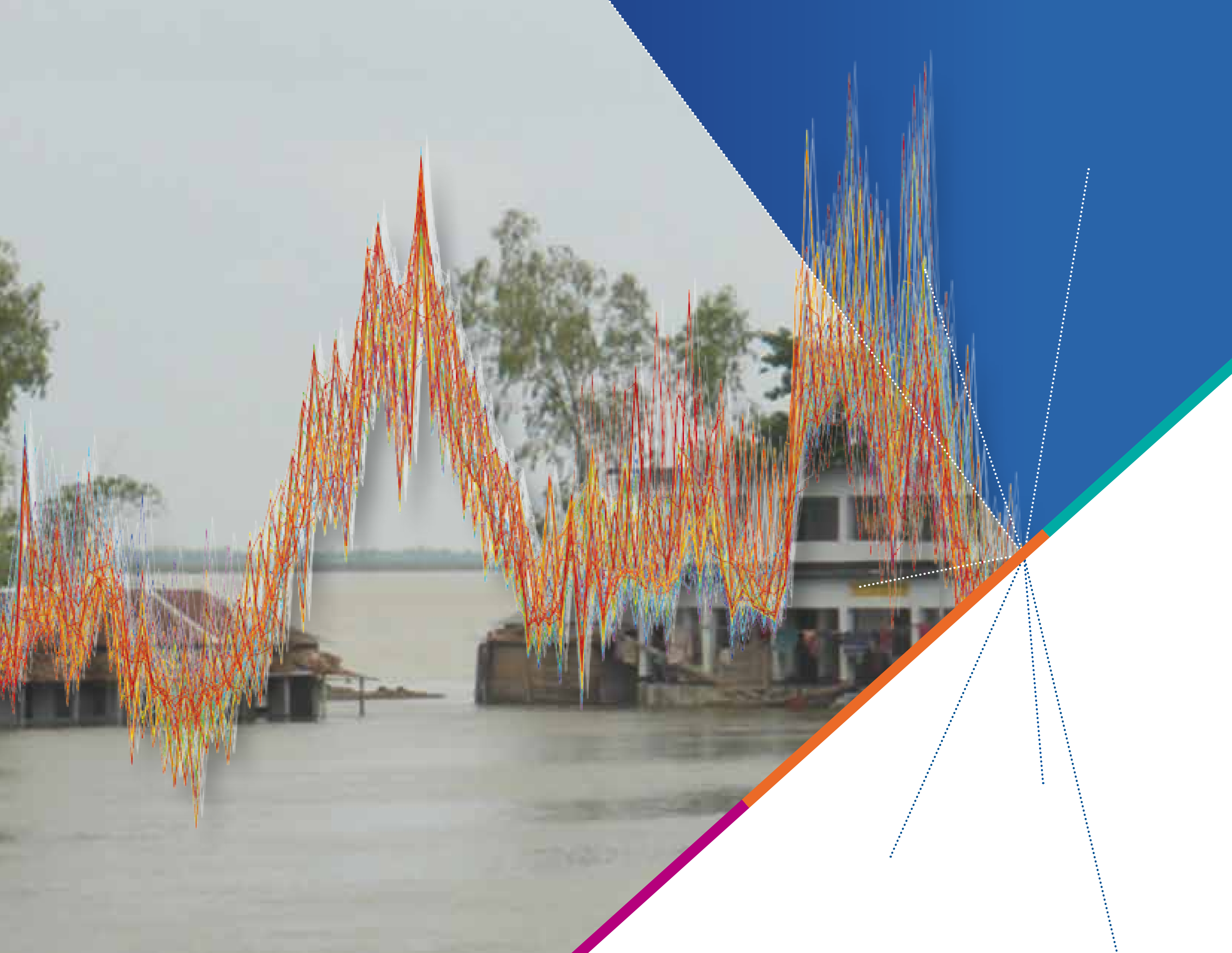

Using Science for Disaster Risk Reduction

REPORT OF THE UNISDR SCIENTIFIC AND TECHNICAL ADVISORY GROUP – 2013

UNISDR
The United Nations Office for Disaster Risk Reduction

Using Science for Disaster Risk Reduction

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FOREWORD

Photo: UNISDR

A resilient planet needs robust science for disaster risk reduction. It is clear from any review of the disaster risk landscape that progress can be made in saving lives, jobs and critical infrastructure by integrating science into both policy making and best practice for disaster management.

In some cases this is very obvious. Meteorologists, for example, have a clear role to play in reducing risk by making forecasts available in a timely way to disaster managers who may need to step up their preparedness and response measures for a likely flood or a drought.

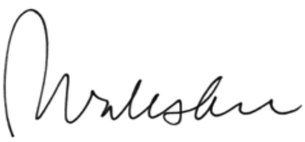
It may be less obvious how long-term weather patterns will influence society in a more profound way and how we should respond. As rainfall intensifies and sea levels rise, how and when should vulnerable populations be re-located permanently out of harm's way? As rainfall diminishes, how much investment should there be in research and development into drought-resistant crop production?

We look to science and technology to find the answers to these important questions.

Scientific enterprise is vitally important not just for supporting mitigation, preparedness and response measures but for the development of policy at the highest levels of government and providing the evidence of the benefits which ensue from investing in disaster risk reduction.

UNISDR is fortunate to have a distinguished Scientific and Technical Advisory Group which has been a precious resource for several years now. This latest report purposely coincides with the Global Platform for Disaster Risk Reduction, and its recommendations are an important contribution to the debate on shaping the Post-2015 international framework on disaster risk reduction.

Looking to the future, science must become even more deeply embedded in our work. As the report expresses it so well in one of its key recommendations, "An all-hazard, risk-based, problem-solving approach should be used in disaster risk reduction to address the multi-factorial and inter-dependent nature of the disaster risk chain and to achieve improved solutions and better optimized use of resources."



Margareta Wahlström,
Special Representative of the Secretary-General
for Disaster Risk Reduction

EXECUTIVE SUMMARY

Disasters destroy lives and livelihoods around the world. Between 2000 and 2012, 1.7 million people died in disasters and an estimated US$ 1.7 trillion of damage was sustained[1]. Disaster risk reduction activities aim to reduce the human, economic and environmental costs of such disasters and science can play an essential role in these efforts, uncovering new ways to prevent, prepare for and respond to disasters and determining which technologies are most effective in reducing disaster risk. As a result of scientific research, across the world there are now programmes to forecast floods, detect tsunami waves, prevent infectious disease outbreaks with vaccination and effectively communicate disaster risk to enhance community resilience.

Thus science is already helping to save lives and livelihoods in some instances. But what do we mean by 'science'? Science is knowledge obtained through study or practice[2]. For disaster risk reduction, science is considered in its widest sense to include the natural, environmental, social, economic, health and engineering sciences, and scientific capacities are interpreted broadly to include all relevant resources and skills of a scientific and technical nature[3].

The more widespread integration of science into disaster risk reduction policy-making will depend on science being 'useful, useable and used'[4]. The United Nations International Strategy for Disaster Reduction (UNISDR) Scientific and Technical Committee's 2009 report 'Reducing Disaster Risks through Science: Issues and Action'[5] discussed how the challenge of integrating scientific learning into policy can be overcome through improved dialogue between scientists and decision-makers, making the case that science can be made *useful* for disaster risk reduction. The case studies in this report describe specific examples of scientific learning being employed to enhance disaster risk reduction, providing ample evidence that science is *useable* for disaster risk reduction. By 2015, the ISDR Scientific and Technical Advisory Group aims to show that science is consistently *used* in disaster risk reduction.

Case studies capture the complexity of disaster risk by exploring the detail of a real-life situation. Individually they identify specific lessons for success in risk reduction; together they demonstrate common over-arching principles, which can be seen running through each study[6]. The case studies in this report were selected from across the breadth of scientific disciplines and from all parts of the globe. They demonstrate that science can:

- be driven by the need to address the adverse effects of disasters on lives, livelihoods, economies and societies
- enable more focused disaster risk assessment
- reduce the impact of disasters by better forecasting
- improve disaster risk mitigation programmes

1 UNISDR. Disaster Impacts/2000-2012. Available at: http://www.preventionweb.net/files/31737_20130312disaster20002012copy.pdf [accessed 02 April 2013].
2 Webster's New World College Dictionary, 4th Edition. Foster City: John Wiley & Sons Inc, 1999.
3 Reid B. Science and Technology and Disaster Risk Reduction: A review of application and co-ordination needs. Geneva: UNISDR, 2013. Available at: http://www.preventionweb.net/posthfa/documents/Science-and-Technology-for-Disaster-Risk-Reduction.pdf [accessed 25 April 2013].
4 Boaz A, Hayden C. Pro-Active Evaluators: Enabling Research to be Useful, Usable and Used. Evaluation.2002; 8(4):44053.
5 UNISDR. Reducing Disaster Risks through Science: Issues and Actions, The full report of the ISDR Scientific and Technical Committee 2009. Geneva: UNISDR, 2009. Available at: http://www.unisdr.org/files/11543_STCReportlibrary.pdf [accessed 8 April 2013].
6 Grynszpan D, Murray V, Llosa S. The value of case studies in disaster assessment. Prehospital and Disaster Medicine. 2011; doi:10.1017/S1049023X11006406.

These case studies identified some common themes for success, including community participation in the development of scientific interventions, clear leadership and high-level commitment to implement and sustain interventions in the long term.

Further case studies are being collected by the Scientific and Technical Advisory Group and are available online at www.preventionweb.net/go/scitech. We encourage scientists and implementers to submit their own case study examples demonstrating the use of science in disaster risk reduction activity. Information on how to prepare and submit case studies can be found on the website.

Looking to the future, the need to achieve more effective interplay of science, policy and practice in support of disaster risk reduction provides a great opportunity for collaborative learning and action. The science community should find better and faster ways to interact with and to communicate findings to policy-makers. For instance, forecasting is already well-developed for some hazards and is expected to improve greatly in the coming decades[7] but the meaning of and uncertainty within forecasts needs careful communication by scientists if policy-makers are to use them to full effect.

Research agendas should be developed in cooperation with all stakeholders, so that scientists' work is focused on solutions to the challenges faced now, and in the future, by policy-makers and implementers. This applies to research throughout the whole risk reduction cycle: through prevention, prediction and early detection to response and recovery. Specific areas for further collaborative work include the disaster risk reduction needs of women who manage households and care for family members, which limits their mobility and increases their vulnerability to disasters; how to mitigate against disasters in settlements with little economic diversification, where most income comes from climate sensitive primary resource industries such as agriculture, forestry, and fisheries; and how to promote sustainable recovery, including both structural and non-structural mitigation measures that will lower the risk of future disasters.

The Scientific and Technical Advisory Group makes the following recommendations:

1. Encourage science to demonstrate that it can inform policy and practice

Through the use of case studies this report demonstrates that science can identify a problem, develop understanding from research, inform policy and practice and make a difference that can be objectively demonstrated when evaluated. The Report, and the associated website, offers tools to promote this sharing of information and thus provide knowledge transfer to policy-makers and other disaster risk reduction partners.

2. Use a problem-solving approach to research that integrates all hazards and disciplines

An all-hazard, risk-based, problem-solving approach should be used in disaster risk reduction research to address the multifactorial and interdependent nature of the disaster risk chain and to achieve improved solutions and better-optimized

7 Foresight. Reducing Risks of Future Disasters: Priorities for Decision Makers. London: UK Government Office for Science, 2012.

use of resources. This requires collaboration and communication across the scientific disciplines and with all stakeholders, including representatives of governmental institutions, scientific and technical specialists and members of the communities at risk to guide scientific research, set research agendas, bridge the various gaps between risks and between stakeholders, and support scientific education and training.

3. Promote knowledge into action

Greater priority should be put on sharing and disseminating scientific information and translating it into practical methods that can readily be integrated into policies, regulations and implementation plans concerning disaster risk reduction. Education on all levels, comprehensive knowledge management, and involvement of science in public awareness-raising, media communication and education campaigns should be strengthened. Specific innovations should be developed to facilitate the incorporation of science inputs in policy-making.

4. Science should be key to the Post-2015 Hyogo Framework for Action

The Scientific and Technical Advisory Group considers it essential to demonstrate, by 2015, that science is routinely used to inform disaster risk reduction and therefore holds a key place in the Post-2015 Hyogo Framework for Action. The Group calls for all scientists to provide evidence of impact by clearly stating how science has responded to a problem, what scientific learning was identified, how their findings were applied to policy and practice and that it makes a difference when implemented.

The Chair's summary from the 2011 Global Platform stated: "the choice before us as Governments, institutions, communities and individuals is to place disaster risk reduction at the forefront of our efforts to preserve and protect the balance of nature, ensure sustainable development and wellbeing for generations to come" and that to do this there is the opportunity to *"actively engage scientific and technical communities to inform decision-making"*[8]. We support and endorse this view which must be fundamental to the 'Hyogo Framework for Action 2', the post-2015 framework for disaster risk reduction.

8 UNISDR. Chair's Summary of the Third Session of the Global Platform for Disaster Risk Reduction and World Reconstruction Conference Geneva, 8-13 May 2011 "Invest today for a Safer Tomorrow – Increase Investment in Local Action". 2011. Available at: http://www.preventionweb.net/files/20102_gp2011chairssummary.pdf [accessed 8 April 2013].

INTRODUCTION

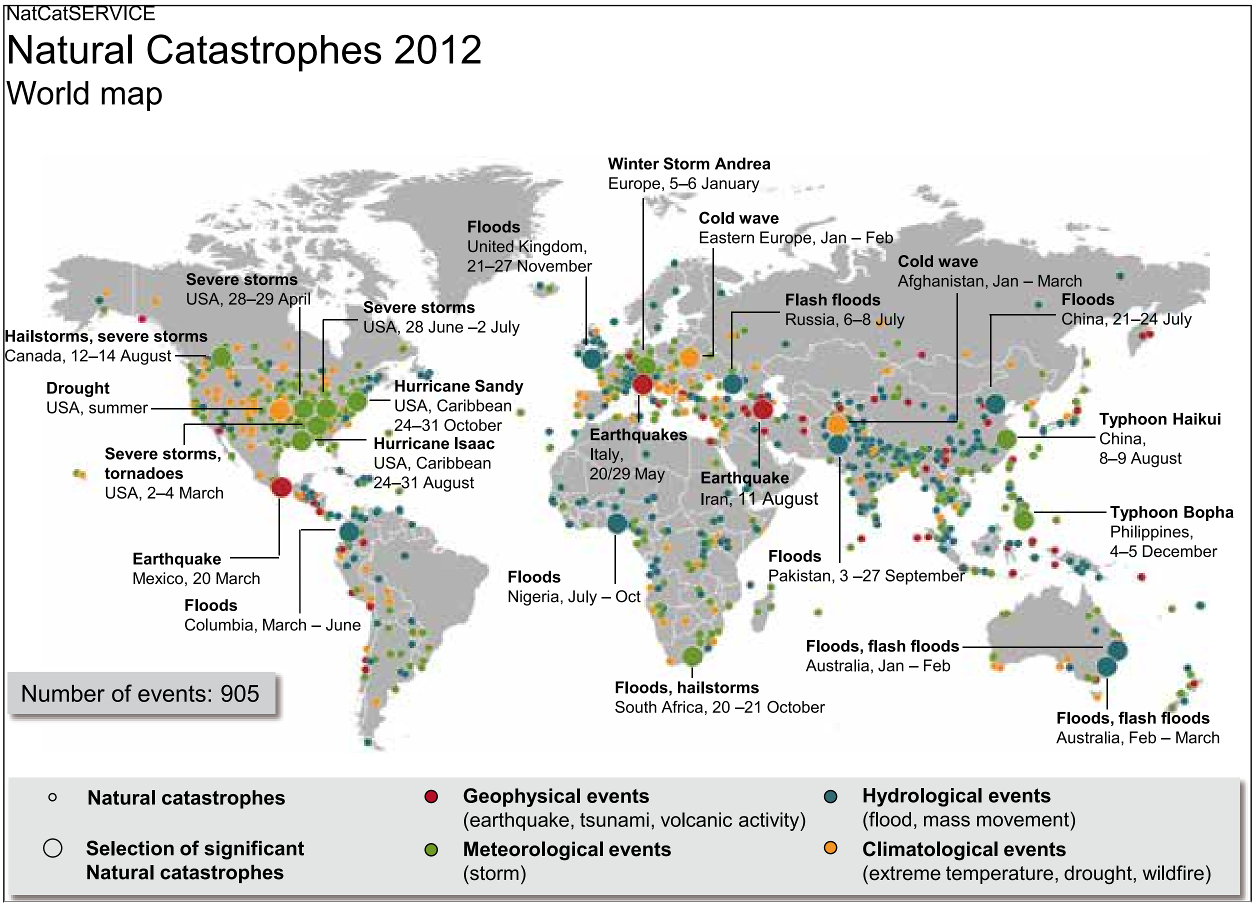


Figure 1: Natural catastrophes 2012 – World map. *Source: Munich Re, 2013*[1]

Disasters destroy lives and livelihoods around the world. Between 2000 and 2012, 1.7 million people died in disasters and an estimated US$ 1.7 trillion of damages were sustained[2]. Scientific research can uncover new ways to prevent, prepare for and respond to disasters and it can determine which technologies are most effective in disaster risk reduction. As a result, across the world there are now programmes to forecast floods, detect tsunami waves, prevent infectious disease outbreaks with vaccination and effectively communicate disaster risk and enhance community resilience; science is helping to save lives and livelihoods.

