID and the Gates Foundation offered a $10 million incentive to 'jump-start' the provision of cash aid to affected locals via mobile phones.

The IPCC[8] has highlighted evidence that suggests climate change is likely to increase both the frequency and intensity of atmospheric natural hazards; particularly heatwaves. However there is still considerable uncertainty over the extent of the impact of climate change on weather and extreme events.[9]

All of these issues must be faced in the context of global economic difficulties. There is also a need to focus on sustainable solutions, driven and fulfilled by local people. The international debate in this area is likely to be driven by the expiration of the Kyoto Protocol (on climate change) in 2012, and Hyogo Framework in 2015.

In February 2012 the Foresight group within the Department for Business, Innovation and Skills, launched "*Improving Future Disaster Anticipation and Resilience*", a new project investigating how to improve anticipation of, and resilience to, disasters.[10] This is part of the Government's response to Lord Ashdown's Humanitarian Emergency Response Review, commissioned by DFID. Its findings will help both UK and international policy makers.

Endnotes

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3 TEEB, *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: a synthesis of the approach, conclusions and recommendations* of TEEB, 2010.
4 United Nations International Strategy for Disaster Reduction (UNISDR), *Reducing Disaster Risks through Science: Issues and Actions*, 2009; Ashdown et al, *Humanitarian Emergency Response Review*, 2011; Disasters Emergency Committee: *Urban disasters – lessons from Haiti*, 2011.
5 UNISDR, *Global Assessment Report on Disaster Risk Reduction*, 2011.
6 UNISDR, *Hyogo Framework for Action 2005-2015 Mid-term Review*, 2010/11.
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9 POSTnote 400, *Climate Variability and Weather*, 2012.
10 http://www.bis.gov.uk/foresight/our-work/policy-futures/disasters

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