Boston University The Frederick S. Pardee Center
for the Study of the Longer-Range Future

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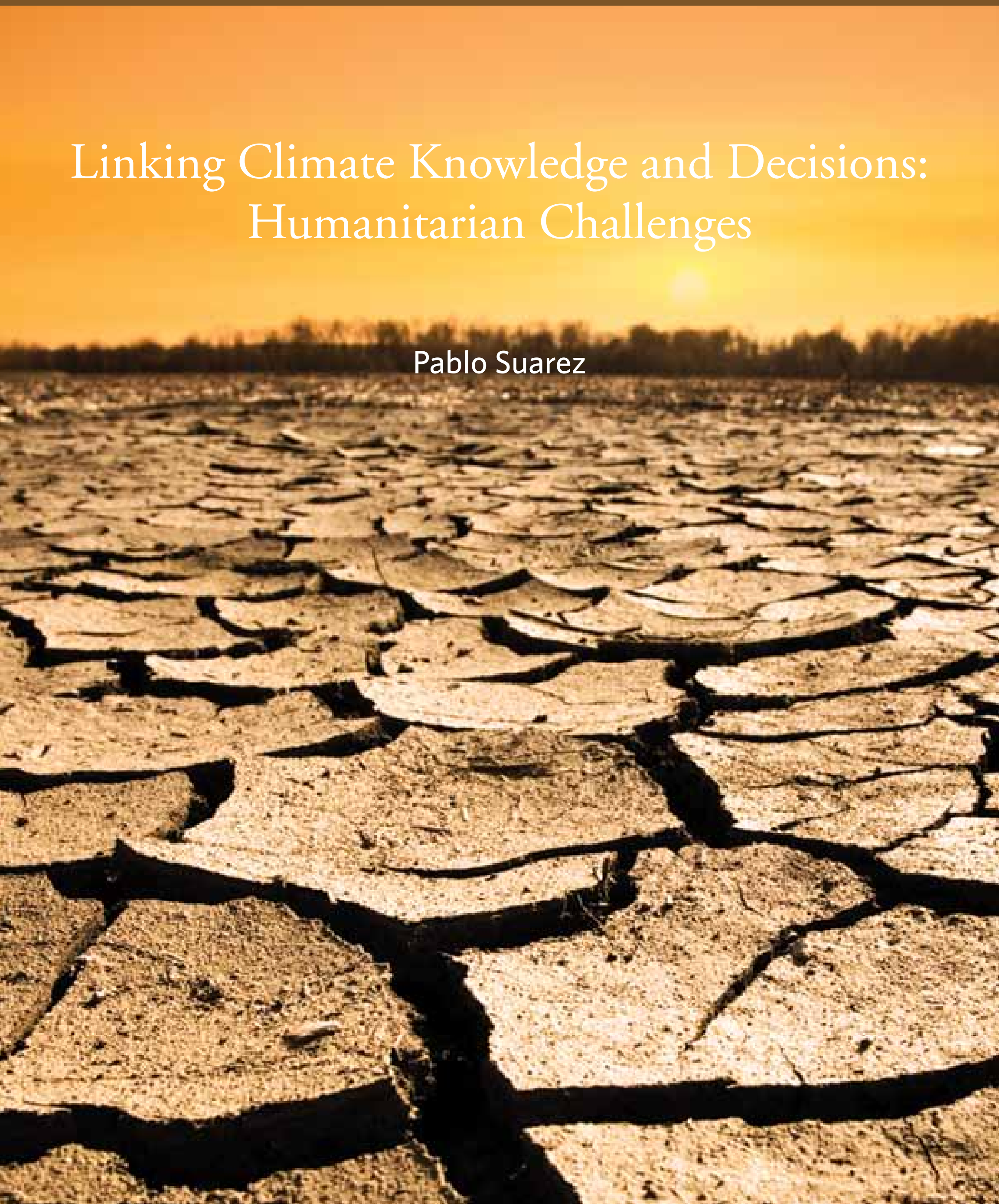
THE PARDEE PAPERS / No. 7 / December 2009

Linking Climate Knowledge and Decisions: Humanitarian Challenges

Pablo Suarez



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Linking Climate Knowledge and Decisions: Humanitarian Challenges