In this report, the Scientific and Technical Advisory Group of the United Nations International Strategy for Disaster Reduction (see Annex) has brought together case studies from around the world to show how scientists and decision-makers have applied research to real-life problems to achieve real impact in disaster risk reduction. In this way, we aim to show that science is useable in disaster risk reduction.

1 Munich Re. Natural Catastrophes 2012 – World Map. Available at: http://www.munichre.com/app_pages/www/@res/pdf/NatCatService/annual_statistics/2012/2012_mrnatcatservice_natural_disasters2012_worldmap_en.pdf?2 [accessed 02 April 2013].

2 UNISDR. Disaster Impacts/2000-2012. Available from: http://www.preventionweb.net/files/31737_20130312disaster20002012copy.pdf [accessed 02 April 2013].

It is hoped that the successes described here will encourage the collaboration of all stakeholders in disaster risk reduction, including representatives of governmental institutions, scientific and technical specialists and members of the communities at risk, to find better ways to integrate science into disaster risk reduction activities.

Disasters and disaster risk reduction

The number, scale and cost of disasters are increasing. Many disaster hazards are becoming more frequent as a result of climate change[3] while human exposure and vulnerability to hazards is increasing: growing and ageing populations, unplanned settlements, and increasing assets all put communities at greater risk of physical and economic harm when a disaster occurs. In addition, between 2005 and 2009 more than 50% of people affected by natural disasters lived in fragile and conflict-affected states[4]. There is strong evidence that conflict and fragility increase the impact of natural disasters, and there is an expectation that disasters and conflict will collide more in the future[5].

Since the International Decade for Natural Disaster Reduction in the 1990s[6], disasters have taken an increasingly high priority on the global political agenda. Increasing attention is being given to the rising impacts of disasters and to ways to reduce the exposure and vulnerability of communities and assets to natural hazards. While the hazard posing a disaster risk – a tsunami, storm or earthquake – generally cannot be influenced, the impact and frequency of disasters can be significantly reduced through the coordinated efforts of governments, experts and communities to mitigate against, prepare for, respond to and recover from disasters. This is disaster risk reduction.

Examples of disaster risk reduction activity include extreme weather forecasting, improving building design and urban planning, provision of insurance to households and businesses, and exercising of disaster plans. Disaster risk reduction requires strategic planning and implementation as well as technical and scientific expertise. It sits at the interface of policymaking, engineering and scientific research, and requires a close and continuous exchange among these fields in order to provide effective and durable solutions.

The adoption of disaster risk reduction strategies requires not only investment but also a different approach to policy development. In disaster-prone areas, the exhaustion of resources in responding to a disaster, and the disruption it causes, can be a perverse obstacle to investment in risk reduction strategies even though they may provide long-term protection and reduce future vulnerability to similar events.

For example, Thailand has frequently experienced flooding. Following the particularly destructive floods in Thailand in 2011 – a disaster which was notable for its intensity but was not unique – it was recognized at the senior government level that the enormous costs invested in clearing up the damage and rebuilding did not buy a durable and reliable system to reduce future vulnerability to similar conditions. Similar or greater expenditures would be required should such conditions recur as the system, largely focussed on response, did not reduce the likelihood of a repeat event, or minimize the

3 Intergovernmental Panel on Climate Change (IPCC). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Summary for policymakers (The SREX Report). Cambridge and New York: Cambridge University Press, 2012. Available at: http://ipcc-wg2.gov/SREX/report/ [accessed 8 April 2013].

4 Harris K, Keen D, Mitchell T. When disasters and conflict collide: London: Overseas Development Institute, 2013.

5 *Ibid*.

6 UNISDR. History. Available at: http://www.unisdr.org/who-we-are/history#idndr [accessed 02 April 2013].

vulnerability of the population. They have therefore undertaken to invest in a more comprehensive system of national water management, relying on a complex mix of science, technological development and adaptive planning [7].

The role of science in disaster risk reduction

Science is knowledge obtained through study or practice [8]. For disaster risk reduction, scientific capacities must be interpreted broadly to include all relevant matters of a scientific and technical nature, where science is considered in its widest sense to include the natural, environmental, social, economic, health and engineering sciences. Similarly, the term 'technical' includes relevant matters of technology, engineering practice and implementation. Scientific and technical work often requires the participation of practitioners and other intermediaries in addition to scholars and scientists [9].

Science can be applied to mitigate risk and vulnerability throughout the whole of the risk reduction cycle: through prevention (where possible), prediction and early detection to resilient systems for response and recovery.

The scientific research agenda for each stage of the risk reduction cycle will reflect the varying degrees of predictability of the challenges to be faced. On the one hand, the need for development of sensor technology for the detection of hazards leads to a research programme with clear-cut goals for the early detection phase of the cycle. On the other hand, the analysis of the complex interactions between human activity and environmental factors in the response phase cannot foreshadow all possible effects. Such research must support the rapid design and development of better interventions to be implemented as the disaster response is mobilized. For example, it is comparatively easy to specify the kind of sensors needed to detect ash particles in the air when a volcano erupts [10], but much harder to specify how the grounding of some flights will disrupt supply chains which deliver needed goods and services, the disruption of which may cause further systemic breakdowns [11].

The over-arching scientific research agenda for disaster risk reduction must offer a vision of this whole cycle, recognizing the different research challenges at each stage and delivering a portfolio of understandings which will support disaster response teams in managing the particular challenges they face. But in order to be integrated into disaster risk reduction policy-making, the output of scientific research must be:

- Useful
- Usable
- Used

This concept of 'Useful, Usable and Used' was discussed by Boaz and Hayden (2002) [12] where they considered the issues around evidence-based policy making, which can present challenges for researchers since the requirement to

7 Royal Thai Government, GFDRR, World Bank. Thai Flood 2011: Rapid Assessment for Resilient Recovery and Reconstruction Planning. Bangkok: World Bank, 2012.
8 Webster's New World College Dictionary, 4th Edition. Foster City: John Wiley & Sons Inc, 1999.
9 Reid B. Science and Technology and Disaster Risk Reduction: A review of application and co-ordination needs. Geneva: UNISDR, 2013. Available at: http://www.preventionweb.net/posthfa/documents/Science-and-Technology-for-Disaster-Risk-Reduction.pdf [accessed 25 April 2013].
10 Durant A, Voss P, Watson M, Roberts T, Thomas H, Prata F et al. Real-time in situ measurements of volcanic plume physico-chemical properties using Controlled METeorological balloons. Geophysical Research Abstracts. 2010; 12:EGU2010-4937
11 Sheffi, Y. Business continuity: a systematic approach. In: Richardson HW, Peter Gordon P, and James E. Moore JE (Eds.). Global Business and the Terrorist Threat. UK: Edward Elgar Publishing Limited, 2009, pp32-41.
12 Boaz A, Hayden C. Pro-Active Evaluators: Enabling Research to be Useful, Usable and Used. Evaluation.2002; 8(4):44053.

deliver `the right information, at the right time, for the right people' can appear to compromise traditional academic roles and responsibilities.

The UNISDR Scientific and Technical Committee's 2009 report 'Reducing Disaster Risks through Science: Issues and action' discussed how this challenge can be overcome through improved dialogue between scientists and decision-makers, making the case that science can be made useful for disaster risk reduction. The case studies in this report provide ample evidence that science is usable for disaster risk reduction and, in 2015, the Scientific and Technical Advisory Group aims to show that science is consistently used in disaster risk reduction.

Case studies

Case studies capture the complexity of disaster risk by exploring the detail of a real-life situation. Individually they identify specific lessons for success in risk reduction; together they demonstrate common over-arching principles, which can be seen running through each study [13].

The Intergovernmental Panel on Climate Change Special Report on Managing the Risk of Extreme Events and Disasters (IPCC/SREX) [14] used case study examples as part of its approach to the topic of adaptation to climate change related extreme events and disasters. The case studies described specific examples where policymakers and governments employed scientifically-proven adaptation measures to minimize the impact of climate-related disasters. Three examples [15] are summarized below:

1. ***Heatwave:*** During the first two weeks of August 2003, a heatwave hit Western Europe, particularly France, with maximum temperatures in Paris of 40°C. This resulted in approximately 14,800 excess deaths in France. In response, the French government led the development of a national heatwave plan, surveillance activities, clinical treatment guidelines for heat-related illness, processes for identification of vulnerable populations, infrastructure improvements, and home visiting plans. In July 2006, France experienced another major heatwave, again with maximum recorded temperatures of 39-40°C. This time only around 2,065 excess deaths were recorded.

2. ***Cyclones:*** Bangladesh has a significant history of large-scale disasters including Cyclone Bhola in 1970, which resulted in approximately 300,000–500,000 deaths, and Cyclone Gorky in 1991 with approximately 138,000 deaths.

   The Government of Bangladesh worked in partnership with donors, nongovernmental organizations, scientific and humanitarian organizations and coastal communities to develop:

   • Multi-storied cyclone shelters, built in coastal regions, providing safe refuge from storm surges for coastal populations

13 Grynszpan D, Murray V, Llossa S. The value of case studies in disaster assessment. Prehospital and Disaster Medicine. 2011; doi:10.1017/S1049023X11006406.

14 Intergovernmental Panel on Climate Change (IPCC). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Summary for policymakers (The SREX Report). Cambridge and New York: Cambridge University Press, 2012. Available at: http://ipcc-wg2.gov/SREX/report/ [accessed 8 April 2013].

15 Murray V, McBean G, Bhatt M, Borsch S, Cheong TS, Erian WF, Llosa S, Nadim F, Nunez M, Oyun R, Suarez SG. Case studies. In: Field CB, Barros V, Stocker TF, Qin D, Dokken DJ, Ebi KL, Mastrandrea MD, Mach KJ, Plattner G-K, Allen SK, Tignor M, Midgley PM (eds.). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge and New York: Cambridge University Press, 2012, pp. 487-542.

- A Storm Warning Centre with capacity to detect the formation of tropical depressions in the Bay of Bengal and send early warnings and special bulletins to alert a wide range of user agencies
- A volunteer network to effectively disseminate cyclone warnings among the coastal communities, enabling time-critical actions on the ground such as evacuation to cyclone shelters.

In 2007, these resources were implemented prior to the landfall of cyclone Sidr. Three million people safely evacuated to cyclone shelters. Sidr resulted in approximately 4,200 deaths - a reduction in mortality from previous cyclones.

3. ***Flood:*** After the catastrophic Mozambique 2000 floods which caused the loss of more than 700 lives with over half a million people losing their homes, and affected more than 4.5 million people, national and international organizations including scientific partners updated their strategies to include disaster preparedness, risk management, and contingency and response capacities. The Government of Mozambique introduced new disaster risk management structures between 2000 and 2007, illustrating the flexibility needed to accommodate the scientific and communication systems with the creation and development of effective and steadily functioning systems of hydrological monitoring and early warning systems at a local, regional, and national level as key components for warnings of flooding threats. During the 2007 floods this new programme of disaster risk reduction demonstrated a reduction in consequences with 29 people killed, 285,000 people affected and approximately 140,000 displaced.

The case studies in this report describe how science has been used in disaster risk reduction to make a real difference in people's lives. They were selected from across the breadth of scientific disciplines and from all parts of the globe. They document programmes that scientists themselves felt made a difference in people's lives and which demonstrate what can be achieved through the interplay of science and policy.

The ten case studies are:

1. **Tsunami Warning and Mitigation for the Indian Ocean Region**
2. **Assessing Vulnerability to Improve Risk Reduction**
3. **Flood Early Warning in Bangladesh**
4. **An Earthquake Early Warning for Japanese Bullet Trains**
5. **Watching the Rains to Build Resilience in the African Sahel**
6. **Flood risk reduction in the Netherlands: The 'Room for the River' project**
7. **Preventing Congenital Rubella Syndrome: Health disaster risk reduction through Rubella vaccination**
8. **An Atlas of Hazards and Disaster Risks to Support Disaster Risk Reduction in China**
9. **Mathematical Models for Cambodia to Reduce the Risk of H5N1 Flu Outbreaks in Poultry**
10. **Building Resilience to Earthquakes in Chile**

Further case studies are being collected by the Scientific and Technical Advisory Group and are available online at www.preventionweb.net/go/scitech. We encourage scientists and implementers to submit their own scientific and technical case study examples demonstrating disaster risk reduction.

CASE STUDY 1:

Tsunami Warning and Mitigation for the Indian Ocean Region

Image 1: The 11th March 2011 Tohoku tsunami striking the eastern coast of Japan.
Source: Newscom/Kyodo/WENN.com.

The Problem

On 26th December 2004, the Indian Ocean was struck by a massive earthquake and tsunami which killed 230,000 people and caused widespread destruction [1]. Although we cannot prevent tsunamis, early warning of their approach combined with physical defences and well-practiced evacuation procedures can save many lives.

Prior to 2004, tsunamis were not considered a high-risk hazard, certainly not outside the Pacific Ocean. Tsunami science was a niche scientific field, with little translation of knowledge into practice, even though scientists published work on a possible ocean-wide tsunami in the Indian Ocean just months before the 2004 event [2]. This combined with rapid population growth of coastal communities in the region set the scene for catastrophic consequences for the Indian Ocean rim in 2004.

The science

The early 1960s saw the development and acceptance of plate tectonic theory, wherein earthquakes and volcanoes were first recognised to be the direct manifestation of the forces that create oceans and build continents [3]. The first global seismographic network was established in 1961 [4], allowing earthquakes to be monitored worldwide.

By the 2000s, great advances had been made in earth observations, computer modelling of hazards and telecommunications. Electronic sensors were developed that could rapidly detect earthquake shaking on land and tsunami waves at sea. For instance, the United States National Oceanic and Atmospheric Administration (NOAA) developed the Deep-Ocean Assessment and Reporting of Tsunamis system, known as DART II, in which a

1 Doocy S, Rofi A, Moodie C, Spring E, Bradley S, Burnham G, Robinson C. Tsunami mortality in Aceh Province, Indonesia. Bulletin of the World Health Organization. 2007; 85(2):273-278.
2 Cummins P, Burbidge D. Small threat, but warning sounded for tsunami research. AusGeo News. 2004; 75:4-7.
3 Dewey JF, Bird JM. Mountain belts and the new global tectonics. Journal of Geophysical Research. 1970; 75(14): 2625-2647.
4 Acoustics and Seismics Laboratory, Institute of Science and Technology, The University of Michigan. Handbook: World-wide Standard Seismograph Network. Ann Arbor:University of Michigan, 1964, pp500.

sensor on the ocean floor detects tsunami waves and communicates these to a surface buoy with satellite telecommunications capability[5] (Figure 1).

Computer models were developed that simulate tsunami impacts on communities[6, 7]; and satellites could now transmit signals to high-speed computers, empowering humans to issue local and pan-oceanic tsunami warnings in minutes[8, 9].

The application to policy and practice

In less than three months following the devastating Indian Ocean tsunami, scientists worked together with policymakers to form an international commitment to develop an Indian Ocean Tsunami Warning & Mitigation System (IOTWS). The IOTWS is now fully operational, comprising a set of Regional Tsunami Service Providers (India, Australia, and Indonesia) issuing tsunami advisories to all National Tsunami Warning Centres of the Indian Ocean rim countries[10].The IOTWS also developed the first international guidelines for tsunami hazard and risk assessment[11].

The most heavily affected nations of Indonesia, Sri Lanka and India developed new disaster management policy frameworks, governance structures and national disaster management plans to address tsunami and other natural disaster risks. For instance, the Indonesian Government developed the Presidential Tsunami Master Plan for Reducing Tsunami Risk[12], which is underpinned by national-scale tsunami hazard mapping to establish tsunami shelters and strengthen warning systems for at risk coastal communities.

Did it make a difference?

The IOTWS now provides warnings to all Indian Ocean country members, reaching millions of people who had no warnings in 2004. Furthermore, tsunami hazard mapping and evacuation planning has been carried out for hundreds of coastal communities.

5 Bernard EN, González FI, Meinig C, Milburn HB. Early detection and real-time reporting of deep-ocean tsunamis. In: Proceedings of the International Tsunami Symposium 2001 (ITS 2001) (on CD-ROM), NTHMP Review Session, Seattle, WA, 7–10 August 2001.

6 Shuto N, Goto T. Numerical simulation of tsunami run-up. Coastal Engineering Japan. 1978;21:5-9.

7 Titov V, Synolakis C. Numerical modeling of tidal wave runup. Journal of Waterway, Port, Coastal and Ocean Engineering. 1998; 124(4):157-171.

8 Rudloff A, Lauterjung J, Münch U, Tinti S. The GITEWS Project (German-Indonesian Tsunami Early Warning System). Natural Hazards and Earth System Sciences. 2009; 9:1381-1382.

