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Knowledge is power

Unlocking the potential of science and technology to enhance community resilience through knowledge exchange

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About the author

Emma Visman has been working with humanitarian and development operational and policy research organisations for more than 20 years. Most recently she has worked with the Humanitarian Futures Programme, King's College London, and in 2011 received a two-year Knowledge Exchange Fellowship with the UK Natural Environment Research Council. Activities undertaken during the Fellowship have included developing an online resource of knowledge exchange or dialogue approaches (Dialogues for Disaster Anticipation and Resilience: www.elrha.org/dialogues) and coordinating an exchange between climate scientists, meteorologists, communities at risk of flood and drought in Kenya and Senegal and partnering humanitarian and development agencies. Emma has also contributed to a number of initiatives aimed at strengthening the integration of disaster risk science within humanitarian and development planning.

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About HPN

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Cover photo: Discussions with communities at risk of flood and drought in Kaffrine district, Senegal, June 2012. ©Emma Visman.

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List of acronyms

ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action
ASEAN	Association of South East Asian Nations
BDRC	Building Disaster Resilient Communities
BoM	Australian Bureau of Meteorology
CCA	Climate Change Adaptation
CCAFS	Consultative Group on International Agricultural Research (CGIAR) Climate Change, Agriculture and Food Security Research Programme
CFAN	Climate Forecast Applications Network
COPE	Community Organisation of the Philippines Enterprise Foundation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DFID	UK Government Department for International Development
DRR	Disaster Risk Reduction
DSS	Decision Support System
ECOWAS	Economic Community of West African States
ELRHA	Enhanced Learning and Research for Humanitarian Action
EW›EA	Early Warning›Early Action
FEWS	Famine Early Warning System
GFCS	Global Framework for Climate Services
HFP	Humanitarian Futures Programme
ICT4D	Information and Communication Technologies for Development
IPC	Integrated Food Security Phase Classification
IRDR	Integrated Research on Disaster Risk
KE	Knowledge Exchange
KMS	Kenya Meteorological Services
KOGAMI	Komunitas Siaga Tsunami
LGU	Local Government Unit
LIPI	Indonesian Institute of Sciences
LWEC	Living with Environmental Change
MACEC	Marinduque Council of Environmental Concerns
NERC	Natural Environment Research Council
OSAT	Organisational Self-Assessment Tool
PACCSAP	Pacific-Australia Climate Change Science and Adaptation Planning Program
PCCSP	Pacific Climate Change Science Program
PfR	Partners for Resilience
PSP	Participatory Scenario Planning
RELU	Rural Economy Land Use Programme

RIMES	Regional Integrated Multi-Hazard Early Warning System
SALI	Sustainable Agricultural Livelihoods Innovation
UKCDS	UK Collaborative on Development Sciences
UNISDR	UN Office for Disaster Risk Reduction
WMO	World Meteorological Organisation

Chapter 1
Introduction

The number of people at risk from natural hazards and human-induced disasters is increasing. At the same time there is growing recognition that science and technology can potentially make a huge contribution to building people's resilience to these risks. One of the major challenges for at-risk people and for the humanitarian actors seeking to assist them is how best to unlock this potential. This Network Paper seeks to address this challenge by analysing how formal scientific learning can support decision-making processes amongst people at risk and those trying to support them. Drawing on a series of case studies across regions, disciplines and sectors, it identifies generic learning and key characteristics regarding those forms of knowledge exchange which have resulted in tangible benefits for at-risk people.

Producing and using knowledge about disaster risk

Data, information and knowledge about disaster risk are created by at-risk people, humanitarian and development agencies and those with formal scientific and technological expertise through observation, experience, experimentation, analysis and reflection. In effect, all of these groups are both producers and users of disaster risk knowledge. However, while the processes which each group employs to develop disaster risk information and knowledge share a number of similarities, 'each tends to privilege certain kinds of information and evidence over others, with a greater or lesser emphasis on qualitative or quantitative methods and indicators'.[1] Moreover, the audiences and decision-making processes for which the information is created vary significantly. There are also marked differences in each group's access to and understanding and use of different information and knowledge sources.

Although there is a wealth of scientific and technological information that can support resilience-building, much disaster risk science focuses on generating data and information, particularly on major shocks. Furthermore, much disaster risk research has historically been undertaken on a hazard-by-hazard basis. There is growing recognition of the need to further understand the 'cascade effect': the multiple links between a range of natural hazards and technological threats, as clearly demonstrated in the 2011 earthquake, tsunami and nuclear disaster in Japan.

People at risk and humanitarian and development agencies need information relevant to the context in which they live or work, concerning both major shocks and the multiple, small-scale and recurrent 'everyday disasters' responsible for the majority of disaster losses, particularly among the most vulnerable sections of society.

1 ALNAP, *Evidence in Humanitarian Action*, 2013, www.alnap.org/story/147.aspx.

This has heightened recognition of the vital importance of strengthening the engagement of social science expertise within efforts aimed at unlocking the resilience-building potential of disaster risk science, particularly as regards risk assessment, risk communication and behavioural change.

There are significant efforts to strengthen international, national and local capacities for scientific research and risk communication, including the Global Earthquake Model (GEM) and the Integrated Food Security Phase Classification (IPC) system.[2] Nevertheless, the crisis in the Horn of Africa in 2011 clearly demonstrated that there remain significant difficulties in developing systems which governments and donors will consistently act upon, and which provide information which is directly useable by at-risk groups.

In managing risk, people use a wide range of sources of local knowledge, including local environmental or agricultural indicators, technical knowledge and socio-cultural and historical information.[3] People living in earthquake-prone areas, for example, have historically built their homes using materials that give structures the flexibility to accommodate shocks, such as bamboo; farmers and pastoralists employ a range of local indicators to forecast the onset and quality of the principal productive seasons. Local knowledge systems operate through established, trusted channels and are integrated within a range of decision-making processes related to community resilience. While the importance of local knowledge has begun to be recognised within international and national policies, for instance in the Hyogo Framework for Action (HFA), the mechanisms for bringing together local and scientific disaster risk information are limited. In addition, while some local knowledge may be commonly owned, other elements may be restricted to particular individuals, and central policies and new value systems may fail to recognise local knowledge, creating a perception that it is an obstacle to development. While there are concerns about the validity of some local knowledge, and past experience may be of limited use in environments undergoing significant change, experiences of dealing with earlier crises can improve understanding of where future crises may exceed existing coping mechanisms.[4]

Many humanitarian and development agencies specifically seek to incorporate local understandings of risk within

2 See www.globalquakemodel.org/gem/aims and www.ipcinfo.org/ipcinfo-about/pt.

3 J. Dekens, *Local Knowledge for Disaster Preparedness: A Literature Review*, International Centre for Integrated Mountain Development, 2007.

4 P. Tschakertand and K. A. Dietrich, 'Anticipatory Learning for Climate Change Adaptation and Resilience', Ecology and Society, 15(2), 2010; B. McGrath et al., *Designing Patch Dynamics*, Columbia University Graduate School of Architecture, Planning and Preservation, 2007.

community-based risk assessment methodologies. Efforts to bring scientific sources of disaster risk information into humanitarian, disaster risk reduction and development planning remain more limited.[5] There is a recognised need to build humanitarian and development agencies' capacities and mechanisms to act on risk, rather than on the impact of risk.[6] Efforts are, for example, underway to identify and develop agreement on the probability thresholds and funding mechanisms required to enable governments and funders to allocate and release the resources required to support forecast-based prevention, risk reduction and preparedness activities. However, while there are important initiatives to support more effective use of science within humanitarian and development planning, this is often on a pilot basis and focused on a specific organisational decision-making process, geographic area, sector or hazard, with limited potential to develop integrated approaches to resilience-building and share learning about those approaches that have proved most effective.

This Network Paper explores some of these issues by documenting and assessing experience from a range of initiatives to strengthen the use of science and technology to support community resilience. Drawing on learning from across geographic regions, decision-making contexts and scientific disciplines, the paper identifies generic learning about those approaches and methodologies that may be most effective in supporting efforts to unlock the potential of science and technology to better support community resilience, with a particular focus on the processes through which disaster risk science and technologies can best be integrated within resilience building. Employing a framework which considers three principal stages of the dialogue process – access, understanding and appropriate application – the paper reviews knowledge exchange approaches employed in a series of case studies, and the resulting impact on at-risk groups and humanitarian and development agencies and scientists. Documentation and recognition of the potential for science and technology to better support community resilience is growing, and has, for example, been highlighted as a priority within discussions for the renewed Hyogo Framework for Action.[7] Governments and donors are also increasing investments in strengthening the integration of scientific understandings of risk within disaster risk management. Whether through incentivisation or development of enforceable minimum standards, it is becoming ever more evident that humanitarian practitioners will be held increasingly accountable for appropriate use of disaster risk science by directly affected groups, national governments, donor agencies and scientific and technical institutions.

Box 1

Supporting dialogue between scientists and humanitarian actors

Since 2006 the Humanitarian Futures Programme (HFP) at King's College London, has been employing a range of approaches to support strengthened dialogue between scientists and humanitarian actors. This work has included an extended exchange between climate scientists, humanitarian and development organisations and community decision takers. Two demonstration studies sought to assess how climate science can better support humanitarian, disaster risk reduction and development planning, and employed a variety of knowledge exchange and dialogue approaches tailored to specific stages of the knowledge exchange process (see Boxes 2, 5, 10). This paper builds on a 2011 working paper entitled *Making Space for Science–Humanitarian Dialogue*,[8] and has been developed within an ongoing Natural Environment Research Council (NERC) Knowledge Exchange Fellowship focused on collating and assessing emerging learning on approaches to support effective dialogue between scientists and humanitarian actors.[9]

Full case studies of the approaches discussed in this paper are available as an Annex at: www.odihpn.org/knowledge-is-power.