Pablo Suarez

Abstract

Future atmospheric conditions are increasingly predictable as a result of scientific and technological advances. From short-term storm forecasts to long-term climate trends, humanitarian organizations now have an unprecedented ability to anticipate threats to people at risk. At the same time, vulnerability patterns are shifting as a result of ongoing processes such as urbanization and the AIDS pandemic, which present complex and dynamic interactions with climate risks. The future looks different: more natural hazards combined with new vulnerabilities will continue to increase the workload of already overstretched humanitarian organizations. Against this background, the complexity and range of possible humanitarian decisions is rapidly expanding, owing to progress in technologies to obtain, process, communicate, and use relevant information, as well as new financial instruments, trends in academic institutions and other promising developments. Humanitarian organizations are adapting to new climate risks, vulnerability patterns, and decision capacity. Yet, regrettably, their efforts seem to be outpaced by the changing threats and opportunities. In order to reduce this gap, it will not be enough to simply train existing staff on new tools, or expand the staff and volunteer base: the humanitarian sector needs to fundamentally restructure its relationship to predictable *climate-related threats, evolving towards knowledge-based entities that can rapidly absorb and act upon the increasingly reliable information about changing risks. This will require not just partnering with key stakeholders, but essentially reconfiguring decision-making processes. Many of the potentially catastrophic climate-related disasters could be managed by the humanitarian sector through adequate monitoring of key system variables, and a systematic approach for preparing to act in response to the many plausible early signs of problems. The tasks ahead are massive; it is imperative to think ambitiously.*

This work builds extensively on collaborations with many organizations and individuals who have encouraged a creative yet systematic approach to linking knowledge with action, notably the Red Cross/Red Crescent Movement, Oxfam America, the International Institute for Applied Systems Analysis, Boston University, the International Research Institute for Climate and Society, the World Food Programme, the Malawi Institute of Management, and The World Bank Development Economics Research Group. The Pardee Center and Chris Jochnick at Oxfam America provided the inspiration and institutional support to make this piece possible. Janot Mendler, Maarten van Aalst, Miquel Muñoz, and Nigel Snoad provided valuable feedback on earlier drafts.

List of Acronyms

ACMAD	African Centre of Meteorological Applications for Development
AIDS	Acquired immune deficiency syndrome
DREF	Disaster Response Emergency Fund
ENSO	El Niño–Southern Oscillation
FEWS NET	Famine Early Warning System Network
GIS	Geographic information system
GPS	Global positioning system
HIV	Human immunodeficiency virus
IASC	Inter-Agency Standing Committee
ICT	Information and communication technology
IFRC	International Federation of Red Cross and Red Crescent Societies
ILO	International Labour Organization
INGC	Instituto Nacional de Gestão de Calamidades (Mozambique)
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
NGO	Non-governmental organization
RDRT	Regional Disaster Response Team
SMS	Short message service
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
TSF	Télécoms Sans Frontiers

The trouble with our times is that the future is no longer what it used to be.

–Paul Valéry

This paper explores the role of climate and knowledge in the longer-range future of humanitarian organizations.[1] The purpose is to present an inevitably incomplete but practical overview of the processes taking shape today that will affect the way we manage climate risks in the long run, and to outline some of the approaches that, if implemented soon, can help make a difference in how the humanitarian sector links knowledge to action.

I. INTRODUCTION

Our ability to reliably anticipate future conditions has been at the foundation of human progress (Daniel 1968). Entire civilizations can collapse if their expectations for the future become inconsistent with reality because of a changing environment (Costanza et al. 2007). While astronomical predictions, divination, and other forms of future telling have been evolving for millennia, what we now know about the future—and how we know it—is fundamentally different from anything experienced before. The remarkable developments in science and technology over recent decades have enabled a new relationship between the decisions we make now and what we think is likely to happen in one hour, one day, one month or even one century. The future looks different.

This is particularly true in the realm of climate-related risks. Human activity has always been sensitive to rainfall, temperature and other climate variables, and we have always had to adapt to changing conditions (Messerli et al. 2000). However, recent advances in observational capacity, scientific understanding, and computer modeling of atmospheric processes have resulted in the development of increasingly reliable forecasts that can help reduce risks.