9 Crawford G. 2005. NOAA Weather Radio (NWR) - a coastal solution to tsunami alert and notification. In: Bernard EN (editor). Developing Tsunami-Resilient Communities. Dordrecht: Springer Netherlands, 2005.

10 United Nations Educational, Scientific and Cultural Organization (UNESCO). Indian Ocean Tsunami Warning System Up And Running [webpage]. 2006. Available at: http://portal.unesco.org/en/ev.php-URL_ID=33442&URL_DO=DO_TOPIC&URL_SECTION=201.html [accessed 20 March 2013].

11 Intergovernmental Oceanographic Commission.Tsunami risk assessment and mitigation for the Indian Ocean; knowing your tsunami risk – and what to do about it. IOC Manual and Guides No. 52. Paris: UNESCO, 2009.

12 Indonesian National Disaster Management Agency. Presidential Master Plan for Tsunami Risk Reduction. 2012.

Gains in tsunami preparedness were demonstrated during the 12 April 2012 magnitude 8.5 earthquake offshore of northern Sumatra, Indonesia. Although no tsunami eventuated, due to the large magnitude and location, a tsunami warning was issued in several countries. In Banda Aceh, where most of the tsunami-related deaths occurred in 2004, over 75% of the population started to evacuate soon after the earthquake[13]. Despite this, traffic jams slowed the evacuation considerably[14], demonstrating that challenges still remain in getting dense populations to safety within very short warning timeframes.

Meanwhile, the 2011 Tohoku tsunami severely tested Japan's highly advanced warning system, seawalls and evacuation plans (Image 1). Tragically 18,000 people lost their lives[15], totalling 4% of the population located in the inundation area. In comparison, the 2004 Indian Ocean Tsunami resulted in over 20% fatalities in the inundation area[16]. While any fatalities are shocking, it is clear that the application of science and technology can save lives.

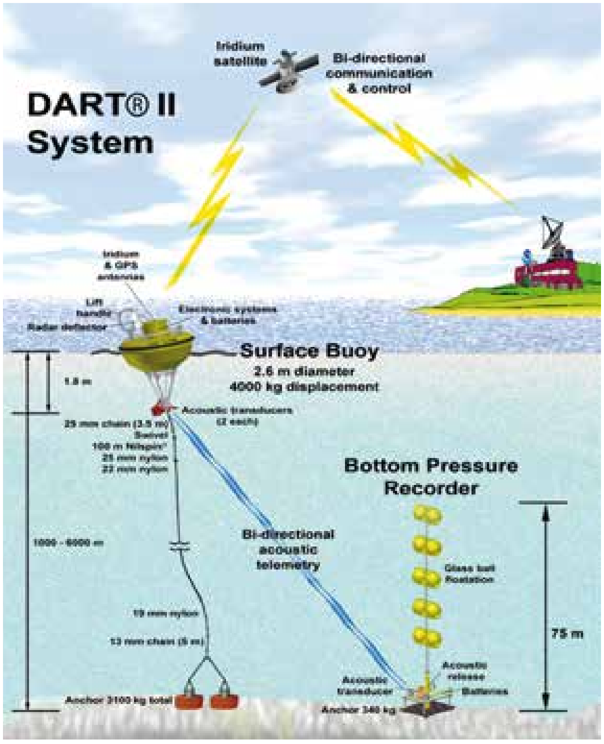


Figure 1: Overview of the DART II System for tsunami detection. *Source: National Oceanic and Atmospheric Administration*[17].

13 Goto Y, Affan M, Fadli, N. Quick Report No. 2: Response of the people in Banda Aceh just after the 2012 April 11 Off-Sumatra earthquake (M8.5). 2012. Available at: http://www.recoveryplatform.org/assets/publication/goto%20report%20aceh%20tsunami%20evacuation%202012.pdf [accessed 8 April 2013].

14 *Ibid.*

15 National Police Agency of Japan. 2013. Countermeasures for the Great East Japan Earthquake: Damage Situation and Police Countermeasures [webpage]. 2013. Available at: http://www.npa.go.jp/archive/keibi/biki/index_e.htm [accessed 8 March 2013].

16 Doocy S, Rofi A, Moodie C, Spring E, Bradley S, Burnham G, Robinson C. Tsunami mortality in Aceh Province, Indonesia. Bulletin of the World Health Organization. 2007; 85(2):273-278.

17 National Oceanic and Atmospheric Administration (NOAA). DART II System. Available at: http://www.ndbc.noaa.gov/dart/dart.shtml [accessed 29 April 2013]

CASE STUDY 2:

Assessing Vulnerability to Improve Risk Reduction

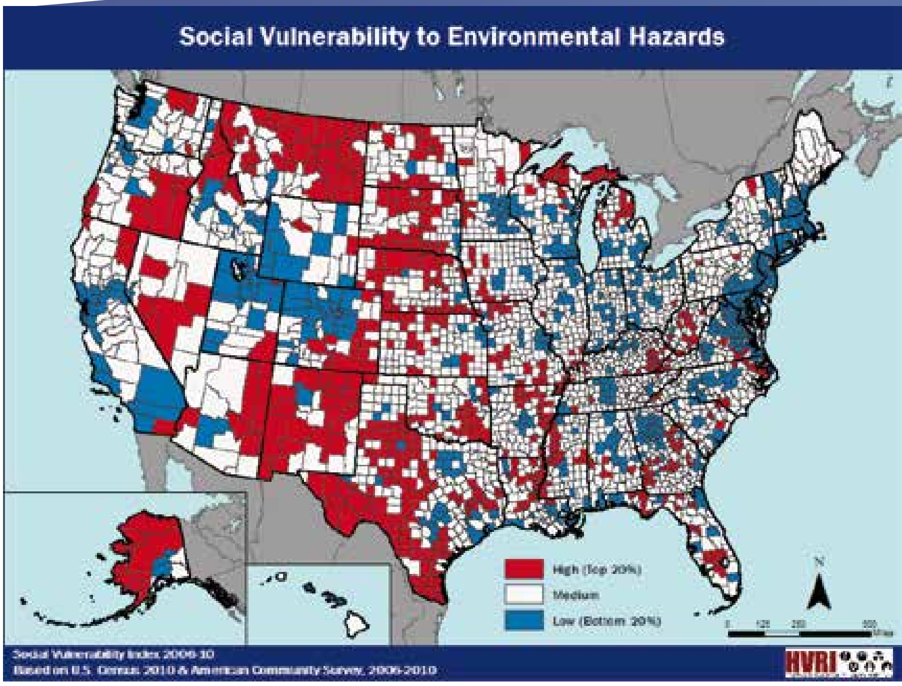


Figure 1: Social Vulnerability Index for the United States, 2006-2010.
Source: Hazards and Vulnerability Research Institute[5].

The problem

The risk of a disaster depends not only the hazard – the likely severity of flooding or height of a tsunami – but also on the physical and social vulnerability of exposed communities[1]. Assessment of vulnerability is therefore essential for effective, targeted disaster risk reduction but our current knowledge of what makes people and places vulnerable to environmental threats is limited.

Until we have an evidence-based method for assessing vulnerability in communities, and for communicating this data in a clear and accessible way, policy-makers cannot make fully informed decisions on effective, targeted disaster risk reduction.

The science

In order to describe the vulnerability of populations, researchers in the United States used social science and risk science to develop a tool for measuring environmental hazard vulnerability[2–4]. Data on the impact of disasters on different communities in the United States were analysed and compared with socioeconomic and demographic data for the affected areas. This process identified a set of factors that are associated with a community's ability to prepare for, respond to, and recover from hazards. These included: urbanicity of an area, race/ethnicity of the population, average education levels, percentage of the population living in poverty and percentage under 5 or over 65 years old[5].

1 IPCC. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Summary for policymakers (The SREX Report). Cambridge and New York: Cambridge University Press, 2012. Available at: http://ipcc-wg2.gov/SREX/report/ [accessed 8 April 2013].

2 Hazards and Vulnerability Research Institute, University of South Carolina. Social Vulnerability Index [webpage]. 2012. http://webra.cas.sc.edu/hvri/products/sovi.aspx [accessed 25 March 2013].

3 Borden K, Schmidtlein MC, Emrich C, Piegorsch WP, Cutter SL. Vulnerability of US Cities to Environmental Hazards. Journal of Homeland Security and Environmental management. 2007; 4(2):Article 5.

4 Cutter SL, Boruff BJ, Shirley WL. Social Vulnerability to Environmental Hazards. Social Science Quarterly. 2000; 84(1):242-261.

5 Hazards and Vulnerability Research Institute, University of South Carolina. Social Vulnerability Index [webpage]. 2012. http://webra.cas.sc.edu/hvri/products/sovi.aspx [accessed 25 March 2013].

Knowledge of these associations was used to construct an index of vulnerability to environmental hazards. This was named the Social Vulnerability Index (SoVI) and calculates a vulnerability score for individual counties across the United States [6]. By applying the SoVI to case studies of previous disasters, the reliability of the SoVI in predicting vulnerability was assessed and improved (Figure 1) [7–9].

The application to policy and practice

The SoVI has been integrated with a mapbased system to produce a decision support tool kit for policy-makers. County-level SoVI data and maps are now produced regularly for the whole of the United States (Figure 2). The Index has been adapted as the theory and practice of vulnerability science has developed, with additional vulnerability factors added, such as vehicle availability and family structure [10, 11].

SoVI data are included in county- and State-level mitigation plans throughout the United States as part of government-required vulnerability assessments. Now, instead of solely indicating where hazards are likely to occur – using tools such as the Spatial Hazards Events and Losses Database for the United States (SHELDUS) [12] – a more detailed risk model can be created for a region by layering hazard mapping with social vulnerability. Decision-makers can use this to determine where resources might be used most effectively to reduce pre-existing vulnerability.

The use of SoVI extends beyond the United States. A global database of country-specific vulnerability data is being established for 197 different countries [13]. The governments of countries including Norway, Portugal, the Philippines, Indonesia and Brazil have incorporated SoVI into planning tools to inform preparedness for future events at the municipal and regional levels [14].

6 Hazards and Vulnerability Research Institute, University of South Carolina. Social Vulnerability Index [webpage]. 2012. http://webra.cas.sc.edu/hvri/products/sovi.aspx [accessed 25 March 2013].
7 Schmidtlein MC, Shafer JM, Berry M, Cutter SL. Modeled earthquake losses and social vulnerability in Charleston, South Carolina. Applied Geography. 2011; 31(1):269-281.
8 Cutter SL, Mitchell JT, Scott MS. Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. Annals of the AAG. 2000; 90(4): 713-7737.
9 Schmidtlein MC, Deutsch R, Piegorsch WW, Cutter SL. A Sensitivity Analysis of the Social Vulnerability Index. Risk Analysis. 2008; 28(4): 1099-1114
10 Hazards and Vulnerability Research Institute, University of South Carolina. Social Vulnerability Index [webpage]. 2012. http://webra.cas.sc.edu/hvri/products/sovi.aspx [accessed 25 March 2013].
11 Cutter SL, Finch C. Temporal and Spatial changes in Social Vulnerability to Natural Hazards. Proceedings, National Academy of Sciences. 2008; 105(7): 2301-2306.
12 Borden K, Schmidtlein MC, Emrich C, Piegorsch WP, Cutter SL. Vulnerability of US Cities to Environmental Hazards. Journal of Homeland Security and Environmental management. 2007; 4(2):Article 5.
13 The GEM Foundation. What We Do – Understanding vulnerability for increased resilience. http://www.globalquakemodel.org/what/global-projects/social-vulnerability/ [accessed 4 April 2013].
14 Cutter SL (Editor). From Social Vulnerability to Resilience: Measuring Progress toward Disaster Risk Reduction. Source 17/2013, Bonn, Germany: United Nations University Institute for Environment and Human Security, and MunichRe Foundation. Forthcoming.

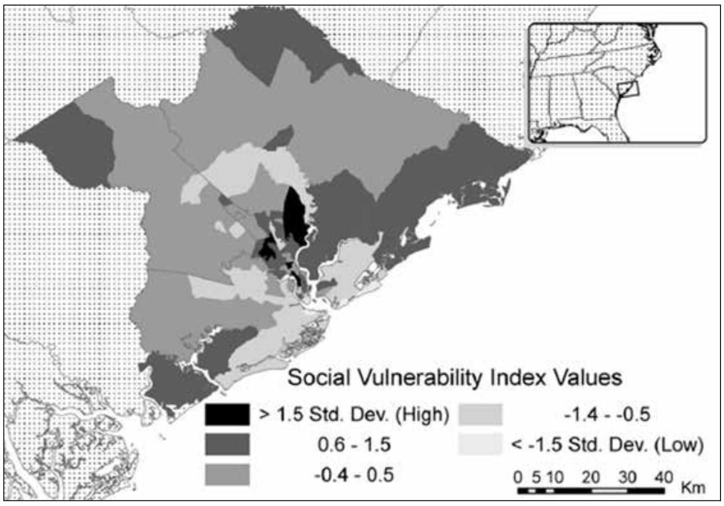


Figure 2: Social Vulnerability Index (SoVI) values for the Charleston area of South Carolina, USA. This was a case study used to test and verify the SoVI. The higher the SoVI value, the greater the social vulnerability in that area. *Source: Schmidtlein et al, 2011* [15].

Did it make a difference?

The impact of this research on policy and practice has been significant, changing the nature of vulnerability assessments in the United States and beyond. Decision-makers now have a tool for making evidence-based decisions regarding hazard preparedness, planning, response, and reduction at the federal, state, and local levels.

In the United States, the SoVI has helped to improve long-term recovery efforts from 2012's Hurricane Sandy. The Federal Emergency Management Agency (FEMA) integrated SoVI into its planning- and decision-support metrics to assess affected communities' likely capacity to respond and recover from the hurricane. This has allowed more targeted allocation of resources for recovery.

SoVI has also had impact on flood control. The US Army Corps of Engineers has responsibility for construction of flood control structures during flood events; in the past, decisions on construction of such structures were based solely on cost-benefit analysis, in terms of the value of property protected. With SoVI, decisions on where to construct flood defences are now be focused on location of vulnerable populations [16].

SoVI data has raised awareness of social vulnerability and the fragility of at risk-populations; it is helping to explain communities' differential recovery from disasters and will help train the next generation of disaster risk reduction scientists and responders.

15 Schmidtlein MC, Shafer JM, Berry M, Cutter SL. Modeled earthquake losses and social vulnerability in Charleston, South Carolina. Applied Geography. 2011; 31(1):269-281.
16 Dunning M, Durden SE. Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning. December 2009.

Image 1: Flooding in Bangladesh.
Source: SHM Fakhruddin.

CASE STUDY 3:

Flood Early Warning in Bangladesh

The problem

In Bangladesh, flooding is common during the yearly monsoon rains and has significant impact on health, the economy and development. In 1998, more than two-thirds of the country was inundated with floodwater for three months, an estimated 1,000 people drowned and millions were left homeless [1].

The Ganges–Brahmaputra-Megna delta is the largest river delta in the world and makes up 80% of the area of Bangladesh. Most years, one-fifth to one-third of the country floods as the rivers overflow [2]. Not only are lives and homes destroyed but agricultural materials and livestock are also lost, resulting in huge economic losses (Image 1). Poorer farmers often purchase stocks on credit; loss of their crop or livestock in a flood can put the household into debt for many years.

Although flooding occurs most years in Bangladesh, it is irregularly timed and affects variable areas, making mitigation and preparedness difficult.

1 Webster P. Improve weather forecasts for the developing world. Nature. 2013; 493:17-19.
2 Babel MS, Fakhruddin SHM, Kawasaki A. A Decision Support Framework for Flood Risk Assessment: An Application to the Brahmaputra River in Bangladesh. In: Chavoshian A, Takeuchi K (Eds.). Floods: From Risk to Opportunity. Oxford: IAHS Press, 2013.

The science

Forecasts giving sufficient notice of likely floods would support timely evacuations, protection of assets as well as tactical decisions regarding the timing of planting and treating crops.

A project to develop and apply such monsoon flood forecasts was undertaken in 2000-09 within the Climate Forecast Applications Network (CFAN), a consortium of international and Bangladeshi organisations and institutes [3].

The resulting forecast system uses a variety of data including: weather forecast data from a European climate model; satellite and surface precipitation data from US satellites and local data collection; daily measures of the Ganges and Brahmaputra streamflow and meteorological data such as wind, humidity and temperature.

Proven statistical techniques then assess how well the precipitation forecasts compare with observed precipitation and make required corrections. Modelling of likely groundwater movement is then added. A probabilistic flood forecast is produced, giving the percentage likelihood of flooding (Figure 1) [4–6].

Testing over the next few years showed that the model's forecasts match well with the rainfall and river flow that is actually observed [7–8].

The application to policy and practice

Since 2004, the Bangladesh Flood Forecasting and Warning Centre (FFWC), with support from CFAN and later the Regional Integrated Multi-Hazard Early Warning System (RIMES), has been using its model to produce daily, 7-10-day flood forecasts. The forecasts are integrated into Bangladesh's disaster-management protocol by local experts.