5 SciDev.net, *Global Review*,(2012), www.scidev.net/global/evaluation/learning-series/scidev-net-global-review-2012.html; H. Jones et al., *Strengthening Science–Policy Dialogue in Developing Countries*', ODI Background Note, December 2009.

6 See, for example, D. Hillier and B. Dempsey, *A Dangerous Delay: The Cost of Late Response to Early Warnings of the 2011 Drought in the Horn of Africa*, Oxfam and Save the Children, 2012; M. E. Hellmuth et al. (eds), *A Better Climate for Disaster Risk Management*, International Research Institute for Climate and Society (IRI), 2011.

7 The Chair's Summary from the Fourth Session of the Global Platform for Disaster Risk Reduction in May 2013 noted that participants had called for 'action to narrow gaps between the scientific community and organizations responsible for implementing disaster risk reduction through the development of collaborative means and methodologies'. See www.preventionweb.net/files/33306_finalchairssummaryoffourthsessionof.pdf.

8 See www.humanitarianfutures.org.

9 This has included collation of knowledge exchange or dialogue approaches within an online resource 'Dialogues for Disaster Anticipation and Resilience', hosted by ELRHA: www.elrha.org/dialogues.

Chapter 2
Integrating disaster risk science within community resilience-building: an overview of the process

Many issues can prevent appropriate application of scientific information within efforts to build community disaster resilience, including constraints in accessibility, usability, scale and salience, legitimacy and trust, cognition or understanding, credibility and levels of confidence and uncertainty, procedural or institutional practices and the availability of choices or scope people have to act on the knowledge being provided to them.[10] To address these challenges, we argue that enabling science to enhance community resilience-building should be understood as a process involving three principal stages of knowledge exchange or dialogue: access, understanding and appropriate application (see Figure 1, which shows the inter-relationships between the processes and channels for exchanging disaster risk knowledge, and Table 1, which sets out the key challenges to knowledge exchange between at-risk groups, scientists and humanitarian and development agencies, and the types of activities that can address them). Knowledge exchange requires a platform and is reliant on the existence or creation of channels for sustained, two-way dialogue between the full range of providers and users of disaster risk knowledge. This approach recognises that at-risk people, humanitarian and development agencies and those with scientific and technological expertise are all *both* producers *and* users of disaster risk knowledge, and that bringing together these knowledge sources produces new and combined risk knowledge better able to support disaster-affected people. In recognising the need for integration across knowledge sources, sectors, disciplines, risks, levels and timeframes of decision-making, the platforms underpinning the process of knowledge exchange need to be able to support a complex web of multi-directional linkages between 'providers' and 'users' of risk knowledge.

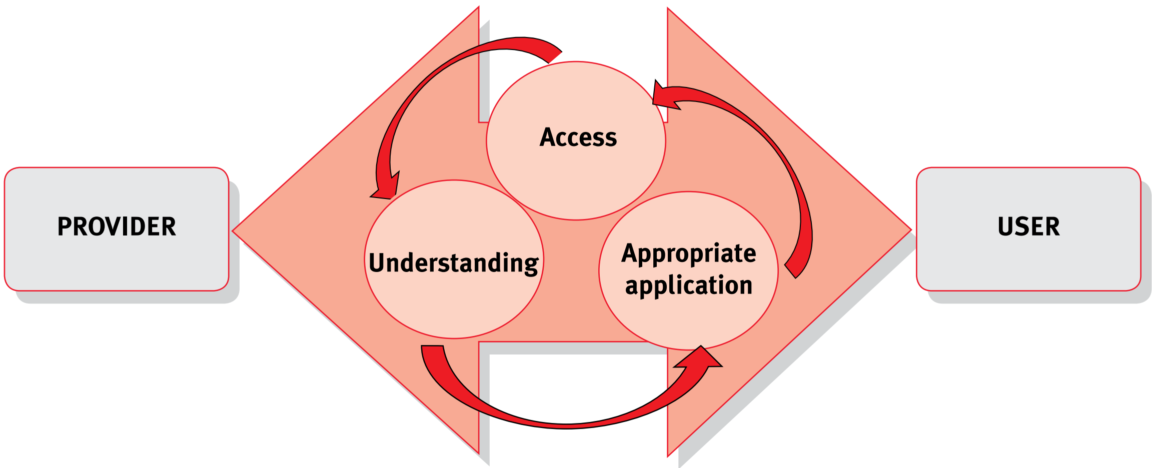
As depicted in Figure 1, below, the process of enabling disaster risk knowledge to enhance community resilience encompasses three inter-connected stages of knowledge exchange: 'access', 'understanding' and 'appropriate application' (the three circles) and is dependent on the creation of ongoing channels for two-way dialogue or knowledge exchange (the two-headed arrow) between the provider and the user of risk knowledge. As opposed to the two-way process of knowledge exchange, knowledge transfer focuses on the movement of knowledge from provider to user.

Access

Making risk information accessible involves building trust through engaging with local knowledge sources and systems and supporting the co-production of information which is useful, useable and used,[11] relevant for users in terms of its temporal and geographic scale and livelihood specificity and provided through trusted and accessible channels.

Figure 1

The process of enabling disaster risk knowledge to enhance community resilience



10 A. Patt and C. Gwata, *Effective Seasonal Climate Forecast Applications: Examining Constraints for Subsistence Farmers in Zimbabwe*, Global Environmental Change-Human Policy Dimensions, 12, 2002.

11 C. Hayden and A. Boaz, *Not Checking But Learning: The Better Government for Older People Evaluation Approach*, Warwick Research Papers – Better Government for Older People Series No 1, Warwick University, 2000.

Table 1: Knowledge exchange activities enabling science and technology to enhance community resilience

Knowledge exchange process	Obstacles to address	Activities
Access	Accessibility Usability Trust	• Directly engaging scientists in participatory risk assessment, co-production of early warning systems and response planning • Engaging through channels trusted by at-risk groups • Bringing together local and scientific knowledge sources to co-produce new combined risk information • Re-interrogating existing data according to community-identified concerns
Understanding	Understanding Conveying level of confidence within scientific understandings of risk	• Instilling respect for the knowledge and value systems of others. • Building scientists' understanding of the information requirements of affected people and humanitarian and development agencies • Strengthening users' understanding about: – Relevant scientific understandings of disaster risk – Levels of confidence and uncertainty, and key differences of opinion • Supporting decision-making under uncertainty
Appropriate application	Procedural or institutional practices Availability of choices	• Translating current scientific understanding to different geographic and decision-making contexts • Developing user-driven services tailored to specific user groups • Creating channels for ongoing, two-way dialogue • Involving at-risk groups in collecting and validating scientific information • Developing approaches which are integrated across timeframes, sectors and decision-making levels • Ensuring access to the resources required to act on the risk information provided

Accessibility

People at risk often have extremely limited access to credible, useable scientific sources of risk information. Information is often provided through inaccessible channels, languages and formats, with requirements to pay for information tailored to specific needs. At-risk groups are, for example, rarely involved in developing early warning systems which can provide timely and relevant information. There have been important efforts to help humanitarian and development agencies to access relevant scientific information, including bringing in experts in specific areas, engaging intermediaries and professional science communicators and linking with and developing 'boundary organisations' (organisations which seek to interpret science on behalf of other organisations, such as SciDev and Sciencewise).[12] However, these rarely result in a sustained increase in institutional capacity. While many scientists working in disaster risk research are extremely keen to support more effective application of their findings, few are afforded an opportunity for direct

12 Humanitarian Futures Programme, 'Planning for Future Climate Change Crises: A Draft Note from Discussions Preparing for the Futures Group Seminar', January 2009, http://www.humanitarianfutures.org.

Box 2

Exchange demonstration studies between climate scientists, humanitarian and development agencies and communities at risk

The demonstration studies in Kenya and Senegal were based on the idea that only through sustained and collaborative partnership will the range of actors involved develop the required understanding, trust and systems to be able to make use of weather and climate information across different decision-making levels and timeframes. The exchange identified, developed and trialled a range of knowledge exchange approaches (including those described in Box 10: 'Knowledge timelines and participatory downscaling', and Box 5: 'Early Warning-Early Action workshop') designed to support the process of accessing, understanding and appropriately applying seasonal and sub-seasonal forecasts among people at risk of drought and flooding. Consisting of a series of community-based workshops and evaluations, tailored systems for providing seasonal and weekly forecasts and flood alerts directly to at-risk groups, technical reviews and national workshops timed around the rainy seasons, the exchanges have benefited all the actors involved: communities at risk, humanitarian and development agencies and participating scientists.

Communities at risk: Participating groups have increased their trust in and use of forecasts provided by national meteorological services, becoming 'demanding customers' of community-based climate services and themselves developing innovative and more relevant channels for communicating climate information. Participating farmers attributed significant yield improvements to their ability to change key agricultural decisions based on improved access to and understanding of seasonal and short-term forecasts. Communities at risk of flooding and drought were able to use forecast information to inform a range of life and livelihood decisions, protecting vulnerable members and household assets when heavy rain was forecast and employing seasonal forecasts and community-managed rain gauges to help with planting decisions.