1. Most of the ideas presented here are derived from experiences involving the Red Cross/Red Crescent Climate Centre, which was established in 2002 with the objective of supporting the International Federation of Red Cross and Red Crescent Societies (IFRC) and its partners in reducing the impacts of climate change and extreme weather events on vulnerable people. Nonetheless, insights are applicable to the larger humanitarian sector.

The temporal and spatial scales of improved forecasts range from highly localized tornado alerts (Bonelli and Marcacci 2008) and short-term tropical cyclone tracks (Goerss et al. 2004) to seasonal rainfall predictions based on El Niño (Dilley 2000) and long-term sea level rise caused by global warming (IPCC 2007).[2]

At the same time, new evidence requires us to frequently update our estimation of future climate threats. For example: almost half a century ago, Herschfield (1961) estimated the "100-year storm" (a precipitation event that has a one percent chance of being reached or surpassed in any given year) for all of the United States. These estimates are still in use for designing urban infrastructure. Decades later, Wilks and Cember (1993) calculated the same variables but using more precipitation data and improved methods. The value associated with the 100-year storm increased by about 20 percent for the Boston area. Such increase in rainfall intensity could result in entire neighborhoods being severed from the urban transportation network (Suarez et al. 2005), impairing access for emergency vehicles. It should be noted that the 1993 estimate does not yet take into account the effects of climate change on intense precipitation, which have since become more evident.

Humanity faces two new challenges: preparing for the increasingly foreseeable weather and climate, and also modifying *decision-making processes* in order to incorporate the availability of new information about the future.

Humanity faces two new challenges: preparing for the increasingly foreseeable weather and climate, and also modifying *decision-making processes* in order to incorporate the availability of new information about the future. We now know more, and with that knowledge comes the responsibility to change the way we act.

While the world's scientists were deciphering emerging patterns in the earth's atmospheric and oceanic systems, and negotiators were debating whether climate change was real and whether something should be done

2. It should be noted that, for some variables, predictability may decrease if technological and scientific advances are outpaced by unforeseen effects of climate change.

about it, humanitarian organizations were unable to properly learn about new developments in science and policy: they were too busy responding to a rapidly increasing number of climate-related disasters. The number of hydrometeorological disasters per year rose from between 200 and 250 in the period 1987–97 to about double that in the first seven years of the 21st century, in contrast to geophysical disasters (such as earthquakes), which remain more or less constant (CRED EM-DAT 2009). In the past quarter century over 95 percent of disaster deaths occurred in developing countries (Linnerooth-Bayer et al. 2005). The number of people killed by natural disasters had been decreasing since the 1970s, mostly due to better disaster preparedness, but in the past years that decrease has been tapering off and even reversing (Red Cross/Red Crescent Climate Centre 2007). As a result, many practitioners experienced excessive workloads precisely when they should have been thinking about how to prepare for a new climate.

In the particular case of humanitarian organizations, the threats and opportunities are massive. There is rapidly growing evidence of predictable relationships between climatic conditions and areas of humanitarian work such as health, shelter, water and sanitation, food security, and conflict. Additionally, when it comes to humanitarian intervention, many decisions and their outcomes are affected by predictable extreme weather events. Given the fact that global climate change is expected to increase a variety of risks (IPCC 2007), a number of questions emerge:

- Will humanitarian staff, volunteers, and people at risk be able to access, understand, and trust forecasts about impending hazards?
- Will individuals, communities, NGOs, and government agencies know what the risks are and what can be done before, during, and after the predicted event to reduce losses?
- Will human and financial resources be available in a timely, appropriate, and sufficiently generous manner to avert predictable and potentially catastrophic outcomes?

It is difficult to answer these questions with optimism given the impacts of entirely predictable disasters as diverse as cyclone Nargis in Myanmar (Webster 2008), the 2005 famine in Niger (Loewenberg 2005), and hurricane Katrina in the United States (Farazmand 2007).