In 2007, six flood-prone unions (equivalent to counties) were developed as pilot sites for community-level use of the forecasts (Figure 2). Community leaders were trained to receive forecasts by cell phone and to use local landmarks to express the likely level of flooding in terms that are clear and useful for villagers. Community leaders

3 *Ibid.*
4 *Ibid.*
5 Hopson TM, Webster PJ. A 1–10-day ensemble forecasting scheme for the major river basins of Bangladesh: Forecasting severe floods of 2003-07. Journal of Hydrometeorology. 2010; 11:618-641.
6 Webster PJ, Jian J, Hopson TM, Hoyos CD, Agudelo PA, Chang H-R, Curry JA, Grossman RL, Palmer TN, Subbiah AR. Extended-Range Probabilistic Forecasts of Ganges And Brahmaputra Floods in Bangladesh. Bulletin of the American Meteorological Society. 2010; 91(11):1493-1514.
7 Hopson TM, Webster PJ. A 1–10-day ensemble forecasting scheme for the major river basins of Bangladesh: Forecasting severe floods of 2003-07. Journal of Hydrometeorology. 2010; 11:618-641.
8 Webster PJ, Jian J, Hopson TM, Hoyos CD, Agudelo PA, Chang H-R, Curry JA, Grossman RL, Palmer TN, Subbiah AR. Extended-Range Probabilistic Forecasts of Ganges And Brahmaputra Floods in Bangladesh. Bulletin of the American Meteorological Society. 2010; 91(11):1493-1514.

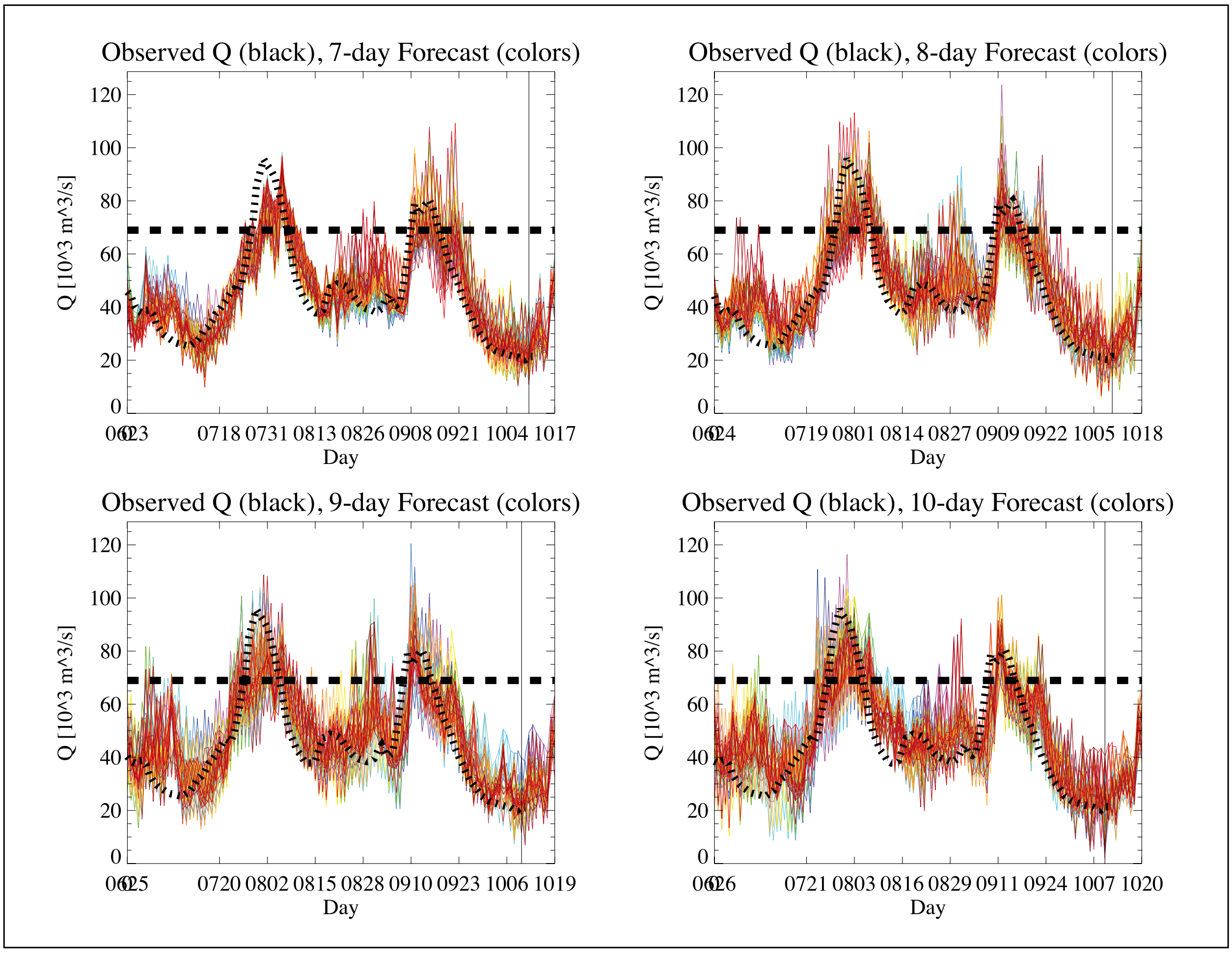


Figure 1: Graphs comparing the CFAN-RIMES model forecasts with observed river flow for the Brahmaputra in 2007. The wide, coloured band represents the output of each of the model's predictions. The thin dotted black line indicates the observed values of river discharge. The closeness of the coloured and black lines shows that the model is reliable in predicting flooding. *Source: RIMES* [9].

advise action such as telling farmers to harvest their crops or take cattle to safety, and telling households to store water, food and personal belongings ahead of a flood.

"We disseminate the forecast information and how to read the flag and flood pillar to understand the risk during the prayer time" reported one village Imam from Sirajgong District.

Did it make a difference?

Bangladesh experienced three major floods in 2007 and 2008. Each was forecast successfully 10 days in advance and action was taken. Communities moved to evacuation points in advance, fisheries were protected by nets, crops were harvested early ahead of impending floods, households were warned to store food and drink in advance, and mechanized boats were readied in case evacuation of farmers on river islands became necessary.

Speaking of the 2008 floods, the Imam from Sirajgong District tells: "In my field, T. Aman [a type of rice] was at seedling and transplanting stage, I used the flood forecast information for harvesting crops and making decisions for seedling and transplantation of T. Aman...Also we saved household assets."

One analysis concluded that approximately US$40 was saved for every dollar invested in the regional forecasting and warning system [10]. The Asian Disaster Preparedness Center estimated that the average savings were US$400-500 per affected household [11]. Preventing the loss of one livestock animal, for instance, was shown to save a household around US$500: about one year's income in Bangladesh.

In flood-prone Bangladesh, flood forecast technology now plays a crucial role in saving lives and properties.

9 RIMES Flood Forecast database. Available at: http://www.rimes.int/wrh/flood-forecast [accessed 5 April 2013].

10 Webster PJ, Jian J, Hopson TM, Hoyos CD, Agudelo PA, Chang H-R, Curry JA, Grossman RL, Palmer TN, Subbiah AR. Extended-Range Probabilistic Forecasts of Ganges And Brahmaputra Floods in Bangladesh. Bulletin of the American Meteorological Society. 2010; 91(11):1493-1514.

11 Asian Disaster Preparedness Centre (ADPC). Flood Forecasts Application for Disaster Preparedness: Post Flood Forecasts Assessment 2008: community Response to CFAN Forecasts. ADPC, 2009.

Image 1: A derailed Shinkansen bullet train, Niigata Prefecture, Japan, 2004. *Source: Japanese Transportation Safety Committee*.

CASE STUDY 4:

An Earthquake Early Warning for Japanese Bullet Trains

The problem

Lying on the 'Ring of Fire' around the Pacific Ocean, Japan is prone to major earthquakes. These earthquakes pose significant risks to infrastructure, especially to the Shinkansen – the Japanese high speed railway system – whose bullet trains travel at speeds of up to 300 km per hour (188 miles per hour). If a train were travelling at such speeds when an earthquake hit it could be derailed, leading to disastrous loss of life. Image 1 shows a Shinkansen bullet train derailed in the Niigata Prefecture, Japan, 2004; none of the 154 passengers on board were injured or killed [1].

1 Ogura M. The Niigata Chuetsu Earthquake - Railway Response and Reconstruction. Japan Railway & Transport Review. 2006; 43; 46-63.

The science

Scientific study of ground movements before and during earthquakes led to the discovery of two different types of seismic wave that transmit an earthquake's energy through the ground: P-waves (P stands for Primary), and S-waves (S for Secondary). P-waves travel fastest from the earthquake's hypocentre but cause only a few preliminary earth tremors. The main earth movements we feel in an earthquake, and that cause most damage, are caused by the slower-moving S-waves (Figure 1) [2]. Scientists have used this understanding to develop better and better seismometers, sensitive measuring instruments which can detect even very weak P-waves [3–5].

2 *Ibid.*
3 *Ibid.*
4 Shimamura M, Yamamura K. A study on the performance of Seismic Early warning system. Proceedings of Railway Mechanics. 2008; 12:131-138.
5 Ashiya K, Sato S, Iwata N, Korenaga M, Nakamura H. Application of earthquake early warning information to earthquake alarm systems in railways. Exploration Geophysics. 2007; 60:387-397.

Based on this scientific advance, the technology of earthquake early warning was developed. When a seismograph detects fast-travelling P-waves, we know that destructive S-waves are likely to follow in a few seconds (depending on where the seismograph is relative to the earthquake's hypocentre). Given that electrical signals travel at much faster speeds than S-waves, automatic response signals can be activated within these few seconds, sending out warnings and activating mechanisms that reduce the vulnerability of transport systems, manufacturing plants, and nuclear and chemical processes[6, 7].

The application to policy and practice

The Urgent Earthquake Detection and Alarm System (UrEDAS) was introduced to the Shinkansen in 1992. Seismometers are placed at points along the train tracks and at the coast (to sooner detect seismic waves from earthquakes off the coast, Figure 1). If P-waves are detected, it is assumed that a large earthquake is coming and the power supply from electricity substations to the tracks is automatically stopped, triggering emergency brakes on all moving trains. The trains therefore come to a halt in the seconds before the earthquakes hit, making them far less likely to derail[8].

Alongside the UrEDAS, anti-seismic reinforcement works – such as quakeproof bridges and tunnels – as well as anti-derailing systems have been introduced to increase the resilience of the physical rail network.

Did it make a difference?

On the afternoon of 11th March 2011, a seismometer at Kinkazan Island on the north east coast of Japan detected seismic P-waves and sent an automatic stop signal via the UrEDAS to the Shinkansen's electric power transmission system, triggering the emergency brakes on 27 bullet trains. Ten seconds after the warning signal went out, a massive 8.9 Magnitude earthquake hit mainland Japan. Although this 'Great East Japan Earthquake', and the following tsunami, caused immense destruction and loss of life in eastern Japan, none of the 19 trains running through the affected area were derailed and no casualties were sustained on the trains.

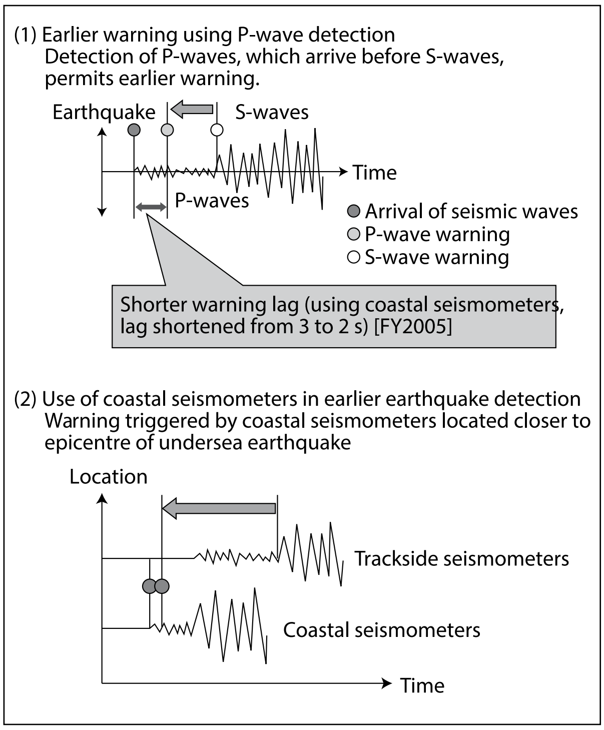


Figure 1: Diagrams showing the additional seconds of warning time given by improved detection of P-waves and use of coastal seismometers. *Source: Ogura, 2006*[9].

6 Shimamura M, Yamamura K. A study on the performance of Seismic Early warning system. Proceedings of Railway Mechanics. 2008; 12:131-138.
7 Ashiya K, Sato S, Iwata N, Korenaga M, Nakamura H. Application of earthquake early warning information to earthquake alarm systems in railways. Exploration Geophysics. 2007; 60:387-397.
8 Ogura M. The Niigata Chuetsu Earthquake - Railway Response and Reconstruction. Japan Railway & Transport Review. 2006; 43; 46-63.
9 *Ibid.*

Image 1: Workshop participant playing the 'Early Warning-Early Action game' with community and civil society leaders in Senegal, November 2012. *Source: AfClix.*

CASE STUDY 5:

Watching the rains to build resilience in the African Sahel

The problem

The vulnerability of rural populations in sub-Saharan Africa to increased climate variability – in the form of drought and flood – and environmental change remains alarming, despite their centuries of experience in adapting to harsh conditions[1]. As 2012 drew to a close, 18.7 million people were threatened by severe food shortages[2]. The recurring food crises in the Sahel can be attributed to a compounding series of socio-political and weather related causes: limited access to food and basic services for the poorest, low food productivity, acute poverty, environmental degradation, rapid population growth (3% per year), weak governance and high dependence on rain-fed agriculture[3]. The importance of early warning has been underlined as a critical element for reducing vulnerabilities and improving preparedness and response to natural hazards.

The science

The 'Rainwatch' Geographical Information System was developed in the mid-2000s to monitor cumulative rainfall at nine stations distributed across, and representing fully, the economically vital southern agricultural region in Niger[4]. Its database includes historical rainfall for each station. By monitoring the rainfall deficit during each monsoon season, and factoring in assumptions of the physically possible range of subsequent rainfall, the Rainwatch project produces commentaries on the monsoon evolution and releases early warnings if drought is anticipated.

Users can view cumulative daily rainfall graphs for each station, with historical trends and extremes added to give context. Graphs can also be created to compare data from different stations in the same year or for the same station across different years (Figure 1)[5].

Rainwatch was designed to deliver science as visual and understandable rainfall products that enable stakeholders to act. Its development was informed by needs on the ground in an effort to increase interactions between local climate information users, their providers, and supporting groups.

The application to policy and practice

Rainwatch products were developed in the late 2000's. From 2011, early warnings for Niger were disseminated widely within West Africa, the United States and Europe at 10- or 15-day intervals.

To integrate the use of Rainwatch data into decision-making and practice, the Africa Climate Exchange (AfClix)[6] – a regional boundary organisation – combined technical expertise in meteorology and social science approaches to engage decision-makers (such as NGOs and government), African climate scientists and local communities in countries beyond Niger. Dialogue was opened around the use and the limitations of the data (Image 1), knowledge exchange was facilitated and networks for communication between the groups were

1 Nimir MB, Elgizouli IA for WorldResourcesReport.org. Expert Perspectives: Climate Change Adaptation and Decision Making in the Sudan. 2011. Available at: http://www.worldresourcesreport.org/responses/climate-change-adaptation-and-decision-making-sudan.
2 Cornforth RJ. The West African Monsoon 2012. Weather. 2013 (in press).
3 Genesio L, Bacci M, Baron C, Diarra B, Di Vecchia A, Alhassane A et al. Early warning systems for food security in West Africa: evolution, achievements and challenges. Atmospheric Science Letters. 2011; 12:142–148.
4 Tarhule A, Saley-Bana Z and Lamb PJ. Rainwatch: A prototype GIS for rainfall monitoring in West Africa. Bulletin of the American Meteorological Society. 2009; 90:1607-1614.
5 *Ibid.*
6 Africa Climate Exchange (AfClix). Available at: http://www.afclix.org [accessed 4 April 2013].