Humanitarian and development agencies: The exchanges increased participating humanitarian and development agencies' access to providers of climate information, resulting in the signing of formal agreements with national meteorological services and engagement in regional climate fora. Exchange between the two country demonstration studies heightened awareness of the potential to employ climate information across a range of humanitarian, disaster risk reduction and development decision-making processes.

Scientists: The exchange process was as much about scientists learning how best to contextualise their learning within the realities of those living in complex risk situations as it was about developing sufficient understanding among affected people and policymakers for them to begin to ask the right kinds of questions. Creating channels to allow community concerns to directly inform scientists opens up the possibility of re-interrogating existing data to identify new and additional relevance, as well as giving affected people an opportunity to influence the focus of current and ongoing scientific research.

interaction with the people most directly affected by their research. While funders place increased emphasis on tangible impact, there are few resources to support the sustained engagement required to achieve it.

Between 2009 and 2012 HFP developed a series of two-way exchanges between climate scientists and meteorologists from national meteorological services in Kenya, Senegal and the UK, universities, including Sussex, Liverpool and Oxford, communities at risk of flood and drought in Senegal and Kenya and humanitarian and development organisations (Box 2). Exchange activities were coordinated by Christian Aid in Kenya, and by the Senegal Red Cross in Senegal. The initiative supported demonstration studies in Senegal and Kenya to assess how climate science can better support humanitarian, disaster risk reduction and development planning, and how such opportunities for direct collaboration can have tangible benefits for all actors: communities at risk, humanitarian and development actors and participating scientists. Likewise, the use of gaming within the Kenya Red Cross' urban risk reduction work showed how early warning messages can quickly become unclear, and that directly affected people can provide important guidance on the most appropriate routes for timely dissemination (Box 6, p. 9). Similarly Early Warning-Early Action workshops directly involved at-risk groups in the development of early warning systems for flood-affected communities (Box 5, p. 8).

Usability and trust

For scientific knowledge to inform the decisions of affected people it must be usable and trustworthy. People living in areas at risk of drought or flooding, for example, require locally relevant forecasts which can support specific decisions, including information on extreme weather events and the start and quality of seasonal rains. Likewise, it is vitally important to work through channels which at-risk groups most trust. As demonstrated across the case studies included here, there are many existing networks through which relevant scientific understandings of risk can reach affected communities: extension service providers, particularly in health, agriculture and livestock,

Box 3

Participatory Scenario Planning in Kenya and Ghana

Fiona Percy, CARE International

In the past, much government planning has been undertaken at the individual line ministry level. Meteorological forecasts have been transmitted at the national and international levels, with little use at the local level. Participatory Scenario Planning (PSP) co-generates information that is locally relevant and useful. The process provides a common platform which helps people at risk and local governments to discuss issues with meteorological services and agree on options for supporting climate-resilient livelihoods. Developing scenarios of probable climate impacts, the process supports more resilient and flexible decision-making, helping communities to live with the uncertainties and risks presented by both short- and long-term changes in climate.[13]

PSPs are undertaken as soon as the seasonal forecast is available from national meteorological services, in advance of each local rainy season. In a workshop setting over one or two days, PSP brings together a wide range of interested actors, including the district meteorological department, local and traditional forecasting experts, community members, district officers from key ministries and local NGOs, to share and compare their weather and climate knowledge. Participants combine local and scientific sources of seasonal forecast information with an assessment of current livelihood status to develop three probabilistic hazard scenarios. They then assess the hazards and risks within each of these to develop impact scenarios, and locally-relevant, livelihood-tailored, actionable advisories for the coming season. These advisories are communicated to local communities through a wide range of channels, including radio and other media, leaders and extension services.

PSPs support more flexible planning and risk management, considering both most likely and alternative scenarios. Government plans for vulnerable sectors such as agriculture are modified according to the advisories. Communities and households are able to make decisions on crop mixes, the timing of operations and livestock management in relation to the potential opportunities and risks communicated. The approach also highlights the need for ongoing channels for dialogue, to enable meteorological services to better respond to the specific needs of different user groups, and integrated approaches to climate services and broader risk management, bringing together relevant sectoral expertise to support decision-making at local, district and national levels.

faith networks, schools, community and local radio, markets, SMS platforms and the networks of national and international humanitarian, disaster risk reduction and development agencies all offer potential means of risk communication depending on the particular context.

Engaging with local knowledge provides significant opportunities to increase the accessibility, usability and legitimacy of scientific information and produce new and combined risk knowledge which is better able to support those most vulnerable to disasters. Both scientific and local knowledge encompass important understanding about risk and resilience. Sometimes this is complementary and shared, and sometimes it is different and conflicting. Scientific understandings of risk can provide information which local sources cannot, for example concerning hazard-prone areas which do not have previous experience or remaining memory of current and emerging risks. Yet local knowledge can address areas current scientific understanding cannot yet reach. Seasonal forecasts cannot, for example, provide information at the geographic and temporal scales which climate-vulnerable groups require, while some local historical knowledge and forecast indicators can usefully inform local decision-making. Participatory Scenario Planning (PSP) (Box 3), developed by CARE International and employed in Kenya and Ghana, brings together local and scientific sources of seasonal forecast information to develop locally relevant, livelihood-tailored actionable information. The approach provides a platform for at-risk people, local government and national meteorological services to jointly develop a range of hazard scenarios and discuss options for supporting climate-resilient livelihoods.

The Blending Approach (see Box 4) developed by Christian Aid combines scientific forecasts with local indicators to develop projections which are more relevant, tailored, contextualised and acceptable to the specific decision-making processes of small farmers dependent on rain-fed agriculture. The Blending Approach and similar methodologies have encompassed the provision of meteorological forecasts alongside community-managed rain gauges and log books. Locally managed rain gauges have informed decisions on planting once a locally-relevant rainfall threshold has been passed, promoted contribution to and use of climate data amongst at-risk groups and enabled at-risk groups to assess the reliability of nationally produced information. They have also extended the reach of observation systems and supported the downscaling of scientific forecasts, which are often provided at national scale/low resolution, to the

13 M. Ambani and F. Percy, *Decision-making for Climate Resilient Livelihoods and Risk Reduction: A Participatory Scenario Planning Approach*, CARE, 2012, www.careclimatechange.org/files/adaptation/ALP_PSP_Brief.pdf.

Box 4

Blending local and scientific knowledge sources to support small-scale farmers in drought-prone areas of Kenya and Tanzania

Richard Ewbank, Christian Aid

In order to develop climate information services which better support small farmers in drought-prone areas of Tanzania and Kenya, Christian Aid and its partners have piloted a Blending Approach. Blending brings local information together with scientific forecasts, increasing the local relevance of the latter and the scientific basis of the former. Even where local indicators are becoming less reliable and/or their use is diminishing, bringing the scientific information into the local environmental, socio-economic and cultural context increases the likelihood that it will be understood, accepted and used. Blending involves eight basic steps:

- Identification of climate information requirements and local climate information sources.
- Assessment of local (bio/cultural) indicators, including perceptions of their reliability and whether and why these perceptions have altered.
- Identification of information confirming the scientific basis for local indicators.
- Identification of scientific climate information sources, and assessment of their reliability.
- Consideration of appropriate approaches for blending local indicators (especially those assessed as reliable and/or science-based) with scientific sources of climate information to best support specific livelihood decisions.
- Identification of the inputs and advisory services required to support these decisions.
- Establishment of systems for the provision of decision-enabling climate services, including a regular uninterrupted supply of short-term forecasts and rain gauges to increase local data collection and validate forecasts.
- Evaluation of the blending process and its impact on livelihood outcomes.

Blending recognises that supporting farmers requires an integrated approach, combining meteorological and climate services with agricultural and marketing support. While the approach has only been undertaken to date on a pilot basis and over a small number of seasons, it has increased access to climate information, strengthened confidence in and willingness to employ national meteorological information and increased agricultural yields and identified complementarities between local and scientific sources of information.

The Blending Approach has identified a number of additional ways in which the complementarities between scientific and community indicators can help in developing climate information services for at-risk people. These include:

- Scientific research on bio-indicators to assess which local indicators have a scientific basis.
- Verifying and/or challenging community perceptions of climate variability and change through comparison with climate records and forecasts.
- Enhancing user understanding of the probabilistic nature of forecasting and how this can be applied, reducing unrealistic expectations of what meteorological science can provide.
- Creating links so that community priorities can be fed back to meteorological and other relevant departments and institutions.

geographic scale and higher-level resolution required to support more localised decision-making. As exemplified by the case study on ‘Climate science mentoring to build capacity in the Pacific and Timor-Leste’ (see Box 8, p. 11), increasing links between international and national scientific institutions also affords opportunities for local validation of international projections.

Understanding

Increasing understanding amongst the range of actors involved encompasses building both scientists’ understanding of the information requirements of directly affected people and humanitarian and development agencies, and strengthening users’ understanding of scientific understandings of disaster risk, the levels of confidence and uncertainty and key differences of opinion within this information, as well as the ways in which science and technology can assist in addressing disaster risks.