Much remains to be done by humanitarian organizations to enable "smart" early action in response to future early warnings, especially given that natural hazards combine forces with non-climatic factors such as structural poverty, questionable governance, or ethnic tensions. However, little has been done about how to proceed. In the seminal work "Ambiguity and change: Humanitarian NGOs prepare for the future," the Feinstein International Famine Center (2004) included environmental factors in its comprehensive review of the global hazardscape, and provided international non-governmental organizations (NGOs) with a valuable outline framework for strategic planning in light of a multiplicity of likely challenges during the decade ahead. Lagadec (2007) surveyed new, unconventional crises such as the 2004 Indian Ocean tsunami and the terrorist attacks of September 11, 2001, and proposed a set of reforms aimed at equipping disaster management institutions with ways to manage the unthinkable. There have been a number of important systemic changes in the humanitarian system over the past several years, mostly stimulated by consultations (such as those led by the Inter-Agency Standing Committee) and system-wide reviews (see Adinolfi et al. 2005, Dalton et al. 2004), resulting in a significantly stronger thematic coordination mechanism—the "Cluster approach." On the practical side, there have also been useful case studies, guidelines, and discussion pieces for practitioners in climate risk management, including adaptation to climate change. Yet there has not been a systematic analysis of how *predictable* climate threats should be fully integrated into humanitarian work over the coming decades.

The next section presents an overview of how our knowledge of the climate system is changing, with implications for humanitarian practitioners. Section III outlines several ongoing trends that are changing the structure of vulnerability to natural hazards, as well as some important developments that fundamentally expand the horizon of possible humanitarian action. Section IV illustrates some of the key challenges and promising opportunities through two case studies. Section V proposes a framework based on the systems analysis concepts of sensor, actuator, and transfer function, drawing analogies from how the civil aviation sector manages risks. Section VI concludes with some suggestions about viable next steps on how to link climate, knowledge, and humanitarian action.

II. CLIMATE SCIENCE AND THE CHANGING KNOWLEDGE OF FUTURE CONDITIONS

Long-term Climate Change

There is solid evidence that the global climate is changing, and that this change is here to stay. The Intergovernmental Panel on Climate Change engaged thousands of the world's leading experts to review the published literature on climate change for its Fourth Assessment Report (IPCC 2007), and the summaries for policy makers present a worrisome picture of the threats that humanitarian organizations need to prepare for. With the planet's rising temperature, glaciers have been melting, threatening the water supply of millions of people. Rainfall patterns have changed in various parts of the globe. Even more worrisome, the frequency and intensity of extreme precipitation events have been rising, as have the number of droughts. We have also witnessed more heatwaves and more intense hurricanes, as well as unprecedented events like the first-ever tropical cyclone in the southern Atlantic in 2004 (Pezza and Simmons 2005). While no single event can be irrefutably blamed on climate change, we know that different conditions in the global climate are increasing the probability of certain disasters (van Aalst 2006).

The worst long-term effects can still be avoided if greenhouse gas emissions are substantially cut. But however aggressively we cut back on fossil fuel use, climate change is bound to continue: the massive amounts of carbon dioxide already in the atmosphere will continue to trap solar energy for many decades. Debates over global regimes for reducing greenhouse gas emissions have so far been influenced by stakeholders that, understandably, oppose measures that would negatively influence their prosperity. As Martinez-Alier has argued (2002), the notion of an externality as a "market failure" can also be understood as a successfully transferred cost. Impacts will fall disproportionately upon developing countries and poor people in all countries—in other words, those who have contributed least to the causes of climate change. For humanitarian organizations, the prospect of insufficient emissions reduction means the imperative of addressing the consequences of climate change: it is time to adapt (IASC 2008).

The range of climate change impacts is vast and complex (Erway Morinière et al. 2009). In terms of health dimensions alone, the IPCC (2007) overview of risks includes:

- Deaths, injuries, and disease from direct impacts of extreme weather events
- Change in range of infectious-disease vectors such as malaria, dengue, and West Nile virus
- Diseases increasing with changes in temperatures, humidity, heatwaves, and drought
- Effects of sea level rise and ocean warming (saltwater intrusion, coastal erosion, coral bleaching, and decline of fisheries): malnutrition, waterborne diseases

Knowledge about expected changes in future climate conditions can help anticipate threats and formulate strategies for adaptation. Humanitarian organizations are still learning how they can best use such knowledge in their work on issues ranging from water, sanitation and food security to shelter, population movement, and conflict.