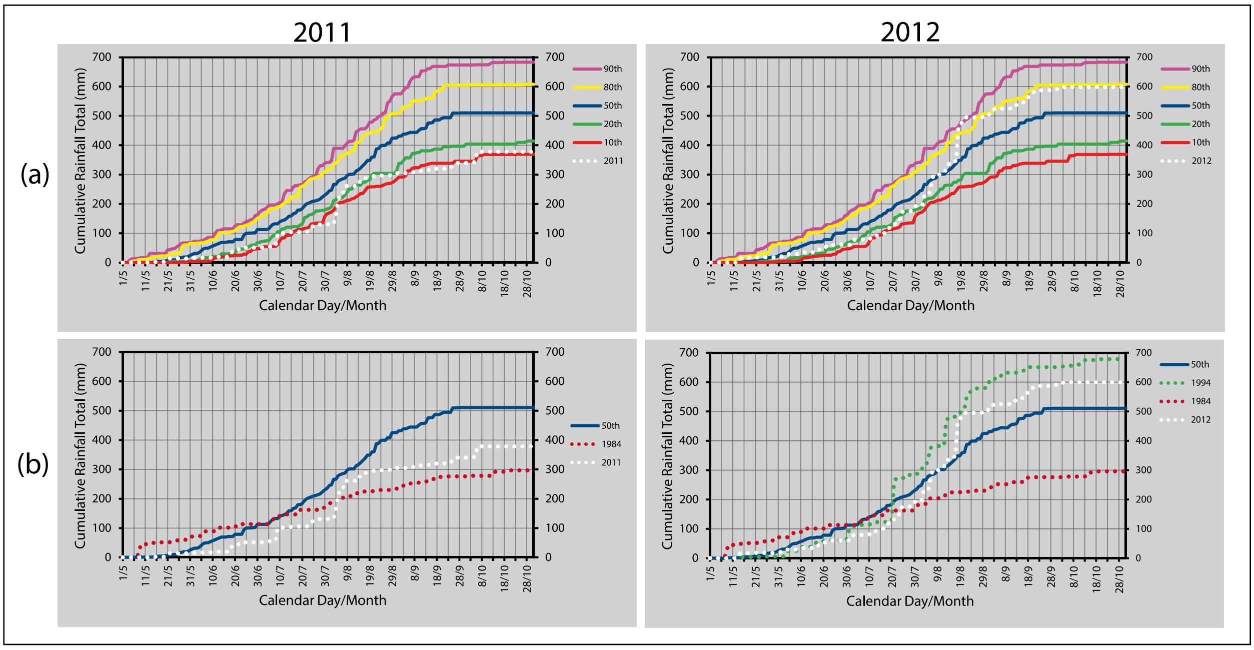


Figure 1: Rainwatch cumulative precipitation depiction for Niamey, Niger, for 2011 (the two graphs on the left) and 2012 (the two graphs on the right). The two top graphs compare the progression of the 2011 and 2012 rainy seasons (white dots) versus indicated historical percentiles for 1965-2000. The two bottom graphs compare the progression of the 2011 and 2012 rainy seasons (white dots) with the severe drought year of 1984 drought year (dark red dots), the very wet year of 1994 (green dots), and the historical median (blue dots). *Source: Boyd et al, 2013*[7].

established to extend Rainwatch to other countries in the African Sahel, including Sudan and Senegal[7]. This approach builds relationships from the national to local level and helps ensure that the Rainwatch products and warnings are designed by the stakeholders themselves according to their information needs.

Did it make a difference?

Real-time monitoring of the very dry 2011 and very wet 2012 monsoon seasons in Niger was accomplished using Rainwatch. In 2011, Rainwatch alerts warned of rainfall deficits and that "… the start of the Niger rainy season has been very poor at six of the nine stations … At some of the driest stations, the 2011 rainfall to date has been less than for the infamous 1984 drought year" (31 July 2011)[8].

The Niger government uses Rainwatch together with information from the Direction de la Météorologie Nationale du Niger (DMN), African Centre of Meteorological Applications for Development (ACMAD), and Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle (AGRHYMET) to understand monsoon development.

In the words of one senior Niger government official: "… [the] possibility of having daily monitoring as provided by Rainwatch seemed to me what the users at agricultural and livestock departments needed to use as input to provide good information for warnings." (Special Advisor to President of Niger for Water and Environmental Issues, Professor Abdelkrim Ben Mohamed, May 17, 2012). In 2011, user-friendly Rainwatch products were provided directly to the Office of the President and the DMN, to help them assess the monsoon. The DMN provides climate information to the Ministry of Agriculture, which then combines it with in-field phenological data to assess the growing season. This information is used by the Council of Ministers to issue early warnings to the Niger people[9].

Rainwatch showed that effective links between climate science and policy decision-making could influence policy and action on the ground. Even in the absence of coherent national climate strategies, individuals with the appropriate tools and methodologies – such as Rainwatch – can establish effective links via a boundary organization like AfClix, across a range of disciplines, regions, and levels of decision-making, to communicate climate risk and uncertainty effectively for action-oriented results. This framework is now being tested to support both rural and urban communities in conflict regions in Sudan[10].

7 Boyd E, Cornforth RJ, Lamb PJ, Tarhule A, Lélé MI, Brouder A. Building resilience in the face of recurring crises in the African Sahel. Nature Climate Change. 2013 (in press).

8 *Ibid.*

9 *Ibid.*

10 Africa Climate Exchange (AfClix). Available at: http://www.afclix.org [accessed 4 April 2013].

CASE STUDY 6:

Flood Risk Reduction in the Netherlands: The "Room for the River" project

The problem

Four major European rivers run into the North Sea through the Dutch delta making almost 60% of the country vulnerable to large-scale flooding[1]. Major flood defence work was undertaken throughout the previous centuries, including the construction of thousands of kilometres of dikes. However, as the Netherlands' population and assets have continued to grow, the land they inhabit beyond the protective dikes has subsided.

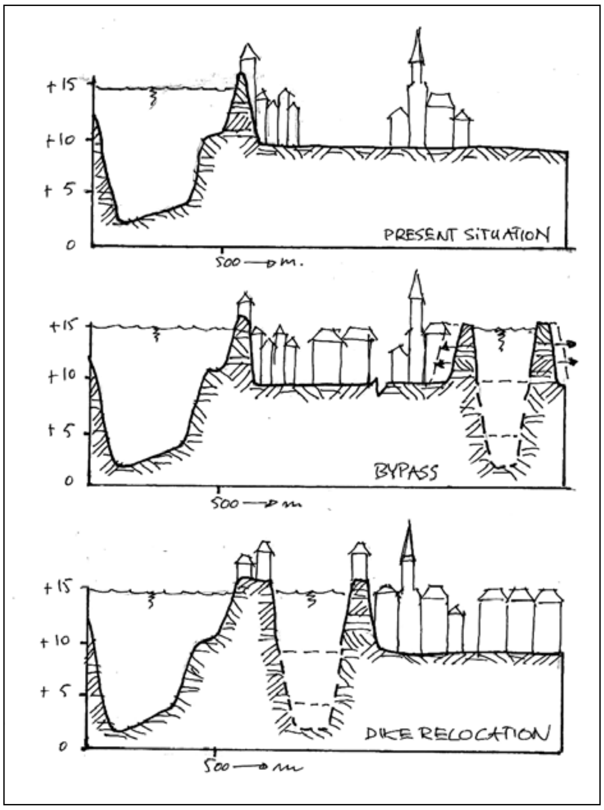


Figure 1: Options for increasing river flow at Nijmegen. The top drawing represents the current situation. The middle drawing shows a bypass channel with 8m-high dikes, excavated down or not, creating a "mini polder". The bottom drawing shows a 200m backward dike relocation creating a side channel in the river around an island of former dike, this channel may be excavated or not. *Source: van Alphen, 2003*[2].

1 Dutch Ministry of Infrastructure and the Environment. Delta Programme 2013. Working on the Delta.The Hague: Ando, 2012.
2 van Alphen J, Alberts J, Kors A. Dig or Dike? Resilience of the Dutch River Rhine System in view of increased discharges: strategy, measures and first examples. ISDB 2003, Niigata, Japan, 7th-10th December 2003.

"January 1995: Europe has been savaged by rainstorms for days. The water level in the Dutch rivers begins to rise rapidly. The risk of dike breaches becomes greater and greater and could result in flooding for miles across the flat Netherlands. A total of 250,000 people are evacuated."[3]

Near floods such as the one in January 1995 highlighted the pressing need to re-think how the rivers could be contained now and in the future. In the Dutch city of Nijmegen, plans for a large riverside urban development, combined with expected river level rises, required a 'now or never' decision on flood prevention[4].

The science

The Dutch Government used engineering science to undertake the 'Resilience Study', modelling the likely effect of flood risk reduction measures along the course of the Rhine and its branches[5].

Experts considered extreme river discharges into the Rhine and how this might increase due to climate change. They factored in sedimentation rates on river beds and scientific understanding of how water flows through channels and around obstacles[6]. They could then create computer models to predict how different interventions might help protect against flooding, now and in the future. These included floodplain lowering, temporary storage of water, removal of obstacles like ferry ramps, channel deepening, backward dike relocations and creation of bypass channels at narrow points in the river[7].

The application to policy and practice

The city of Nijmegen straddles the Waal River – the largest branch of the Rhine – at a point where the river makes a large bend and rapidly narrows, creating a bottleneck. The expected increase in extreme river discharge, due to climate change, could result in river levels rising by 80cm at Nijmegen in the coming decades. In addition, a proposal was recently made to build 12,000 new houses behind the protective dike on the north side of the river. If allowed, this development would reduce options for improving flood defences now and in the future.

3 Nijssen P, Schouten M. Dutch national Room for the River project: Integrated approach for river safety and urban development.1st IS.Rivers conference, 26-28 June 2012, Lyon, France.
4 van Alphen J, Alberts J, Kors A. Dig or Dike? Resilience of the Dutch River Rhine System in view of increased discharges: strategy, measures and first examples. ISDB 2003, Niigata, Japan, 7th-10th December 2003.
5 *Ibid.*
6 *Ibid.*
7 *Ibid.*

The knowledge and principles employed in the 'Resilience Study' were therefore used to evaluate the specific options available that would protect Nijmegen from the predicted river level rises and the likely flood risk. The options included deepening the river bed in the bend itself, lowering downstream floodplains, digging a new bypass channel to carry water in times of flooding, and inland relocation of the current dike to widen the river channel (Figure 1)[8, 9].

Local government officials and engineering experts assessed these options in consultation with communities, taking account of the social and economic needs of local communities and each option's potential for improving the environmental quality of the area[10].

The decision was taken to relocate a stretch of the dike at the river bend, moving it 350 metres inland. Detaching the old stretch of dike from the new dike layout and flooding the area in between the two will create a new side channel in the river, providing extra river flow capacity. The one kilometre stretch of former dike will become an island in the river, to be developed with new housing and nature reserves and connected by a new bridge (Figure 2). The channel will be developed for water recreation, with urban waterfront development at points along the new dike.

Did it make a difference?

At Nijmegen, the threat of river flooding has been turned into an opportunity to create a whole new waterfront and an urban island in the River Waal. This was a difficult decision to make as relocation of the dike will result in the demolition of fifty houses and a number of businesses[11]; however this was seen as the best, safest and most future-proof option to protect Nijmegen from floods now and in the future.

The plans have received international recognition for combining flood safety construction with close community involvement (International Waterfront Award, 2011) and for communication strategy (Red Dot Public Space Award, 2011)[12].

Figure 2: The 'Room for the River' plan at Nijmegen. The green line indicates the current line of the protective dike. The red line shows the position of the proposed relocated portion of dike. In the bottom image, the new river channel is shown in blue and the new island in yellow/green. The white arrows represent the bridge connections planned for the island.
Source: Nijssen and Schouten, 2012[13].

8 *Ibid.*

9 van Alphen JSLJ. How to eliminate a hydraulic bottleneck: Nijmegen the first example in the Netherlands. Proceedings of the Second International Symposium on Flood Defence 2002. New York: Science Press, 2002, pp.651-658.

10 van Alphen J, Alberts J, Kors A. Dig or Dike? Resilience of the Dutch River Rhine System in view of increased discharges: strategy, measures and first examples. ISDB 2003, Niigata, Japan, 7th-10th December 2003.

11 Nijssen P, Schouten M. Dutch national Room for the River project: Integrated approach for river safety and urban development.1st IS.Rivers conference, 26-28 June 2012, Lyon, France.

12 *Ibid.*

13 *Ibid.*

Image 2: A child receives a rubella vaccination.
Source: Wellcome Images.

CASE STUDY 7:

Preventing Congenital Rubella Syndrome: Health disaster risk reduction through Rubella vaccination

The problem

When a woman contracts the disease rubella (or German measles) in early pregnancy, her unborn baby also becomes infected. While the woman may experience only a mild illness, the unborn baby will suffer major birth defects such as deafness, blindness, heart defects, and blood disorders. Severe learning disabilities can also occur; these may worsen throughout life and may also be associated with deformities of the skull (such as a small head size, as seen in Image 1). In some cases the unborn baby will die from the infection[1, 2].

Rubella is an infectious disease caused by a virus. It spreads from person to person through sneezing and coughing. Outbreaks of rubella are public health disasters:in the 1960s a rubella epidemic swept through the world In the United states alone, approximately 11,000 babies died and 20,000 babies were born with birth defects[3, 4].

The science

In the first half of the twentieth century, the link between rubella and birth defects was not known. At that time, the fact that intrauterine infections could cause fetal damage, birth defects and fetal loss was largely unrecognised. Rubella was a fairly common infectious disease, mostly occurring in children but also in adults, including pregnant women.

In 1941, an Australian eye doctor called Norman Gregg was treating babies born with eye problems. He noticed that there were many more such infants that year than in the preceding years. One day he overheard two mothers talking about how they had both suffered from rubella when pregnant[5]. This led him to review the medical records of many mothers and babies. He connected the increased numbers of such damaged infants he had observed to a large epidemic of rubella which had recently occurred[6].

Gregg went on to show that rubella in early pregnancy could be linked to many serious birth defects in children[7].

This was a new discovery and, at first, even the possibility that such an apparently trivial illness could be so destructive was dismissed by some influential medical voices. It took some time - and further proof from scientists in other parts of the world - before doctors and policy-makers were convinced Gregg's findings were correct. The birth defects seen in babies infected with rubella while in the womb were later named Congenital Rubella Syndrome (CRS).

The application to policy and practice

A vaccination to prevent rubella first became available in 1969. The world now had a way of preventing the harm caused by rubella infection.

Since that time, increasing numbers of countries around the world have introduced the vaccine into their national immunisation policies. This is mostly done by vaccinating all the children in a population when they are still young (Image 2).

1 US Centers for Disease Control and Prevention (CDC). Rubella: Make Sure Your Child Gets Vaccinated. http://www.cdc.gov/features/rubella/ [accessed 9 April 2013].
2 DC. Progress Toward Control of Rubella and Prevention of Congenital Rubella Syndrome – Worldwide, 2009. Morbidity and Mortality Weekly Report. 2010; 59(40): 1307-1310.
3 US Centers for Disease Control and Prevention (CDC). Rubella: Make Sure Your Child Gets Vaccinated. http://www.cdc.gov/features/rubella/ [accessed 9 April 2013].
4 Witte JJ, Karchmer AW. Epidemiology of rubella. American Journal of Diseases of Children. 1969; 118:107-12.
5 De Quadros CA. Vaccines: Preventing Disease and Protecting Health. Geneva: World Health Organization, 2004, pp.53.
6 Gregg NM. Congenital Cataract following German Measles in the Mother. Transactions of the Ophthalmological Society of Australia. 1941; 3:35-46.
7 Gregg NM. Further observations on congenital defects in infants following maternal rubella. Transactions of the Ophthalmological Society of Australia. 1944; 4: 119-131.

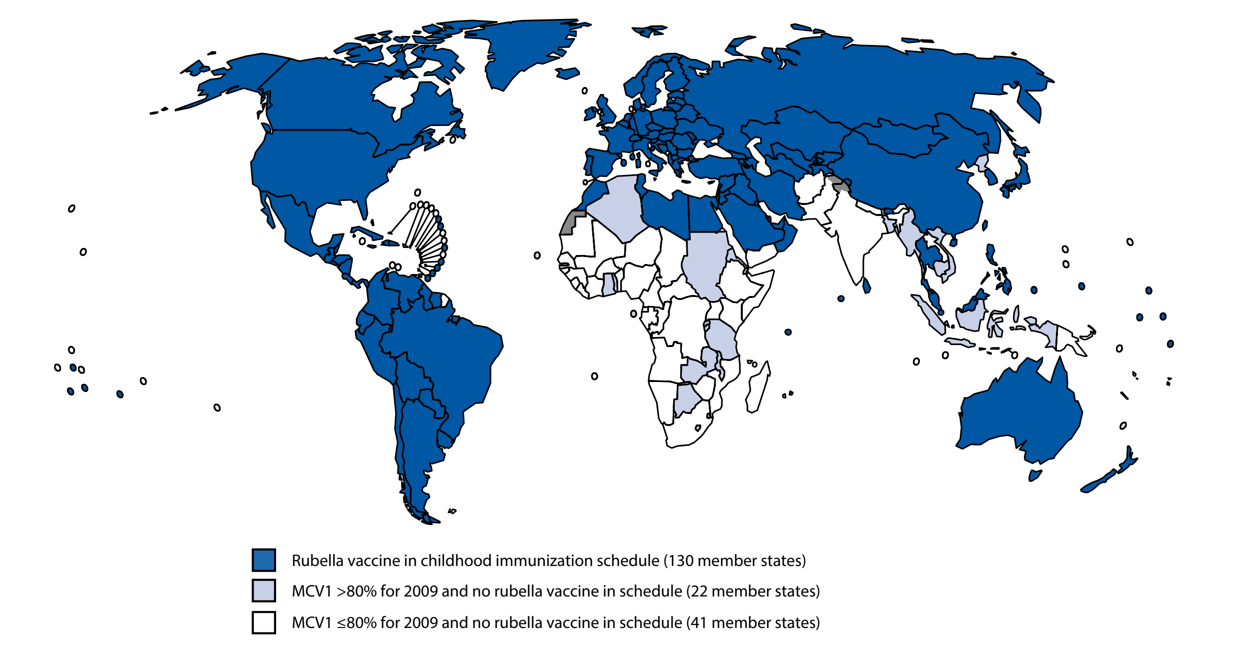


Figure 1: Countries using rubella vaccine and countries meeting WHO criteria for rubella vaccine introduction, 2009. *Source: CDC, 2010*[8].