Cognition and understanding

Effective risk communication entails overcoming linguistic, scientific, sectoral and language differences and social and cultural barriers. ‘Hard’ or infrastructural resilience-building measures, such as evacuation shelters, are rarely effective without complementary risk communication and education initiatives. Since 2009 the Red Cross/Red Crescent Climate Centre has been investing in innovative alternatives to traditional forms of communication, developing a series of participatory games to stimulate learning and creativity in addressing complex, real-world problems. These games seek to engage people’s minds and emotions through the learning process. Serious games can provide a memorable and fun way of learning, moving players from ‘Huh?’ moments of confusion to ‘A-ha!’ moments of understanding. Participatory gameplay can be catalytic in creating a fruitful atmosphere of collaboration amongst actors with different languages, perspectives and priorities. They can

Box 5

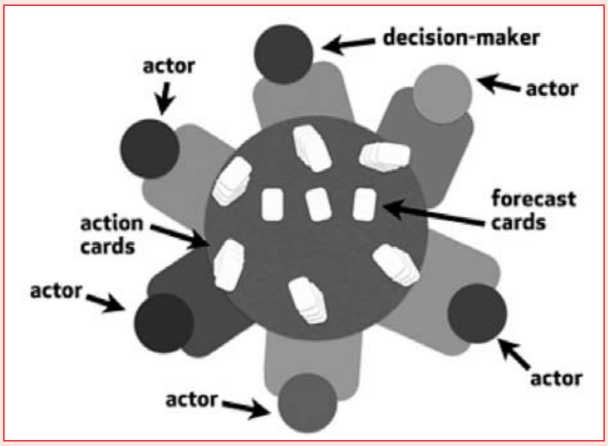
Early Warning-Early Action workshops: bridging the gap between climate scientists and communities at risk

Arame Tall, CCAFS

The Early Warning-Early Action (EW›EA) approach seeks to bridge the gap between national climate information providers, boundary organisations and community users, and provides a framework for developing user-driven climate information services at regional, national, district and community levels. Each EW›EA workshop consists of a three-day facilitated dialogue bringing together these key stakeholders to jointly develop a plan of action to communicate timely, accurate and actionable early warnings to vulnerable communities. Ten pilot EW›EA workshops were conducted in Senegal, Kenya, Uganda, Ethiopia, Niger, Burkina Faso and Mali between 2009 and 2012. The workshop format comprised five principal elements:

1. Prior preparation by climate forecasters and users of climate information.
2. A series of modules on topics relevant to climate risk management, tailored to a specific decision-making process.
3. Mediated dialogues between providers and users to agree a plan and allocate specific roles and responsibilities for communicating and applying salient climate information services for local users.
4. A forecast scenario game, putting participants in the role of a vulnerable community member who has to decide whether to undertake a preparedness measure on the basis of a warning message received from the national meteorological service.
5. A joint community visit.[14]

As illustrated in the figure, in the EW›EA scenario game participants are divided into small, mixed scientist/user groups and presented with a series of probabilistic forecasts over different time periods relevant to the decision-making process which the exercise is seeking to support (for flood early warning, for example, forecasts may be given for ten days, 48 hours, 24 hours and three hours). Participants then have to decide what they consider the most appropriate action given the forecast timeframe and information provided. Participants take turns to act as the decision-maker, who is tasked with deciding between the series of possible preparedness actions proposed by the other participants, who challenge the decision-maker and discuss their preferred actions.



Participants take turns to play the role of a decision-maker having to select an early action based on a received early warning. Source: PETLab & Red Cross/Red Crescent Climate Centre.[15]

In each country where EW›EA workshops were undertaken, communication between national disaster management actors and national meteorological agencies has improved. In Uganda, EW›EA activities led to the development of a national institutional framework for climate service provision and communication, as well as the development of a plan of action for implementation. In Senegal and Kenya, where EW›EA activities were incorporated within existing projects run by Christian Aid in Mbeere and by the Senegal Red Cross in Kaffrine, EW›EA workshops have contributed to yield increases by strengthening farmers' capacity to anticipate and prepare for predicted climate shocks.

stimulate creativity amongst participants as peers, and enable the engagement of literate and illiterate people. While the Centre has developed a wide range of gaming approaches (available at http://www.climatecentre.org/site/games-catalogue), those particularly useful in supporting exchange of knowledge between the providers and users of disaster risk knowledge are discussed in Boxes 5, 6 and 7.

Building scientists' understanding of the information needs of at-risk groups and disaster risk managers

Scientists often assume that they know the information that users want and can unilaterally identify the 'humanitarian' significance of scientific understanding of risk. Scientists

14 The Early Warning-Early Action methodology was developed by Arame Tall in collaboration with Pablo Suarez of the Red Cross/Red Crescent Climate Centre and PETLab, based at Parsons The New School for Design, New York. Its development was funded by a grant from the Africa Climate Change Fellowship Programme funded by START, the UK Department for International Development and Canada's International Development Resource Centre. Full instructions for the scenario game are available at http://petlab.parsons.edu/redCrossSite/rulesBTS.html.

15 This game and others can be found at http://petlab.parsons.edu/redCrossSite.

Box 6

‘Ready’ and ‘Telephone’: using participatory games in urban risk reduction in the slums of Nairobi, Kenya

Erin Coughlan, Red Cross Red Crescent Climate Centre, Daniel Mutinda, Kenya Red Cross, Anne Mette Meyer, Danish Red Cross

To assess the risks facing people living in crowded, informal settlements in Nairobi, the Kenya Red Cross (KRC) and the Red Cross/Red Crescent Climate Centre carried out a Climate Risk Assessment in 2012 employing participatory games to support focus group discussions. Attendees included representatives from existing disaster risk reduction groups, the provincial administration and the Kenya Meteorological Service (KMS), in addition to a cross-section of slum residents. Previous surveys had shown flood risk to be a key concern in these areas, and model projections for climate change in East Africa indicate that the risk of extreme rainfall is likely to increase, as is average rainfall.

Two games were used within the risk assessment. In the first game, ‘Ready’, players formed three competing teams, each identifying a variety of actions that they could take in response to a flood risk in their neighbourhood. Each team prioritised eight actions, and drew them on an index card. Teams were then given 20 dice and asked to divide the dice amongst the eight actions according to how difficult it was to complete them (more dice corresponded to increased difficulty). Gameplay lasted for 90 seconds, during which team members scattered around the room to ‘complete’ their actions by rolling the dice repeatedly to attain a certain number combination. The group that completed the most actions before the deadline won a prize.

Discussion following this exercise considered and compared the wide range of actions which were completed by each of the teams during the game, and how these were similar to or different from actions that are completed by the community in real life. This enabled participants to identify common issues and priorities and focus on their capacities and what they were able to do to reduce the risk of disaster. The discussion enabled participants to identify key enabling factors, such as the existence of an early warning system giving the community sufficient time to prepare, which can be included in future programming.

In the second game, ‘Telephone’, participants lined up one behind the other in three teams. The person at the front of the line was given a nearly incomprehensible message about the probability, lead time, location and amount of a forecasted rainfall event. The information was then transferred from one person to the next until it reached the end of the line; the team reaching the end of the line with the correct information first won the game.

During the debrief after the game, participants were asked to describe the existing early warning information system in their community. They were quick to offer parallels with the game, with messages becoming garbled during the process of communication, and ways in which the long ‘telephone line’ can be shortened to deliver clearer messages.

Both of these games have helped improve humanitarian programming and decision-making. KMS has expressed interest in developing a flood early warning system for Nairobi based on upstream rainfall and river levels, and KRC has indicated its interest in disseminating such alerts. The approach also highlighted that the provincial administration is a main player in the existing early warning system and has an integral role in risk reduction programming.

who participated in exchange activities (see Box 2, p. 5) recognised that, in better appreciating specific user needs, there are significant opportunities to both re-examine and more fully exploit existing data and identify new research questions that are more relevant to the particular decision-making requirements of at-risk groups.

It is equally clear that efforts to enable disaster risk science to better support community resilience need to extend to capacity-building of national scientific institutions. While one of the long-term aims of the Pacific-Australia Climate Change Science and Adaptation Planning Programme mentoring initiative (see Box 8, p. 11) is to support more effective use of climate science within national adaptation processes, the initiative has also enabled the local validation of forecasts produced by international climate centres.

Credibility

Scientific understandings of risk vary greatly across hazards, regions, timeframes, institutions and individuals. Some scientists believe that it is not useful for them to discuss differences of scientific opinion in front of affected groups or policymakers in case this underplays the large parts of disaster risk science on which scientists are agreed and fails to differentiate largely ‘settled’ areas from ongoing or new research.[16] Some scientists have been unwilling to engage in resilience-building efforts, considering the levels of confidence to be too low or fearing that affected people will misunderstand and misapply the information provided, further heightening existing vulnerabilities. Others have been willing to engage in advocacy where they see current preparedness

16 Sense About Science, ‘Making Sense of Uncertainty: Why Uncertainty Is Part of Science’, 2013, www.senseaboutscience.org.

Box 7

Participatory game design

Carina Bachofen and Pablo Suarez, Red Cross Red Crescent Climate Centre

The Red Cross/Red Crescent Climate Centre has begun to engage decision-makers directly in participatory game design by inviting them to reflect on complex real-world systems and disaggregate their elements into essential building blocks for game design. Strong facilitation by experts familiar with the methodology for participatory game design is vital to this process. Technical expertise, especially regarding the representation of risk, is also integrated into game design. For example, the game 'Paying for Predictions' specifically mimicked the seasonal forecast for extreme rainfall issued for West Africa in 2008.

Participatory game design involves six steps:[17]

1. Define the communication challenge
What conversation should game play elicit? What types of decision-making strategies should emerge during game play? What is the 'A-ha!' moment players should experience?

2. Define what needs to be represented in the game
What are the key elements that will be used to construct the rules, process and emotional triggers of the game? Who can make decisions in the game? What are possible actions? What combinations of competing priorities and trade-offs should players face during game play?

3. Define the emotional triggers of the game narrative
What feelings should the game elicit? How will information lead to different individual or collective decisions that have one or more emotional consequences? What tensions should arise during game play as both expected and unexpected consequences present themselves?

4. Refine the game
Boil the narrative down to its essential elements related to information, choices, decisions, actions and consequences.

5. Develop rules
Create a game that captures the desired learning and dialogue experience in a way that is engaging and memorable. The rules of play need to be simple, but also need to lead to the emergence of a complex and rich system. At this stage it is usually necessary to engage professional game designers.

6. Play!
Try out the game prototype. Discuss with participants the consequences of different actions and how to improve the prototype. Tweak game dynamics, rules and emotional triggers. Iterate.

Employing the six-step methodology within the Partners for Resilience Program (PfR), staff from the Nicaragua and Guatemala Red Cross Societies designed a game, 'Upstream-Downstream', designed to engage vulnerable river basin communities in a dialogue about climate, disasters and ecosystems. Community participants appreciated how successful strategies during game play paralleled the importance of shared risk management in real life. Collective action during gameplay boosted people's confidence and willingness to invest in dialogue about ways to take action in reality, including payment for ecosystem services to manage flood and drought risks. It also encouraged the PfR team to further develop the game to promote dialogue about managing changing risks.

While the impact of this participatory approach is the subject of ongoing research, demand is rapidly increasing. Experience to date indicates that engaging decision-makers in participatory game design offers three significant benefits: the game better reflects a real world system when designed by those most familiar with the context; interest in and enthusiasm for the game increase; and better insights can be generated amongst the participants regarding the system that the game mimics. This in turn can contribute more deeply than game play alone would do to the higher objective of climate risk management.

to be insufficient given current scientific understanding of risk. The tsunami preparedness NGO KOGAMI, for example, has brought international, national and local scientific expertise to bear in its efforts to raise awareness and strengthen local government preparedness activities, making connections with seismologists from the California Institute of Technology, the Indonesian Institute of Sciences (LIPI) and Padang City's Andalas University to ensure that its efforts are informed by relevant scientific understandings of risk.[18]

There have been a series of instances in recent years which clearly demonstrate the necessity for scientists to find better ways of conveying the probabilistic nature of current scientific understandings of risk, as well as the importance of raising levels of 'scientific literacy' amongst both policymakers and affected users. The Kenyan Meteorological Services (KMS), for example, faced severe criticism when rains forecast for October–December 2009 did not materialise as farmers had understood they would.[19] While the forecasted rains did occur, they did not arrive until late in the season, by which time farmers had already lost their agricultural investments. Fortunately for KMS, the rains arrived just as farmers were threatening to take KMS to court. The

17 For a full description of the process, see 'Can Games Help People Manage the Climate Risks They Face? The Participatory Design of Educational Games', www.climatecentre.org/downloads/File/Games/AW-wps-games-v5.pdf.

18 See Case Study 5 in the Annex, www.odihpn.org/knowledge-is-power.

19 Personal communication from the Kenya Meteorological Services

Box 8

Climate science mentoring to build capacity in the Pacific and Timor-Leste

Lily Frencham, Pacific-Australia Climate Change Science and Adaptation Programme, and Jill Rischbieth, CABI

The Pacific Climate Change Science Program (PCCSP) and the ensuing Pacific-Australia Climate Change Science Adaptation Planning Programme (PACCSAP) have provided a platform for scientists and decision-makers in Australia, 14 Pacific countries and Timor-Leste to work together to increase scientific understanding and capacity with regard to climate change and variability in the region.

Initially developed in response to requests from Pacific scientists for longer-term collaborative learning opportunities, the Mentoring and Attachment Program has combined 'attachments' (visits from partner country representatives to Australia) and 'mentoring visits' (which see PACCSAP science mentors spend time in the partner country). Feedback from the mentoring initiative has been overwhelmingly positive. The opportunity for Pacific scientists to learn from and establish professional relationships with leading Australian scientists has been welcomed. For many of the Pacific scientists the mentoring programme provided their first opportunity to present at international science conferences and co-author peer-reviewed journal papers. The approach has also supported two-way learning. Australian scientists participating in the programme feel that the integrity of scientific research is enhanced by the mentoring.

As Dr Debbie Abbs (CSIRO) explained, 'I asked David Hiriasia, the Director of the Solomon's Meteorological Service, to "laugh-test" the results coming from our models. The local meteorological knowledge that David brings to the research partnership is critical to building a better understanding of their country's climate.'

Director of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) was sacked for not warning the 12 million residents of Metro Manila about a strong tropical storm, Typhoon Conson, in July 2010. He was criticised for having failed to mention that the disturbance had a wide radius, meaning that, although the eye of the typhoon passed north of Manila, the city was still struck by fierce winds.[20] In Italy, an investigation into the earthquake in L'Aquila, Italy, in 2009, in which 300 people died, concluded that members of the National Commission for Forecasting and Predicting Great Risks had provided 'incomplete, imprecise, and contradictory information', and six scientists and an official were found guilty of manslaughter.[21]

20 'PAGASA Chief Sacked', abs-cbnNEWS.com, 8 June 2010, www.abs-cbnnews.com.

21 N. Nosengo, 'Italian Court Finds Seismologists Guilty of Manslaughter', Nature, 23 October 2012.

Box 9

The Decision Support System in Bangladesh

S. H. M. Fakhruddin, RIMES

The Decision Support System (DSS) is designed to interpret, translate and communicate science-based risk information in location-specific, user-friendly products. Scientific data from local, national, regional and international sources across a range of disciplines is combined and the flood early warning needs of at-risk communities are identified through Participatory Flood Risk Assessment and Management Planning.

The initiative has increased the lead time of local-level flood forecasting. During floods in 2007 and 2008, its ten-day forecasts were used in national- and community-level disaster emergency response planning. People in the communities where the approach was piloted undertook a range of activities when they received the flood forecast message. They stored dry food and safe drinking water, protected household assets, vegetable patches and fishponds, harvested rice and jute crops early and prepared to evacuate themselves and their livestock to higher ground. At the same time, they planned alternative livelihood options for immediately after the flooding, including revised rice planting and undertaking fishing and boat-making. According to a World Bank analysis, every dollar invested in the approach realised a return of $40 in benefits over a ten-year period.[22]

Conveying the levels of confidence and uncertainties within scientific understandings of risk

For information users to be able to appropriately apply science to a livelihood decision, and take the consequences if things go wrong, it is imperative that scientists transparently convey the levels of confidence within their current understandings of risk. Employing the Decision Support System (DSS) (see Box 9), the Climate Forecast Applications Network (CFAN) and Regional Integrated Multi-Hazard Early Warning System (RIMES) have developed an early warning system for flood-risk communities in Bangladesh. When forecasters explained that they would be correct perhaps seven times out of ten, participating farmers recognised the value of this information. As one put it: 'Only God knows 100% what will happen. Right now we take chances every year and

22 A. R. Subbiah et al., *Background Paper on Assessment of the Economics of Early Warning Systems for Disaster Risk Reduction, Joint World Bank–UN Project on the Economics of Disaster Risk Reduction*', World Bank, 2009, http://risk.earthmind.net/files/World-Bank-2008-Economics-Early-Warning-Systems.pdf; P. J. Webster et al., 'Extended Range Probabilistic Forecasts of the Ganges and Brahmaputra Floods in Bangladesh', *Bulletin of the American Meteorological Society*, 91(11), 2010.

Box 10

Knowledge Timelines and Participatory Downscaling

Dominic Kniveton, University of Sussex

Knowledge Timelines and Participatory Downscaling have both been used in the exchange demonstrations in Kenya and Senegal described in Box 2. They stem from recognition that knowledge from scientists and local communities are both valuable and can complement each other. Acceptance and understanding of the inherent uncertainties in climate information is fundamental to the appropriate use of this information.