Following good progress in rubella immunisation in the 1990s, the Pan-American Health Organization (PAHO) resolved in 2003 to eliminate rubella and CRS from the region by 2010[8].

Did it make a difference?

The number of World Health Organization (WHO) Member States using rubella-containing vaccine in their national immunisation programmes is continuing to grow, increasing from 83 of the 190 Member States (44%) in 1996 to 130 of 194 (67%) in 2009[10] (Figure 1).

Rubella has been eliminated in the WHO Region of the Americas[11]; this means less than 1 case of CRS per 100,000 births. Their experiences have been turned into guidance to support elimination in other regions of the world. Lessons identified include: high-level commitment and partnerships are essential; link political commitment with technical strategies; use proven surveillance tools; recognise outstanding performance by individual countries; provide on-going training for surveillance staff[12].

8 Periago MR. Elimination of Rubella and Congenital Rubella Syndrome: We Did It Together! The Journal of Infectious Diseases. 2011; 204 (Suppl 2): i.
9 CDC. Progress Toward Control of Rubella and Prevention of Congenital Rubella Syndrome – Worldwide, 2009. Morbidity and Mortality Weekly Report. 2010; 59(40): 1307-1310.
10 Strebel PM, Gacic-Dobo M, Reef S, Cochi SL. Global Use of Rubella Vaccines, 1980-2009. The Journal of Infectious Diseases. 2011; 204:S579-S584.
11 Periago MR. Elimination of Rubella and Congenital Rubella Syndrome: We Did It Together! The Journal of Infectious Diseases. 2011; 204 (Suppl 2): i.
12 Irons B, Morris-Glasgow V, Andrus JK, Castillo-Solorzano C, Dobbins JG and the Caribbean Surveillance Group. Lessons Learned From Integrated Surveillance of Measles and Rubella in the Caribbean. The Journal of Infectious Diseases. 2011; 204:S622-S626.

The WHO Regional Office for Europe has now set a target for elimination of CRS in its Member States[13, 14].

Gregg's scientific work has saved countless lives and prevented much disability, family tragedy and economic loss around the world. However, CRS still affects an estimated 110,000 infants in developing countries each year[15, 16], meaning the full benefits of his work are yet to be realised.

Image 1: A newborn baby with 'microcephaly' or small head size. *Source: mastersinhealthcare.net.*

13 CDC. Progress Toward Control of Rubella and Prevention of Congenital Rubella Syndrome – Worldwide, 2009. Morbidity and Mortality Weekly Report. 2010; 59(40): 1307-1310.
14 British Paediatric Surveillance Unit. 23rd Annual Report 2008-2009. London: Royal College of Paediatrics and Child Health, 2009.
15 CDC. Progress Toward Control of Rubella and Prevention of Congenital Rubella Syndrome – Worldwide, 2009. Morbidity and Mortality Weekly Report. 2010; 59(40): 1307-1310.
16 Cutts FT, Vynnycky E. Modelling the incidence of congenital rubella syndrome in developing countries. International Journal of Epidemiology. 1999; 28:1176-84.

CASE STUDY 8:

An Atlas of Hazards and Disaster Risks to Support Disaster Risk Reduction in China

Image 1: Covers of the three Atlases of natural disaster risk in China. *Source: The People's Insurance Company of China, 19923, Shi, 20034 and Shi, 2011*[1].

The problem

Covering 9.6 million square kilometres[2], and with the largest population of any country in the world, China frequently experiences a variety of hazards resulting in great casualties, economic losses and damage to infrastructure.

1 Shi P (Chief Editor). Atlas of Natural Disaster Risk in China. Beijing: Science Press, 2011.

2 Chinese Government. Official Web Portal, China Factfile, Land area [webpage]. Available at: http://english.gov.cn/2006-02/08/content_182551.htm [accessed 21 March 2013].

If the country is to introduce and maintain effective and appropriate disaster risk reduction, it must first understand the temporal and spatial patterns of the hazards and disaster risks it faces.

The science

In response to the inauguration of the United Nations' International Decade for Natural Disaster Reduction in 1989[3], the Chinese government launched a project to produce an Atlas that integrates the vast array of scientific data on natural hazards and disaster risks available in China.

Data for the Atlas was systematically identified from a national database of natural hazard related disasters, official government statistics, and from newspapers and other media sources. Collated data was validated by scientists then brought together for spatial and temporal analysis of hazards, exposure and vulnerability in a comprehensive risk assessment process. This allowed disaster risks to be quantified, prioritised and communicated in an accessible, meaningful manner using learning from risk communication science.

The first edition, *Atlas of Natural Disasters in China*[4], was published in 1992. This was updated and improved in the 2003 *Atlas of Natural Disaster System of China*[5] and again in the *Atlas of Natural Disaster Risk of China*[6], published in 2011 (Image 1).

The application to policy and practice

Since 1997, the Atlases have been used in the development of the Chinese Government's National Comprehensive Disaster Prevention and Reduction Plans[7–9].

For instance, analyses in the 2003 *Atlas of Natural Disaster System of China*[10] highlighted the regional variation of natural hazards across China and the projected trends of these (Figure 1). As a result, the

3 UNISDR. Disaster Reduction Mandate [web page]. Available at: http://www.unisdr.org/we/inform/resolutions-reports/disaster-reduction-mandate [accessed 21 March 2013].

4 The People's Insurance Company of China and Beijing Normal University. Atlas of Natural Disasters in China (Chinese and English versions). Beijing: Science Press, 1992.

5 Shi P (Chief Editor). Atlas of Natural Disaster System of China. Beijing: Science Press, 2003.

6 Shi P (Chief Editor). Atlas of Natural Disaster Risk in China. Beijing: Science Press, 2011.

7 China National Committee for IDNDR. The National Natural Disaster Reduction Plan of the People's Republic of China (1998-2010). Beijing: China National Committee for IDNDR, 1998.

8 China National Committee of Disaster Reduction. National Plan for Comprehensive Disaster Reduction During the "Eleventh Five-Year Plan" Period of the People's Republic of China. Beijing: China National Committee of Disaster Reduction, 2007.

9 China National Committee of Disaster Reduction, National Plan for Comprehensive Disaster Reduction (2011-2015) of the People's Republic of China. Beijing: China National Committee of Disaster Reduction, 2011.

10 Shi P (Chief Editor). Atlas of Natural Disaster System of China. Beijing: Science Press, 2003.

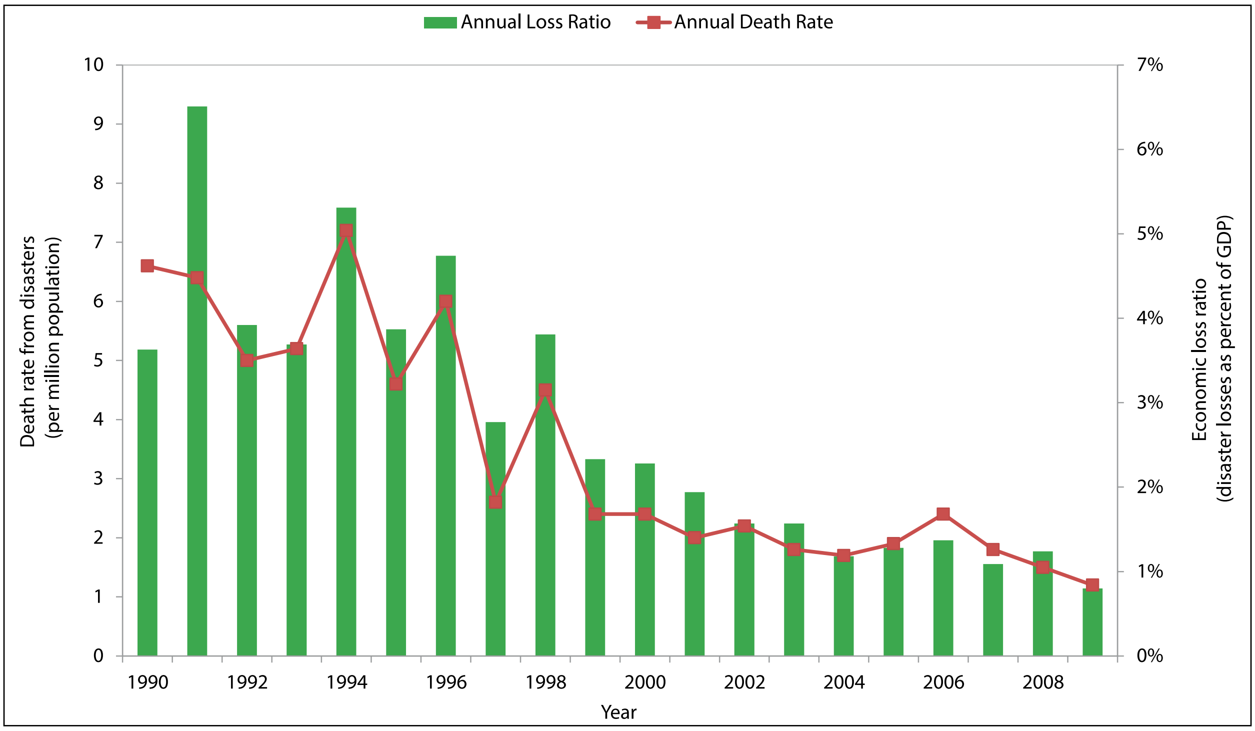


Figure 1: Loss ratios (economic losses from disasters expressed as a percentage of GDP) and death rates from disasters (number of deaths per million people) in China, 1990-2009. Data from the Wenchuan earthquake event, 2008, is not included. Based on data from Fang et al, 2011 [11].

National Plan for Comprehensive Disaster Reduction During the "Eleventh Five-Year Plan" [12] introduced more regionally-focused plans and activities for disaster risk reduction in China.

In 2011, the *Atlas of Natural Disaster Risk of China* [13] was similarly used in the development of the plan for 2011-2015 [14]. Based on the integrated natural hazard risk-mapping in the atlas, the plan laid out the task of building a multi-level, integrated disaster relief reserve system for China. This aimed to link central, regional and local activities in order to meet the Chinese government's commitment that people affected by disasters receive primary aid to sustain basic survival needs within twelve hours of a disaster striking.

At a local level, Shenzhen City, China's first Special Economic Zone, used local knowledge and experience with the Atlas' high-resolution maps of typhoon risk to develop its urban planning for disaster risk reduction policy. This policy supports the rapid urban development in the city whilst ensuring that buildings and infrastructure will be resilient to local hazards now and in the future.

The Atlases have also been used to inform disaster insurance policy and practice. For instance, the Chinese government's agriculture insurance program [15], launched in 2007, used the Atlas to inform regional crop risk assessment and premium determination. The Atlases are also widely used by domestic and international insurers, re-insurers and relevant stakeholders in the industry.

Did it make a difference?

In the past 30 years, China has promoted and implemented disaster risk reduction, using the scientific evidence communicated in the three Atlases and with increasing emphasis on evidence-based risk assessment and on regional variations [16, 17]. The resulting efforts have significantly increased the regional capacity in disaster prevention and risk mitigation. This work is believed to be a contributing factor to the general decrease in annual deaths from disasters, and the reduction in relative economic losses, seen in China in the last two decades (Figure 1) [18].

11 Fang W, Shi P, Wang J. Integrated Risk Governance - Database, Risk Map and Network Platform. Beijing: Science Press, 2011.
12 China National Committee of Disaster Reduction. National Plan for Comprehensive Disaster Reduction During the "Eleventh Five-Year Plan" Period of the People's Republic of China. Beijing: China National Committee of Disaster Reduction, 2007.
13 Shi P (Chief Editor). Atlas of Natural Disaster Risk in China. Beijing: Science Press, 2011.
14 China National Committee of Disaster Reduction, National Plan forW Comprehensive Disaster Reduction (2011-2015) of the People's Republic of China. Beijing: China National Committee of Disaster Reduction, 2011.
15 Wang M, Shi P, Ye T, Liu M, Zhou M. Agriculture insurance in China: history, experience, and lessons learned. International Journal of Disaster Risk Science. 2011; 2(2):10-22.
16 Shi P, Shuai J, Chen W, Lu L. Study on Large-Scale Disaster Risk Assessment and Risk Transfer Models. International Journal of Disaster Risk Science. 2010; 1(2):1-8.
17 Ye T, Shi P, Wang J, Liu L, Fan Y, Hu J. China's Drought Disaster Risk Management: Perspective of Severe Droughts in 2009-2010. International Journal of Disaster Risk Science. 2012; 3(2):84-97.
18 Fang W, Shi P, Wang J. Integrated Risk Governance - Database, Risk Map and Network Platform. Beijing: Science Press, 2011.

Image 1: A live animal market in Cambodia.
Source: Maria Van Kerkhove.

CASE STUDY 9:

Mathematical Models for Cambodia to Reduce the Risk of H5N1 Flu Outbreaks in Poultry

The problem

Highly pathogenic avian influenza, subtype H5N1 (HPAI/H5N1), first crossed the species barrier into humans in 1997, when an outbreak of 18 human cases was identified in Hong Kong. This outbreak resulted in 6 deaths. In late 2003, H5N1 crossed the species barrier a second time, infecting a family from Hong Kong that had recently travelled to Fujian Province in China.

Since 2003, H5N1 has been confirmed in domestic poultry and/or wild birds in 61 countries throughout Asia, Africa and Europe. During this period, 620 humans have become infected with the virus, 367 of whom have died (Figure 1). Many of these people have reported exposure to ill or dead poultry prior to illness.

The movement of poultry through live-bird markets (LBM), which are common in Asian countries because of a cultural preference to consume freshly slaughtered meat, has been shown to be an important factor in the circulation of HPAI/H5N1 in Vietnam and Hong Kong [1, 2].

The dense concentration and high turn-over rate of live birds in LBM provide ample conditions for virus amplification [3] and therefore LBM may be an important reservoir for HPAI or act as a "hub" of circulation [4]. HPAI surveillance programs in several countries including Vietnam, Thailand, Cambodia, China and Hong Kong have demonstrated that HPAI/H5N1 is circulating in LBM.

The science

The degree of connectedness of animal networks, that is the frequency with which links between premises and LBMs are made via people, animal movement and/or sharing of equipment, has been shown to influence the potential for widespread epidemics of disease [5].

Using data collected from LBM and other sources, models have been developed to describe animal movement practices and their contact structures. These can then be used in designing targeted animal and human health surveillance, disease prevention and control activities [6]. This is particularly important in resource-limited settings where such activities may be limited [7]. However, little has been understood about poultry market chains in countries where HPAI/H5N1 is endemic or recurrent.

The application to policy and practice

A comprehensive study was conducted to describe the current movements of live poultry throughout Southern Cambodia in order to understand how these movements could influence the potential spread of HPAI at local, regional and national levels [8, 9].

The results have demonstrated that live poultry movement in Southern Cambodia is one-directional, highly connected and highly centralized. It was found that:

- Approximately 83,000 live chickens and 35,000 live ducks were traded across the networks each week;
- Most poultry movement occurs via middlemen and market sellers on trucks and motorbikes into markets, semi-commercial farms and stock houses located in Phnom Penh, Cambodia;

1 Kung NY, Guan Y, Perkins NR, Bissett L, Ellis T, Sims L, Morris RS, Shortridge KF, Peiris JS. The impact of a monthly rest day on avian influenza virus isolation rates in retail live poultry markets in Hong Kong. Avian Disease. 2003; 47:1037.
2 Sims LD, Ellis TM, Liu KK, Dyrting K, Wong H, Peiris M, Guan Y, Shortridge KF. Avian influenza in Hong Kong 1997-2002. Avian Disease. 2003; 47:832-838.
3 Webster RG. Wet markets: a continuing source of severe acute respiratory syndrome and influenza? Lancet. 2004; 363:234-36.
4 Senne D, Pearson J, Panigrahy B. Live poultry markets: a missing link in the epidemiology of avian influenza. In: Beard C, Easterday B (Eds). Proceedings of Third International Symposium on Avian Influenza. Richmond: United States Animal Health Association, 1992, pp.50-58.
5 Kao RR, Green DM, Johnson J, Kiss IZ. Disease dynamics over very different time-scales: foot-and-mouth disease and scrapie on the network of livestock movements in the UK. Journal of the Royal Society Interface. 2007; 4(16):907-916.
6 Dent J, Kao R, Kiss I, Hyder K, Arnold M. Contact structures in the poultry industry in Great Britain: Exploring transmission routes for a potential avian influenza virus epidemic. BMC Veterinary Research. 2008; 4:27.
7 Stark K, Regula G, Hernandez J, Knopf L, Fuchs K, Morris R, Davies P. Concepts for risk-based surveillance in the field of veterinary medicine and veterinary public health: Review of current approaches. BMC Health Services Research. 2006; 6(1):20-27.
8 Kung NY, Guan Y, Perkins NR, Bissett L, Ellis T, Sims L, Morris RS, Shortridge KF, Peiris JS. The impact of a monthly rest day on avian influenza virus isolation rates in retail live poultry markets in Hong Kong. Avian Disease. 2003; 47:1037.
9 Sims LD, Ellis TM, Liu KK, Dyrting K, Wong H, Peiris M, Guan Y, Shortridge KF. Avian influenza in Hong Kong 1997-2002. Avian Disease. 2003; 47:832-838.