Knowledge Timelines

Communities are asked to compare their understanding of local weather and climate patterns with knowledge available from the scientific community. The approach aims to explore the different types of knowledge that people use to make decisions; to understand the similarities and differences in these knowledge sources; and to build understanding about the levels of confidence and uncertainty across both community and scientific knowledge sources. In the Knowledge Timelines approach:

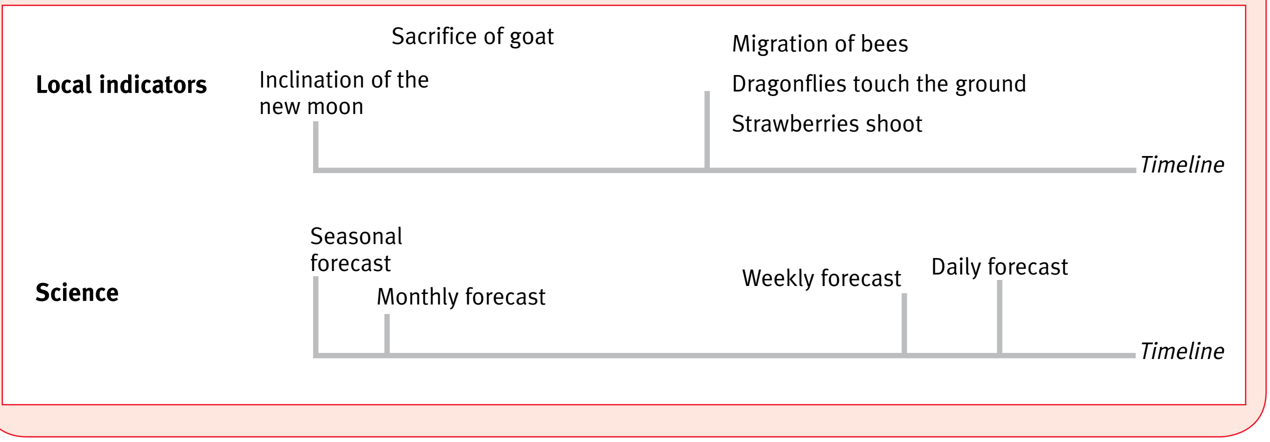
- The audience is encouraged to recall a past climate event using non-climate events to jog their memory (for example a significant political or social event).
- Participants are then asked to discuss the different climate or weather information that people had before the climate event occurred.
- The scientific information available for this event is then detailed and the uncertainty and confidence in the information is described in terms of spatial and temporal scale.
- The audience then describes the confidence and uncertainties they have in the information they currently use.
- The group then compares and contrasts the features of each knowledge type.

The exercise revealed that both scientific and local knowledge types are accurate sometimes and inaccurate at other times. The figure below depicts discussion from the use of the Knowledge Timelines with farmers' groups participating in the Sustainable Agricultural Livelihoods Innovation (SALI) project being undertaken by Christian Aid and Christian Community Services Mount Kenya East (CCSMKE) in Mbeere District, Kenya. The discussion compared the types and timeframes of local and scientific weather and climate information, and the levels of confidence in these various information sources.

Participatory Downscaling

Participatory Downscaling aims to develop a shared understanding of the uncertainties in climate and weather information and the impact of these uncertainties on the decisions of at-risk groups and humanitarian and development agencies. It also seeks to support local capacity to translate national and regional climate and weather information into climatic and weather outcomes on a scale relevant to local decision-making processes. The approach is based around a simple event history technique:

- Starting with a time series of observed atmospheric data, a sample of years are selected that represent different atmospheric-related events.
- For each event, one or two non-climate culturally, politically or economically important events are selected to provide a mental trigger to participants of the year of the event being referred to.
- For each year, starting with the most recent, and without revealing the flood or rain conditions that year, participants are asked to discuss whether the location in which they were in that year experienced a wet, dry or average rainy season and whether the communities where they lived experienced the weather-related hazard of interest.
- The national and regional observational records of the rains and weather-related hazard are then revealed to the participants and the range of experiences then collated for years which were similar in terms of rainfall at a national and regional level.
- The seasonal rainfall forecast is then revealed for each year.
- A group discussion is then held about the humanitarian and development implications of this range of outcomes at the local scale for the same national event.



that means we are right as often as wrong. Seventy per cent means I am ahead'.[23]

The range of approaches employed by the climate science-humanitarian policy exchange demonstration studies in Kenya and Senegal (Box 2) made clear to participating climate scientists that users are adept at making decisions in situations of uncertainty. Scientists engaging with the Sustainable Agricultural Livelihoods Innovation (SALI) project in Mbeere District, Kenya, noted that 'when provided with straightforward explanations and context-specific local examples, participating farmers eagerly took to probabilistic information'.[24] Villagers in Kaffrine District, Senegal, participating in a parallel exchange undertaken with flood-risk communities, likewise recognised the value of probabilistic forecasts, stating that: 'God is the one who provides, but your knowledge contributes to it'.[25]

Appropriate application

Efforts to unlock the potential of science and technology to enhance community resilience need to extend beyond communication to support people at risk in appropriately applying relevant science and technology. Appropriate application requires facilitating the translation of knowledge into informed and better decisions, identifying spaces for ongoing exchange and co-production of knowledge, creating channels so that the concerns of directly affected people inform research agendas and improving access to the resources required to effectively act on enhanced risk knowledge. Major constraints to the appropriate application of scientific knowledge by humanitarian and development agencies and at-risk communities include procedural or institutional practices (for the agencies) and the availability of choice and resources to act on information received (for affected communities).

Procedural or institutional practices

There is growing awareness of the major disjuncture between the current top-down focus on international, regional and national frameworks for resilience and approaches to support people-centred resilience.[26] There are few spaces for systematic dialogue between those with specific scientific and technological knowledge and either those groups most directly affected by this learning, or humanitarian actors operating at city, district and local levels. For those involved in initiatives to strengthen the application of scientific understandings of risk there are few established resources or structures to identify and support shared and accumulated learning.

Both the scientific and humanitarian and development communities suffer from a lack of incentives to foster the sustained inter- and intra-sectoral collaboration required to support effective dialogue. Despite increased emphasis on 'impact', research funding accords greater weight to papers accepted by prestigious peer-reviewed journals than to the application of scientific learning to achieve tangible benefits for at-risk people.[27] Operational humanitarian and development agencies are keen to demonstrate areas of particular expertise and organisational difference, with both operational and funding agencies judged more by results for beneficiaries than by how well their policies and programmes are informed by disaster risk science.

Box 11

Focus group discussions for participative climate risk communication

Gabriela Marques Di Giulio, University of São Paulo, Brazil

A four-year Climate Project has been considering the relationship between urban growth, vulnerability and adaptation on the São Paulo coast in Brazil, an area of unsafe, unregulated settlements, where scarce drinking water and poor sanitation are coupled with pressures from tourism and the oil and gas industries. Involving more than 70 researchers, the project has investigated how solutions may require better understanding of local and regional government knowledge, concerns and actions related to climate.

Recognising that policymakers and local people obtain evidence from a variety of sources beyond scientific materials, and have to make decisions in contexts of political, economic and social complexity, the project has undertaken a series of focus group discussions with researchers, disaster risk managers, neighbourhood leaders and youth groups. These have sought to analyse how 'those who make science' and 'those who use science to make decisions' engage in dialogue, and how scientific information is or is not useful in urgent and pressurised decision-making contexts.

Focus group participants have welcomed the opportunity to share their experiences and the challenges they face, while researchers have recognised the value of focus groups in improving their understanding of stakeholders' perceptions of risk and sharing relevant scientific understanding.

23 E. Visman, B. Dempsey and S. H. M. Fakhruddin, 'Understanding Uncertainty To Prevent Humanitarian Crises', SciDev.net, 21 November 2012, www.scidev.net.

24 R. Ewbank, *Strengthening Access to Climate Information: The Impact of the Sustainable Livelihoods Project*, Christian Aid, 2012.

25 *Operationalising Climate Science: An Exchange Between Climate Scientists and Humanitarian and Development Policy Makers: Senegal Demonstration Case Study*, November 2012, www.humanitarianfutures.org, p. 12.

26 I. Borowski et al., 'Spatial Misfit in Participatory River Basin Management: Effects on Social Learning, A Comparative Analysis of German and French Case Studies', *Ecology and Society*, 13(1), 2008; C. Pahl-Wostl, 'A Conceptual Framework for Analysing Adaptive Capacity and Multi-level Learning Processes in Resource Governance Regimes', *Global Environmental Change*, 19(3), 2009.

27 P. Jensen, 'Scientists Who Engage with Society Perform Better Academically', *Science and Public Policy*, 7(35), 2008.

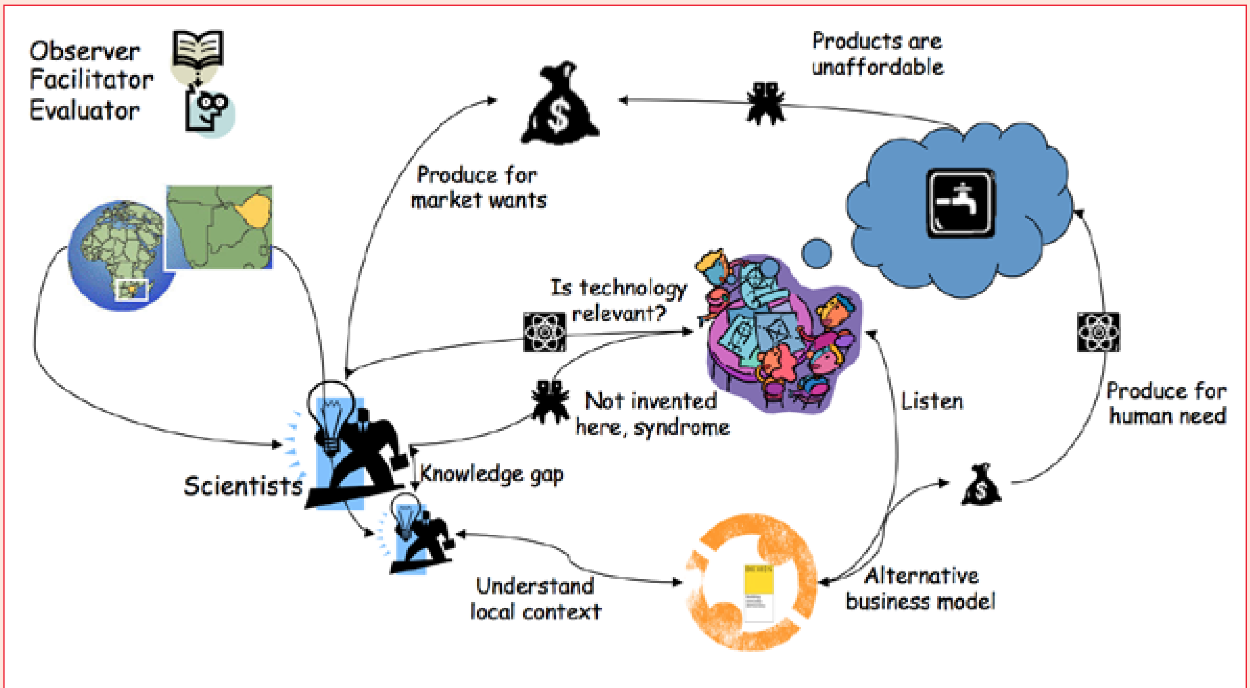
Box 12

A systems approach to dialogue about new technologies in Zimbabwe, Peru and Nepal