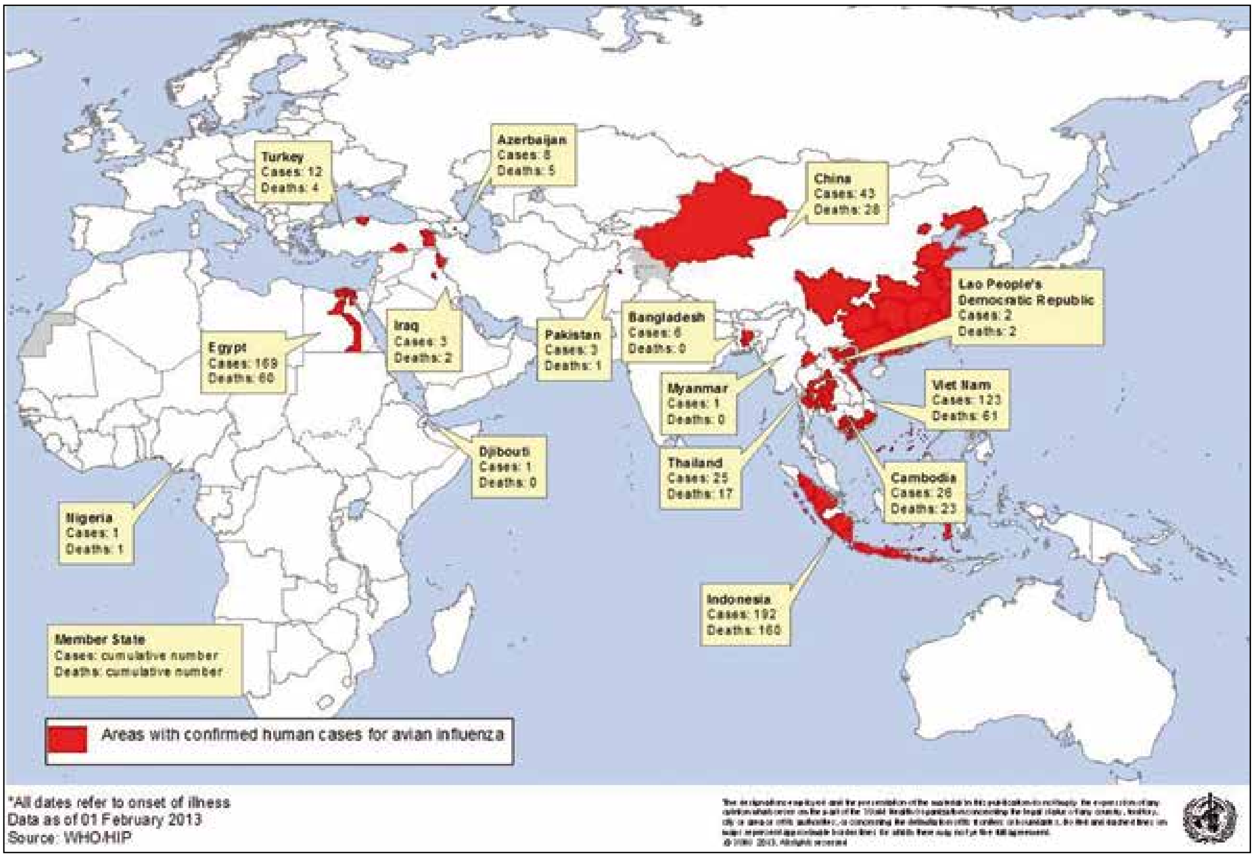


Figure 1: Countries with confirmed H5N1 influenza reported in human populations between 2003 and 2013.
Source: World Health Organization, 2013[10].

- Approximately 85% of middlemen trade live birds >10 km from where they purchased the birds; and
- Live poultry originating in 11 of Cambodia's 24 provinces and from regions in Southern Vietnam were sold directly to the three main LBM in Phnom Penh.

The investigators found that the unidirectional movement of poultry into Phnom Penh made LBM in Phnom Penh a potential hub for the spread of H5N1, making them ideal locations for surveillance and control[11, 12].

Did it make a difference?

These studies have been able to identify critical points for active HPAI surveillance and have informed Cambodia's HPAI subsequent surveillance activities. Although this does not replace the need for routine and regular surveillance, the identification of critical points for targeted intervention favours the prudent use and conservation of resources.

Given the rapid global spread of HPAI/H5N1 in recent years, surveillance of poultry populations and LBM will remain a high priority for monitoring and control efforts against HPAI in Cambodia and elsewhere. Understanding poultry movement is essential for the development of appropriate and targeted recommendations for active HPAI/H5N1 surveillance programs. The results of this and similar studies can therefore be used to inform the selection of markets that best suit particular objectives of a surveillance system, in particular whether the objective is monitoring of the HPAI status of poultry populations in rural areas or early detection of incursion in markets with high potential for spread.

10 World Health Organization (WHO). Areas with confirmed human cases for avian influenza A (H5N1) reported to WHO, 2003-2013. Geneva, 2013. Available at: http://gamapserver.who.int/mapLibrary/Files/Maps/2003_AvianInfluenza_GlobalMap_01Feb13.png [accessed 29 April 2013].

11 Kung NY, Guan Y, Perkins NR, Bissett L, Ellis T, Sims L, Morris RS, Shortridge KF, Peiris JS. The impact of a monthly rest day on avian influenza virus isolation rates in retail live poultry markets in Hong Kong. Avian Disease. 2003; 47:1037.

12 Sims LD, Ellis TM, Liu KK, Dyrting K, Wong H, Peiris M, Guan Y, Shortridge KF. Avian influenza in Hong Kong 1997-2002. Avian Disease. 2003; 47:832-838.

CASE STUDY 10:

Building Resilience to Earthquakes in Chile

Image 1: Tie-column reinforcement cages extending from foundations of a new building; these are a key feature of 'confined masonry' construction. *Source: Brzev, Astroza and Yadlin, 2010*[1].

The problem

Hundreds of thousands of people have lost their lives due to the collapse of buildings during earthquakes in the last two decades; billions of dollars of financial loss have also been sustained. Building vulnerability generally results from a lack of understanding of engineering science and poor enforcement of building codes. The problem is most severe in developing countries where populations are growing, towns and cities are expanding and buildings are more vulnerable to damage[2–4].

The science

Scientists have studied the ways in which materials and structures are affected by strong shaking as experienced in an earthquake. By exposing structures to physical forces in the laboratory, and by studying the effects of real-life earthquakes, scientists can see how structural elements like beams, columns and walls behave under earthquake ground shaking, what type of damage they experience and how collapse takes place. This has brought an understanding of how to construct buildings to better withstand earthquakes.

For instance, buildings constructed in the 'confined masonry' style, have been designed to withstand earthquakes better than buildings built with other, more traditional building techniques[5]. 'Confined masonry' buildings are characterized by masonry walls combined with reinforced concrete confining elements, such as tie-column and tie-beam reinforcement cages (Image 1), and, in some cases, concrete bands through walls[6–8].

Building codes with seismic provisions are the most common tool used to put this scientific knowledge into practice. If adequately enforced, seismic building codes result in earthquake-resistant buildings that are less likely to collapse even in severe earthquakes, thus ensuring the safety of inhabitants.

Seismic code provisions are generally based on earthquake hazard maps and are more stringent in high hazard regions and for structures with high importance such as schools, hospitals, fire and police stations, and critical facilities. Building codes are generally updated regularly to incorporate new knowledge and experience gained from major earthquake events.

The application to policy and practice

The South American country of Chile experiences frequent earthquakes which have claimed many lives[9]. Chile has a long history of regulated 'confined masonry' construction practice, starting in the 1930s, after the 1928 Talca earthquake of magnitude 8.0[10].

Seismic design provisions for buildings were first formally laid out in 1940[11]. From the 1960s onwards, the Chilean

1 Brzev S, Astroza M, Yadlin MO. Performance of confined masonry buildings in the February 27, 2010 Chile earthquake. EERI report. Confined Masonry Network, 2010. Available at: http://www.confinedmasonry.org/performance-of-confined-masonry-buildings-in-the-february-27-2010-chile-earthquake [accessed 9 April 2013].

2 Jain SK. Historical developments in India towards seismic safety and lessons for future. Proceedings of the 14th World Conference on Earthquake Engineering, Beijing, China, October 2008.

3 Maqsood ST, Schwarz J. Building vulnerability and damage during the 2008 Baluchistan Earthquake in Pakistan and past experiences. Seismological Research Letters. 2010; 81(3):514-525.

4 Maqsood ST, Schwarz J. Comparison of seismic vulnerability of buildings before and after 2005 Kashmir Earthquake. Seismological Research Letters. 2010; 81(1):85-98

5 Meli R, Brzev S, Astroza M, Boen T, Crisafulli F, Dai J et al for the Confined Masonry Network. Seismic Design Guide for Low-Rise Confined Masonry Buildings. Oakland: Earthquake Engineering Research Institute, 2011. Available at: http://www.confinedmasonry.org/wp-content/uploads/2009/09/ConfinedMasonryDesignGuide82011.pdf [accessed 11 April 2013].

6 *Ibid.*

7 International Association for Earthquake Engineering (IAEE). Guidelines for Earthquake Resistant Non-Engineered Construction. Columbia and Delhi: IAEE, 2004.

8 Chilean Ministerio de Tierras y Colonización. Ordenanza General de Urbanismo y Construcción. Decreto Supremo Nº 1.099 de 1940. Santiago, 1940.

9 Ene D, Crafaleanu I-G. Seismicity and Design Codes in Chile: Characteristic Features and a Comparison with some of the Provisions of the Romanian Seismic Code. Constructii. 2010; 2:69-78.

10 Brzev S, Astroza M, Yadlin MO. Performance of confined masonry buildings in the February 27, 2010 Chile earthquake. EERI report. Confined Masonry Network, 2010. Available at: http://www.confinedmasonry.org/performance-of-confined-masonry-buildings-in-the-february-27-2010-chile-earthquake [accessed 9 April 2013].

11 Chilean Ministerio de Tierras y Colonización. Ordenanza General de Urbanismo y Construcción. Decreto Supremo Nº 1.099 de 1940. Santiago, 1940.

government funded research work into seismic design codes for the country[12] and, in 1997, new building regulations were introduced which gave provisions for all new buildings to be designed and constructed in the 'confined masonry' style[13]. The regulations specify how buildings should be constructed and include standards such as the required strength for clay and concrete masonry units such as bricks and blocks. The regulations include the newest methods and techniques available[14].

The 1997 building regulations have been enforced well, with local authorities requiring that seismic and structural computations in the design of new buildings are verified by an independent professional[15].

Similar examples are seen in other areas of the world, particularly in Pakistan, which is also heavily affected by earthquakes. The new Building Code of Pakistan[10] was prepared after the 2005 Kashmir earthquake; these guidelines move away from the use of traditional adobe structures and adopt 'confined masonry' as the main building typology[16, 17]. More than 400,000 buildings were reconstructed in the affected areas after the 2005 earthquake, using the new code and with the aim to 'build back better'[18]. Other examples include the introduction of the Dhajji Diwari building typology (clay brick confined by small timber elements) in Kashmir[19].

Internationally, 'confined masonry' technology is being promoted by earthquake engineering experts. For instance, the Confined Masonry Network[20] has developed guidelines on seismic design for low-rise constructions, targeting countries where 'confined masonry' is not yet used[21].

Did it make a difference?

Over 200,000 people died in the magnitude 7.0 Haiti earthquake in January 2010 but when a magnitude 8.8 earthquake struck central Chile the next month, on 27th February 2010, only around 300 people lost their lives due to collapsed buildings[23] (Image 2). Well-enforced, science-based seismic building codes have been suggested as a major reason for the low number of casualties in the Chile earthquake[24, 25]. The earthquake was the most severe since the 1930s and produced significant ground-shaking over a large area of the country. Despite this, 'confined masonry' buildings of all sizes performed very well and it is estimated that only about 1% of the total building stock in the affected area was damaged[26]. Similarly in Pakistan, buildings constructed in line with seismic codes have survived several moderate and strong earthquakes over the past five decades with no or only minor damage[27, 28]. In this way, integration of science into building practice can and does save lives and livelihoods.

Image 2: A building with a collapsed ground floor as a result of the February 2010 earthquake in Chile. *Source: Brzey, Astroza and Yadlin, 2010*[22].

12 Ene D, Crafaleanu I-G. Seismicity and Design Codes in Chile: Characteristic Features and a Comparison with some of the Provisions of the Romanian Seismic Code. Constructii. 2010; 2:69-78.
13 Instituto Nacional de Normalizacion (INN). Norma Chilena Oficial 2123.Of 1997. Confined masonry – Requirements for structural design. Santiago: INN, 1997.
14 Ene D, Crafaleanu I-G. Seismicity and Design Codes in Chile: Characteristic Features and a Comparison with some of the Provisions of the Romanian Seismic Code. Constructii. 2010; 2:69-78.
15 *Ibid.*
16 Maqsood ST, Schwarz J. Comparison of seismic vulnerability of buildings before and after 2005 Kashmir Earthquake. Seismological Research Letters. 2010; 81(1):85-98
17 Ministry of housing and public works. Building Code of Pakistan – seismic provisions. Islamabad, 2007.
18 Maqsood ST, Schwarz J. Comparison of seismic vulnerability of buildings before and after 2005 Kashmir Earthquake. Seismological Research Letters. 2010; 81(1):85-98
19 Maqsood ST, Schwarz J. Building vulnerability and damage during the 2008 Baluchistan Earthquake in Pakistan and past experiences. Seismological Research Letters. 2010; 81(3):514-525.
20 www.confinedmasonry.org/ [accessed 11 April 2013]
21 Meli R, Brzev S, Astroza M, Boen T, Crisafulli F, Dai J et al for the Confined Masonry Network. Seismic Design Guide for Low-Rise Confined Masonry Buildings. Oakland: Earthquake Engineering Research Institute, 2011. Available at: http://www.confinedmasonry.org/wp-content/uploads/2009/09/ConfinedMasonryDesignGuide82011.pdf [accessed 11 April 2013].
22 Brzev S, Astroza M, Yadlin MO. Performance of confined masonry buildings in the February 27, 2010 Chile earthquake. EERI report. Confined Masonry Network, 2010. Available at: http://www.confinedmasonry.org/performance-of-confined-masonry-buildings-in-the-february-27-2010-chile-earthquake [accessed 9 April 2013].
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24 *Ibid.*
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DISCUSSION

What the case studies tell us

The case studies published in this report, and those in the collection online, show that science can impact on disaster risk reduction and that science can be used to implement effective evidence-based policy and practice. Specifically, the case studies demonstrate that science can:

1. be driven by the need to address the adverse effects of disasters on lives, livelihoods, economies and societies (as shown by the case studies on*: Indian Ocean tsunami early warning, Japanese bullet train warnings, Building codes in Chile, the Hazard Atlas of China)*
2. enable more focused risk assessment *(H5 flu monitoring in Cambodia, the Hazard Atlas of China, Assessing Vulnerability)*
3. reduce impact by better forecasting *(Flood Early Warning in Bangladesh, Sahel Rainwatch)*
4. improve disaster risk mitigation *(Netherlands flood risk reduction, Congenital Rubella Syndrome)*

The case studies also indicate that it can take time from the recognition of a problem to finding and implementing a scientifically-evaluated solution (*Congenital Rubella Syndrome, Sahel Rainwatch*)

Common themes for success appear to be community participation in the development of interventions, clear leadership and high-level commitment to implement and sustain interventions in the long term.

Looking to the future – Ensuring Science is Useful, Useable *and* Used

The need to achieve more effective interplay of science, policy and practice in support of disaster risk reduction provides a great opportunity for collaborative learning and action. Opportunities for the science community to learn to find better and faster ways to interact with and to communicate findings to policy makers should be developed. Support for the development and implementation of solutions for emerging problems should be strengthened. Already applied research, such as in the health and engineering sciences, provides a sound grounding in translating findings into practical solutions for prevention, preparedness, response and recovery. Lessons identified here should be shared with other science disciplines.

In summary a holistic, all-hazard, risk-based and problem-solving approach should be used to address the multifactorial and interdependent nature of the disaster risk chain and to achieve improved disaster risk reduction. This requires the collaboration of all stakeholders, including suitable representatives of governmental institutions, scientific and technical specialists and members of the communities at risk. By working in partnership to share the outputs of scientific research, and by building translational science – motivated by the need for practical applications that help people, communities, schools, hospitals and all partners – disaster risk reduction decision-making will be more easily informed.