David Grimshaw, ICT4D

Practical Action have supported discussion about how nanotechnology – materials and systems working with matter on an ultra-small scale – may increase access to safe drinking water. Related 'nanodialogues' sought to introduce the views and values of people for whom clean water is an everyday problem into debates about responses that might involve nanotechnology. Bringing together Practical Action, the UK think tank Demos and the University of Lancaster, workshops were held in Zimbabwe in 2006. Further initiatives took place in Peru in 2007–2008 and Nepal in 2009. All employed a systems approach to better understand the complex social, cultural, technological, contextual, environmental and behavioural issues and constraints around the availability of safe water supplies, and the potential for nanotechnologies and other new science/technology to address these. The Rich Picture, below, represents the complex relationships and connections identified through employing the systems approach, demonstrating the need to bridge knowledge gaps between local and global scientists, listen to local people, understand the context and dimensions of needs and develop new business models.

Early engagement of users built ownership and consensus. Work in Nepal also made clear that technology may come from a number of scientific disciplines. While initially focused on nanotechnology, the work in Nepal is, for example, now applying synthetic biology to develop an arsenic biosensor (http://www.arsenicbiosensor.org). The work has also demonstrated that engaging with scientists and developing appropriate new technologies is a long-term process, and that dialogue is only the beginning. Sustaining that conversation over many years is a key element of success.



A rich picture of the problem situation, taken from D. Grimshaw, J. Stilgoe and L. Gudza, *The Role of New Technologies in Potable Water Provision: A Stakeholder Workshop Approach*, 2006, http://www.eldis.org/assets/Docs/45506.html.

Availability of choices and resources to use information

People focused on survival needs and pressing current concerns understandably find it difficult to think about potential future crises. The person at risk contextualises and prioritises externally derived information within the complex risk situation in which they live – scientific information is only one piece in a complicated, dynamic picture. Responses to new, externally derived scientific information which may seem illogical or irrational to an outsider may be rational for a person at risk. Participatory Scenario Planning (Box 3) seeks to increase people's capacity to plan for both current, short-term issues, as well as longer-term potential changes. In a similar vein, researchers in the Climate Project undertaken by the University of Campinas in Sao Paulo, Brazil, have conducted focus groups to support participative climate risk communication (Box 11). The focus groups have enabled scientists to better appreciate the variety of sources from which policymakers and at-risk groups obtain

Box 13

The BDRC Learning Circle in the Philippines

Jessica Dator-Bercilla, Manila Observatory and Ateneo School of Government, Ateneo de Manila University, Antonia-YuloLoyzaga, Manila Observatory, Miguel Magalang, Marinduque Council on Environmental Concerns and Shirley Bolanos, Building Disaster Resilient Communities Learning Circle and Coastal Core Sorsogon, Inc.

In 2007 community-based practitioners started working with the Manila Observatory and the University of the Philippines to develop an intensive course on disaster risk reduction (DRR). This led to the development of the Building Disaster Resilient Communities (BDRC) Learning Circle and the Scientists and Community Practitioners' Dialogue. The initiative encourages dialogue between community practitioners and scientific institutions and local experts in a wide range of areas, including risk assessment, community-based early warning systems and climate-resilient food security strategies. It also allows participating scientists to develop new, more inclusive approaches to risk research. Deeper understanding of risks gave partners the confidence to develop advocacy initiatives aimed at mainstreaming DRR and climate change adaptation (CCA) within local, sub-national, national, regional and international platforms. Partners tested a simplified mainstreaming process at the *barangay* or village level and transformed knowledge accrued through their extended period of partnership into a 12-step DRR and CCA mainstreaming toolkit to support Local Government Units (LGUs), from village to provincial levels, in development planning. The mainstreaming process provided an avenue to ensure the financial and other investments required for DRR and CCA interventions amongst communities at risk.

evidence, as well as the complex political, economic and social contexts in which they make decisions.

Providing scientific information without providing access to the resources required to act on it can raise false expectations and heighten stress amongst already disempowered groups. This highlights the importance of integrated approaches which bring together the people most directly affected with those engaged in risk governance, who have access to resources. Early Warning-Early Action (Box 5, p. 8) and PSP (Box 3, p. 6) workshops bring together at-risk groups and disaster risk managers, alongside the sectoral expertise required to develop integrated approaches to addressing the range of risks experienced by people living in multi-hazard environments.

Creating frameworks for ongoing, two-way dialogue

Establishing ongoing and more inclusive frameworks for risk communication offers tremendous opportunities for enhancing risk governance, including by creating channels through which the concerns of people at risk can directly inform district, national and regional planning and scientific research agendas. Practical Action and partners have employed a systems approach to stimulate consideration of how nanotechnology might address issues around the availability of clean water, enabling users to directly inform the focus and application of emerging technologies (Box 12). As well as encouraging community practitioners to directly engage expertise from across a range of scientific institutions, the Building Disaster Resilient Communities (BDRC) Learning Circle in the Philippines, which was supported by Christian Aid and DFID, enables participating scientists to develop new, more inclusive and trans-disciplinary approaches to risk research (Box 13).

Directly engaging affected communities in disaster risk science also offers significant opportunities to extend the reach of current scientific capacities. With intermittent or limited hydrometeorological and volcanic observation systems identified as one of the barriers to improving forecasting for both these types of hazard,[28] engaging at-risk groups creates new opportunities to collect and validate scientific data and forecasts, as well as building trust in the information developed as a result (see Boxes 2, 3 and 4).

28 UK Government Office for Science, *Reducing the Risks of Future Disasters: Priorities for Decision Makers*, Foresight, Final Project Report, 2012.

Chapter 3
Lessons and ways forward

This Network Paper has outlined knowledge exchange approaches that have sought to support three key stages of the knowledge exchange process: access, understanding and appropriate application. In exploring the processes that enable science to enhance community resilience, the paper identifies a number of shared characteristics and common requirements concerning those approaches that have been successful in achieving tangible impacts for at-risk communities. This chapter draws these together and considers the types of learning process which support such interactions.

Shared characteristics of successful knowledge exchange approaches

Access

Dialogue approaches that have resulted in tangible benefits for at-risk people recognise affected groups as active contributors and users of risk knowledge, rather than passive recipients. Such approaches identify and contextualise the relevance of scientific learning to produce information tailored to specific life and livelihood decision-making processes and timeframes, and provide it through trusted, accessible sources. It is also clear that such approaches can improve the quality and relevance of existing and future research. Scientists can re-interrogate existing research and data to identify additional or new understandings which better meet the concerns of at-risk groups. User concerns can also identify and drive important new areas of scientific research and technological development.

Understanding

While science and technology have enormous potential to enhance community resilience, current levels of scientific understanding of risk vary greatly across different types of hazard, timeframes and geographic scales. While some scientists are reticent to communicate information which is uncertain, efforts to increase the use of science amongst at-risk groups have repeatedly recognised that at-risk people are used to making decisions in situations of uncertainty. Moreover, it is dangerous to oversimplify information which is necessarily complex.[29] For example, where national meteorological and hydrological services fail to accurately convey the probabilistic nature of the forecasts they provide, they set the forecast up for potential failure.[30] If the low-probability event occurs, then users will perceive the forecast to be wrong and, as a consequence, their confidence in scientific methods may well be dented. If people at risk are clear on the probabilities, they can make their own informed 'best-bet' decisions, supplementing forecasts with local sources of information where available and relevant. As CARE's Adaptation Learning Programme puts it, 'Empowering people to make decisions based on knowledge of uncertainty as well as … forecasts can allow communities to deal with any eventual future adversity and to adapt socio-economic activities to an evolving environment, whatever this might be'.[31] Efforts to strengthen the use of science within community resilience-building are therefore strongly aligned with approaches which build capacity to communicate and appropriately act on uncertain information. As such, building resilience may be as much about equipping 'people with the means to ask the right questions rather than having them know all the answers'.[32]

Learning from this research also highlights the importance of viewing efforts to support more effective use of science within community resilience-building not as stand-alone knowledge exchange activities, but as part of a cooperative learning process which supports learning by doing, or experiential learning. Each of the parties involved in efforts to enable science to enhance community resilience may be both a provider and user of risk information. Successful approaches recognise and clarify the respective roles and strengths of each actor, fostering mutual respect for each other's knowledge sources and value systems.

Appropriate application

Undertaking knowledge exchange work can create high expectations, both regarding how well scientists will be able to meet resilience-building needs, and ensuring access to the resources required to appropriately act on risk information. Approaches need to be able to demonstrate some tangible benefits from engaging in knowledge exchange processes within timeframes relevant to at-risk people and aid agencies. To be effective and sustainable, knowledge exchange efforts need to have benefits for, or seek to meet the impact requirements of, all participants.

A number of the approaches described in this Network Paper question assumptions that the science which knowledge exchange brings will necessarily be appropriate in addressing the principal concerns of at-risk people. This highlights the importance of developing frameworks for dialogue which are 'user-driven', bring together a range of expertise from different sectors and disciplines and remain open to engaging with a range of possible scientific disciplines and technologies. Recognising knowledge exchange as a process, it is clear that achieving each stage

29 A. Stirling, 'Keep It Complex', *Nature* (468), 2010.
30 'The credibility of a probabilistic forecast is likely to be more resilient than that of a deterministic prediction.' Patt and Gwata, 'Effective Seasonal Climate Forecast Applications', p. 192.

31 N. Nicholles and O. Vardakoulias, *Why Community-Based Adaptation Makes Economic Sense*, Policy Brief: Climate Change, NEF and CARE, undated, www.careclimatechange.org/adaptation-initiatives/alp.
32 B. Harvey et al., *Climate Change Communication and Social Learning: Review and Strategy Development for CCAFS*, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Working Paper 22, 2012, http://cgspace.cgiar.org/handle/10568/24456, p. 40.

of that process is dependent on creating opportunities for ongoing dialogue supportive of transformative learning. Achieving tangible benefits for at-risk people requires recognition that a lack of formal scientific input is only one of the obstacles to enhanced disaster risk management. Efforts aimed at unlocking the disaster risk reduction potential of science need to support the development of more inclusive systems of risk governance, concerning issues ranging from resource allocation to the creation of opportunities for directly affected communities to inform and shape ongoing and future scientific research which has the potential to significantly transform their lives.

Ways forward

Drawing together learning from its efforts to strengthen dialogue between scientists, humanitarian actors and at-risk people, the Humanitarian Futures Programme, together with a wide range of partners, has drafted a set of proposed principles designed to support and underpin efforts to create platforms for sustained dialogue between providers and users of disaster risk knowledge. These have been presented and discussed at various fora, including the ASEAN Disaster Risk Assessment forum in March 2013 and the 2013 CCAFS initiative to develop a manual for training intermediaries to communicate climate information services to farmers.

A growing number of humanitarian and development agencies and scientists recognise the need for increased dialogue to unlock the resilience-building potential of science and technology. HFP's efforts and approaches to promote this dialogue have been widely welcomed – the ASEAN Secretariat, for example, worked with HFP in designing the agenda for its March 2013 Disaster Risk Assessment forum, and ECOWAS similarly engaged HFP when integrating the issue of strengthened science–disaster risk management dialogue within its November 2013 information-sharing, early warning and disaster risk reduction forum – and institutions focused on promoting science policy have been extremely supportive. Even so, it has proved extremely difficult to identify the resources required to develop channels for sustained dialogue between those with scientific and technological expertise, people at risk and humanitarian actors. Within efforts to foster strengthened science–humanitarian dialogue, the need to identify specific and sufficient resources is a recurring recommendation.

More fundamentally, learning from this review of initiatives that have successfully enabled scientific and technological learning to enhance community resilience makes clear that the types of interaction and learning required necessitate significant shifts in both value and governance systems. Enabling at-risk groups to gain access to usable risk information, understand and contextualise it, and access the resources to apply it appropriately requires new, user-driven frameworks for risk governance. A number of major international frameworks to guide humanitarian and development, climate change adaptation and disaster risk reduction efforts and shape scientific research and its application are under development and review.[33] These discussions offer significant opportunities to create global frameworks which support and encourage synergies between scientists and humanitarian actors which respect complementary areas of expertise and establish more systematic and integrated use of relevant scientific understandings of risk across humanitarian and development decision-making levels and timeframes.

There are three key issues to address:

1. Strengthening links between efforts to integrate science within community resilience-building

There is growing interest and an emerging community of practice that recognise the tremendous potential in enabling science and technology to better support community resilience. This has, however, led to a wide range of insufficiently coordinated initiatives focusing on different aspects of 'science–humanitarian' dialogue. This lack of coherence diminishes the benefits of more inclusive approaches and risks dissipating interest, as many of the same actors are invited to participate in different,

Box 14

Proposed principles of a framework for dialogue between providers and users of disaster risk science to support community resilience

Supporting the appropriate application of relevant understandings of risk is a process which needs to be:

- Founded on addressing community concerns.
- Two-way.
- Integrated:
  – Transdisciplinary.
  – Contextualised within multi-hazard environments.

It also must:

- Allow for differences of scientific opinion/knowledge sources.
- Blend academic/formal and local sources of disaster risk knowledge.
- Support difference levels of decision-making.
- Be systematic.
- Include (and explain) processes to assess the reliability of knowledge sources.
- Appropriately convey uncertainties/the probabilistic nature of information.
- Encompass systems of accountability and measure impact on the part of the providers and specific users.

33 Examples include proposed future developments and frameworks for the UN Conference on Sustainable Development, the Hyogo Framework for Disaster Risk Reduction and the Millennium Development Goals, as well as Future Earth, the UN Framework Convention on Climate Change (UNFCCC) and the World Meteorological Organisation (WMO) Global Framework for Climate Services (GFCS).

but closely related, initiatives. Greater effort is needed to link efforts across regions, disciplines and sectors to facilitate collective action and further develop the growing community of practice and body of learning concerning those mechanisms which enable science and technology to support community resilience.

2. 'Push or pull': are efforts to strengthen the use of science within community resilience-building best supported by enforcement or incentive?

Among initiatives aimed at strengthening the use of science within community resilience-building there are a wide range of views about the most effective mechanisms for engendering the culture changes required across the academic, scientific, humanitarian and development communities, as well as among at-risk groups. There are a range of possible options under development or discussion, including:

- Guidelines to support each of the major communities of practice.[34]
- Revised incentive systems to encourage collaboration and integration, rewarding at-risk groups and humanitarian and development agencies for ensuring appropriate integration of relevant scientific understandings of risk, and scientists for research which supports community resilience.
- Minimum standards[35] of practice or accountability to identify the extent to which:
  - Scientists should be responsible for appropriately communicating the levels of confidence and uncertainties within the information they provide.
  - Donors should ensure that the work they support is appropriately informed by relevant scientific understandings of risk.
  - Humanitarian and development policymakers should ensure that their work integrates relevant scientific understandings of risk.
  - At-risk groups should undertake efforts to develop and employ understandings of risks which directly affect them.

Comparison with good practice in the insurance industry (see Box 15) makes clear how important it is that humanitarian agencies have in place the organisational capacities, partnerships and systems required to ensure that their resilience-building efforts are informed by relevant scientific understandings of risk. Experience from the insurance industry shows that enabling disaster risk science to inform organisational activities does not require institutional expertise in all risk areas, but it does require the organisation to have sufficient institutional expertise to develop partnerships with relevant sources of expertise, and to monitor the use of internally and externally sourced information.

34 For example M. Duncan et al., 'Integrating Science into Humanitarian and Development Planning and Practice To Enhance Community Resilience: Initial Guidance for Non-governmental Organizations', draft document for review, 2013.

35 For example Partners for Resilience, *Minimum Standards for Local Climate-Smart Disaster Risk Reduction*, Policy Brief, 2012.

Box 15

Extracts from Industry Good Practice for Catastrophe Modelling: A Guide To Managing Catastrophe Models as Part of an Internal Model Under Solvency II, Association of British Insurers, December 2011

'To make proper and timely decisions on risk management issues, senior management must have an overall understanding of where the company is exposed to catastrophe risk, and what its key drivers are. This can be obtained through regular, transparent reports and presentations that highlight changes in exposure and modelling approach.'

'Key … risk specialists should have an overall understanding of the building blocks … Senior managers do not need to have the same level of knowledge … but there should be regular, transparent and evidenced exchanges of information between the two groups.'

'Outsourcing of critical or important operational functions or activities shall not be undertaken in such a way as to lead to any of the following:

- materially impairing the quality of the system of governance of the undertaking concerned
- unduly increasing the operational risk
- impairing ability of the supervisory authorities to monitor the compliance of the undertaking with its obligations
- undermining continuous and satisfactory service to policy holders.'

3. Creating spaces for systematic dialogues across key stakeholder groups

A range of ongoing initiatives clearly demonstrate that inclusive channels for dialogue between at-risk people, humanitarian and development agencies and those with scientific and technological expertise can increase the uptake of relevant scientific understandings of risk, create demanding 'customers' and enable at-risk people to inform the focus of research which directly affects them.

More fundamentally, the creation of channels for dialogue between scientists, at-risk groups and humanitarian agencies opens up important opportunities for strengthening inclusive risk governance. This requires that all participants review and openly share their objectives in engaging in knowledge exchange initiatives. In recognising where these are complementary and where they differ, participating actors can jointly develop ways of measuring impact and frameworks for collaboration which explicitly recognise and seek to provide benefits for, and meet the impact requirements of, all participating groups.

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