When setting policy, decision-makers need to examine the merits of each possible risk reduction measure and decide, based on the evidence, whether or

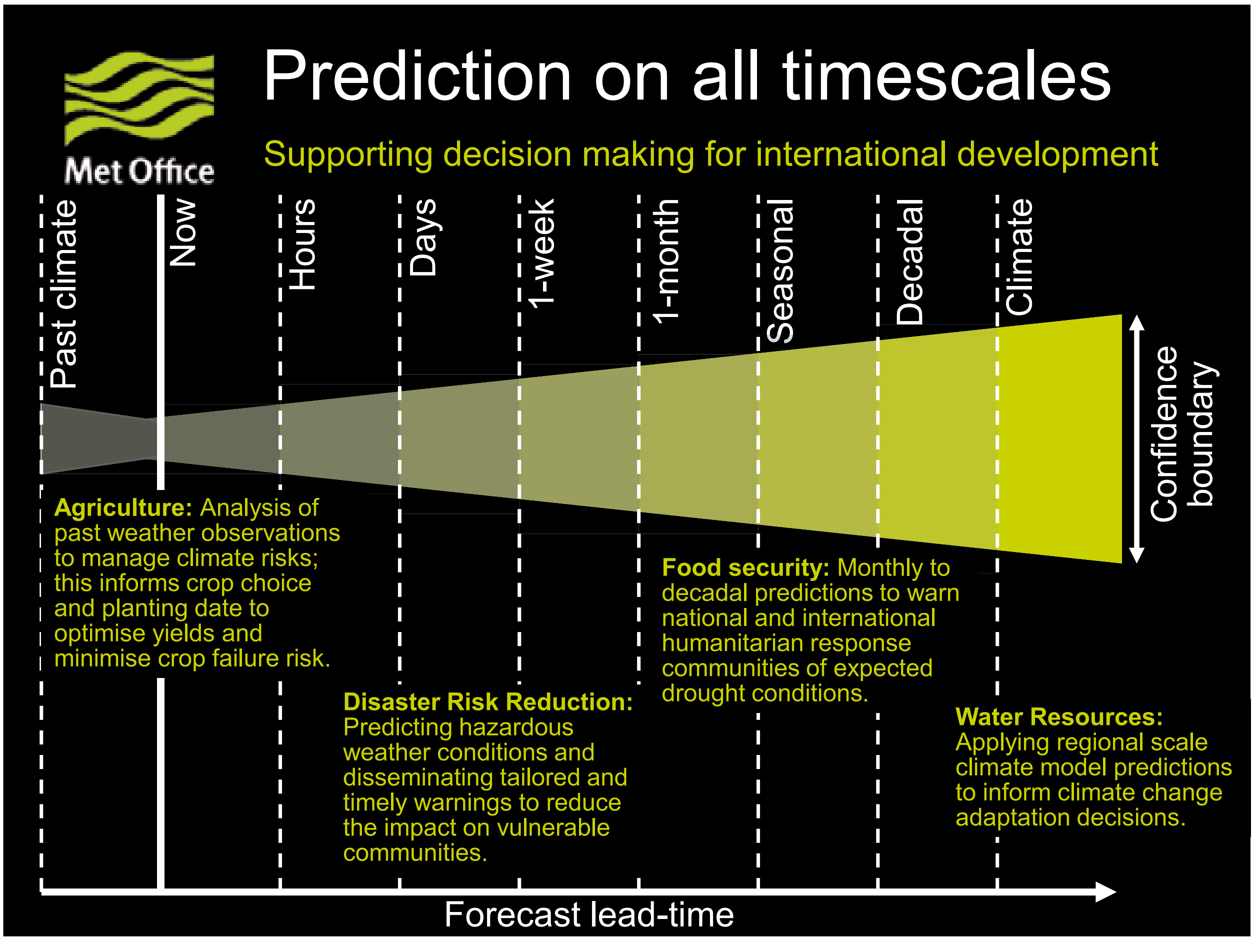

Figure 2: The current ability to produce reliable forecasts for natural hazards. This indicates that the further ahead we try to make forecasts, the less certain we are of the forecasts' reliability. *Source: The UK Met Office*[1.]

not investment in enhanced resilience is justified. There are some challenges to making such evaluations, for example:

- Whether an intervention is preferred will depend on the value placed on human life, the discount rate and time horizon used, and the range of costs and benefits that are included in the analysis. Decision-makers should not accept cost-benefit ratios uncritically, and scientists preparing them should make important assumptions clear. Over the coming decades this could lead to more refined and useful analyses being produced.
- The reliability of information about the future can be uncertain. This is especially true for very infrequent hazards. Such uncertainty makes it difficult for users of forecasts, from farmers to government ministers, to act confidently on forecasts and early warnings. Figure 2 illustrates our current ability to produce reliable forecasts for natural hazards showing a widening of confidence boundaries (and thus a reduction in reliability or certainty) the further into the future we try to predict.

The challenge of evaluating costs and benefits can be at least partially addressed in time but it will take several decades of committed action to build up bodies of scientific evidence on two important issues: evidence of effectiveness for different interventions, and records of reliability for different forecasting models.

In the short-term, there are evidence-based scientific systems that can assist policy-makers with the uncertainty around the costs and benefits of possible disaster risk reduction interventions. These could be adopted immediately alongside the longer-term effort and include:

- Policy measures designed to be flexible to accommodate different possible outcomes (and therefore different potential benefits). For example, the response to the West Africa floods in 2008 was greatly

1 Personal communication: Professor Julia Slingo, UK Met Office Chief Scientist. Presented at 'Building Global Resilience to Natural Hazards: Translating science into action' conference, Wilton Park, UK, 28-30 January, 2013.

Figure 3: Current and future ability to produce reliable forecasts for natural hazards. This summary is based on expert opinion and evidence drawn from reviews commissioned for the UK Government's Foresight report. *Source: The Foresight Report, 2012*[2].

	Ability to Produce Reliable Forecasts					
	Now			2040		
	Spatial	Magnitude	Temporal	Spatial	Magnitude	Temporal
Geophysical Hazards						
Earthquakes	2	1	1	3	2	1
Volcanoes	3	2	2	5	3	3
Landslides	2	2	1	3	3	2
Tsunamis	2	2	1	3	3	2
Hydrometeorological hazards	6 days ahead					
Storms	3	3	4	5	5	5
Floods	3	3	4	5	5	5
Droughts	5	5	5	5	5	5
Hydrometeorological hazards	6 months ahead					
Storms	2	2	2	3	3	3
Floods	2	2	2	4	4	4
Droughts	2	2	2	4	4	4
Infectious Disease Epidemics						
Known Pathogens	2	5	2	4	5	4
Recently emerged pathogens	1	4	1	2	4	2
Pathogens detected in animal reservoirs	1	1	1	2	3	2

Low ability 1 · 2 · Medium ability 3 · 4 · High ability 5

Source: Foresight

enhanced because preliminary preparations for a possible full response were made in advance, based on probabilistic forecasts[2].

- Seeking out and exploiting disaster risk reduction co-benefits when making other investments, for example in infrastructure planning and in the management of ecosystems. If future disaster risk is factored into the way in which investments are designed, additional benefits may be obtainable at little additional cost.
- Developing collaborative initiatives between public and private sector. For instance, mobile service providers could use their emerging technology to share data on the location of populations, harnessing the potential for mobile communications to provide early warnings without adding substantially to public sector disaster risk reduction costs. Social media providers could engage still further in the distribution of early warnings; banks could make it easier and cheaper to send remittances; and insurers could expand the markets they serve. In this way the private sector has much to contribute to disaster risk reduction.

Regarding the challenge of uncertainty of future forecasts, the UK Foresight Report 'Reducing Risks of Future Disasters: Priorities for Decision Makers' looks out to 2040 and takes a broad and independent view of disaster risk reduction[3]. The report highlights that science has considerable potential to improve the quality of information in the forecasting of many disasters, but that acting on that advice in a prudent and balanced way will be critical to reducing impacts. It highlights that science already explains why disasters happen, where many of the risks lie and, for some disasters, forecasts when they will occur. It helps to calculate risk, identify actions to reduce it and enable people to take preventative action. However for disaster forecasting to be most effective it needs to be timely, specific and reliable.

Using expert opinion and evidence drawn from a range of commissioned interviews, the Foresight Report described the current ability to anticipate hazards and how it is likely to change in 30 years' time; this is summarized

2 Tall A, Mason SJ, van Aalst M, Suarez P, Ait-Chellouch Y, Diallo AA, Braman L. Using seasonal climate forecasts to guide disaster management: The Red Cross experience during the 2008 West Africa floods. International Journal of Geophysics. 2012: doi:10.1155/2012/986016.

3 Foresight. Reducing Risks of Future Disasters: Priorities for Decision Makers. London: UK Government Office for Science, 2012.

in Figure 3. This Figure shows our ability to forecast hazards now and in 2040, where three dimensions of forecasting are considered: where hazards strike (spatial), when (temporal) and to what degree (magnitude). Relative to other hazards, the ability to forecast hydrometeorological hazards is highly developed. Improvements in this field have largely been driven by the use of

probabilistic forecasting, a standard feature of weather forecasting. By contrast, routine probabilistic forecasting is currently an aspiration for many geophysical and biological hazards. Despite significant advances in understanding of the underlying processes of these hazards, the ability of scientists to forecast them is relatively underdeveloped.

In the next few decades, scientific advances in the understanding of natural hazards can be expected to continue but the speed of improvement will not be uniform and progress in data analysis and advances in technology will play a role in this process. How fast and how far such improvements will proceed is uncertain. But if progress continues at the current rate, there will be increasingly reliable forecasts identifying the timing and location of some future natural hazards.

Scientific advances in anticipating hazards can only be exploited for disaster risk forecasting and reduction if exposure and vulnerability of people and assets are also assessed and this information used to guide action. Application of exposure and vulnerability assessments in developing countries is important as the quality and coverage of current data in these areas are generally very poor. In these settings, the combination of poverty, inequality and poor basic infrastructure increases vulnerability and the ability to cope effectively with the aftermath of disasters; science can improve the understanding of these issues. Equally, knowledge about underlying social, economic, and ecological determinants of global illness and premature death that will be exacerbated by disasters can be enhanced. Areas where greater understanding is required include:

- Where women manage households and care for family members, which limits their mobility and increases their vulnerability to disasters; further knowledge is important to understand their disaster risk reduction needs.

- In settlements with little economic diversification – where most income comes from climate sensitive primary resource industries such as agriculture, forestry, and fisheries. These are more vulnerable than diversified settlements and disaster risk reduction in this setting requires more research.

- Sustainable recovery, including both structural and non-structural mitigation measures that will lower the risk of future disasters. Further research is needed to improve implementation.

Scientific research can provide evidence to improve prevention, preparedness, response and recovery to natural and man-made disasters, including those related to climatic change. The Chair's summary from the 2011 Global Platform stated: "*the choice before us as Governments, institutions, communities and individuals is to place disaster risk reduction at the forefront of our efforts to preserve and protect the balance of nature, ensure sustainable development and well-being for generations to come"* and that to do this there is the opportunity to "*actively engage scientific and technical communities to inform decision-making*" [4]. We support and endorse this view which must be fundamental to the 'Hyogo Framework for Action 2', the post-2015 framework for disaster risk reduction.

4 UNISDR. Chair's Summary of the Third Session of the Global Platform for Disaster Risk Reduction and World Reconstruction Conference Geneva, 8-13 May 2011 "Invest today for a Safer Tomorrow – Increase Investment in Local Action". 2011. Available at: http://www.preventionweb.net/files/20102_gp2011chairssummary.pdf [accessed 8 April 2013].

RECOMMENDATIONS

Following the considerations above, the Scientific and Technical Advisory Group makes the following recommendations:

1. Encourage science to demonstrate that it can inform policy and practice

Through the use of case studies this report demonstrates that science can identify a problem, develop understanding from research, inform policy and practice and make a difference that can be objectively demonstrated when evaluated. The Report, and the associated website, offers tools to promote this sharing of information and thus provide knowledge transfer to policy-makers and other disaster risk reduction partners.

2. Use a problem-solving approach to research that integrates all hazards and disciplines

An all-hazard, risk-based, problem-solving approach should be used in disaster risk reduction research to address the multifactorial and interdependent nature of the disaster risk chain and to achieve improved solutions and better-optimized use of resources. This requires collaboration and communication across the scientific disciplines and with all stakeholders, including representatives of governmental institutions, scientific and technical specialists and members of the communities at risk to guide scientific research, set research agendas, bridge the various gaps between risks and between stakeholders, and support scientific education and training.

3. Promote knowledge into action

Greater priority should be put on sharing and disseminating scientific information and translating it into practical methods that can readily be integrated into policies, regulations and implementation plans concerning disaster risk reduction. Education on all levels, comprehensive knowledge management, and involvement of science in public awareness-raising, media communication and education campaigns should be strengthened. Specific innovations should be developed to facilitate the incorporation of science inputs in policy-making.

4. Science should be key to the Post-2015 Hyogo Framework for Action

The Scientific and Technical Advisory Group considers it essential to demonstrate, by 2015, that science is routinely used to inform disaster risk reduction and therefore holds a key place in the Post-2015 Hyogo Framework for Action. The Group calls for all scientists to provide evidence of impact by clearly stating how science has responded to a problem, what scientific learning was identified, how their findings were applied to policy and practice and that it makes a difference on implementation.

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ANNEX: The History of the Science and Technical Advisory Group Report

The 'Hyogo Framework for Action 2005-2015 (HFA) – Building the Resilience of Nations and Communities to Disasters', is the inspiration for knowledge, practice, implementation, experience and the science for disaster risk reduction.

This report has been prepared by the United Nations' International Strategy for Disaster Reduction (UNISDR) Scientific and Technical Advisory Group and presents recommendations related to science in support of the outcomes of the Third Session of the Global Platform for Disaster Risk Reduction. The report is being launched at the Fourth Session of the Global Platform for Disaster Risk Reduction in May 2013. It includes emerging priority issues in support of the implementation of the Hyogo Framework for Action and as we build towards a Post-2015 Framework for Disaster Risk Reduction [1]. The report builds on 'Reducing Disaster Risks through Science: Issues and Action', presented at the Second Session of the Global Platform by the UNISDR Science and Technical Committee (STC) [2] and is based on work with the 2011 Statement on Science and Technology for the Third Session of the Global Platform for Disaster Risk Reduction [3], its scientific, technical and thematic networks, the Global Assessment Report 2013 (GAR), the Mid Term Review of the Hyogo Framework for Action [4], the Intergovernmental Panel on Climate Change Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)40 [5], the outcomes of the International Disaster Risk Conference (IDRC, Davos 2012) [6] and the work of the Integrated Research on Disaster Risk (IRDR) programme and many other scientific and technical partners.

In 2011 it was agreed amongst other actions that the Scientific and Technical Advisory Group should:

- Review the findings of the report 'Reducing Disaster Risks through Science: Issues and Action' presented at the Second Session of the Global Platform by the ISDR STC for the 2013 Global Platform Session and consider how these recommendations have been implemented;
- Establish a process for a comprehensive review of science and technology for disaster risk reduction leading up to the discussion on the future of disaster risk reduction after 2015.

The Chair's Summary of the Third Session of the Global Platform for Disaster Risk Reduction and World Reconstruction Conference (Geneva, May 2011), entitled 'Invest today for a Safer Tomorrow - Increase Investment in Local Action' [7] stated, at 7.8, that there is the opportunity to "Actively engage and support scientific and technical communities to inform decision-making."

1 UNISDR. Towards a Post-2015 Framework for Disaster Risk Reduction. 2012. Available at: http://www.preventionweb.net/files/25129_towardsapost2015frameworkfordisaster.pdf [accessed 8 April 2013].

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3 UNISDR. Statement on Science and Technology for the Third Session of the Global Platform for Disaster Risk Reduction. 2011. Available at: http://www.irdrinternational.org/wp-content/uploads/2011/07/GlobalPlatform_Final-Science-Statement.pdf [accessed 8 April 2013].

4 UNISDR. Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. Mid-term Review 2010-2011. Geneva: UNISDR, 2011. Available at: http://www.unisdr.org/files/18197_midterm.pdf [accessed 8 April 2013].

5 Intergovernmental Panel on Climate Change (IPCC). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Summary for policymakers (The SREX Report). Cambridge and New York: Cambridge University Press, 2012. Available at: http://ipcc-wg2.gov/SREX/report/ [accessed 8 April 2013].

6 Global Risk Forum. 4th International Disaster and Risk Conference IDRC Davos 2012 [webpage]. http://idrc.info/pages_new.php/IDRC-Davos-2012/831/1/ [accessed 8 April 2013].

7 UNISDR. Chair's Summary of the Third Session of the Global Platform for Disaster Risk Reduction and World Reconstruction Conference Geneva, 8-13 May 2011 "Invest today for a Safer Tomorrow – Increase Investment in Local Action". 2011. Available at: http://www.preventionweb.net/files/20102_gp2011chairssummary.pdf [accessed 8 April 2013].

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