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Seasonal Forecasts

The seasonal nature of climate is influenced by the temperature of ocean waters, which under certain circumstances can change in predictable ways. Computer models of oceanic and atmospheric circulation combined with statistical analysis allow scientists to forecast temperature and rainfall anomalies in various parts of the globe with a lead time of months. The best-known case is the El Niño–Southern Oscillation (ENSO), an anomaly in sea surface temperature and atmospheric pressure that occurs from time to time in the tropical Pacific Ocean. ENSO is the major single source of climate variability on seasonal-to-interannual scales (Glantz 2001). There is abundant evidence of the relationship between El Niño events and precipitation patterns in various regions of the globe.

Seasonal climate forecasts based on El Niño have the potential to help millions of people by enabling them to plan ahead (Murphy et al. 2001). Seasonal rainfall forecasts can allow food security officials to prepare for potential food shortfalls, and farmers to modify their practices including choice of seeds, agricultural practices, and financial strategies. Responding to this potential, multiple organizations have started working together to produce and apply seasonal climate forecasts. For a review of experiences, see Hellmuth et al. (2007) and Patt et al. (2007).

With a few notable exceptions such as the Famine Early Warning System Network (FEWS NET), humanitarian organizations remain largely dissociated from the scientific institutions and forecasting tools that can help understand the options for managing seasonal threats. The literature points to the relevance of predictable problems involving how seasonal forecasts are formulated, communicated, understood, trusted, and used. Constraints range from institutional barriers (Patt and Gwata 2002) to decision-making biases and errors of judgment explained by behavioral sciences (Suarez and Patt 2004).

Short-term Predictions

Weather forecasters are increasingly able to estimate the likelihood of extreme weather-related threats, thanks to a denser network of meteorological stations, more remote sensing capabilities, and stronger computing power. Surprisingly, little is being done to develop comprehensive risk management plans to deal with likely, predictable weather-related crises affecting the most vulnerable sectors of the global population. Examples for helping those at risk include evacuation before flash floods and hydration campaigns for the elderly before and during heatwaves. Predictions can also be used to take advantage of opportunities when favorable conditions are expected.

In many cases, vulnerable people also can benefit from observations of recent weather events in nearby locations. If it has just rained intensely upstream, villagers living on the river's floodplain should expect the water level to rise—it may be time to move people and valuables to higher ground. Similarly, if there has been abundant rain in nearby drylands, pastoralists can take their livestock to graze in places that may take several days of walking to reach. Health practitioners can prepare for increased workload on malaria and diarrhoeal diseases based on unusual precipitation. These kinds of interventions are beginning to emerge in various places, but humanitarian organizations have yet to systematize the timely delivery of reliable, understandable information to people who can benefit from what is known. Of course, information is not enough: there should also be an action plan for responding to the information.

Recent notorious disasters have triggered some progress. However, as in the case of the global tsunami warning system that is beginning to take shape (Kintisch 2005), the focus tends to be on the production and dissemination of timely predictions. There is a largely unaddressed need to resolve the failures of warning systems at the behavioral level: inadequate institutional and human response to the availability of the forecast can also have devastating effects (Cyranoski 2005). With climate change, we should expect more unprecedented extreme events that, while predictable with a lead time of hours or even days, are unlikely to be perceived as serious threats by people at risk because such events have never been experienced in living memory.

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Linking Information to Decisions for the Most Vulnerable

Johnson and Holt (1997) note that the existing system for sensing, recording, and reporting weather conditions and producing forecasts has been developed primarily in response to the demands of specific market needs, such as airline navigation and agribusiness, and not necessarily the needs of those most vulnerable to climate risks. A drought in Europe or North America is unlikely to directly result in human deaths, whereas an equally severe drought in sub-Saharan Africa may kill millions. Yet there is one meteorological station for every 25,460 km^2 of the African continent, compared to about one per 716 km^2 in the Netherlands (UNDP 2007, 173). Similar disparities are common regarding the length and quality of the historical record. Several commentators have highlighted the social implications of a differentiated production of, and access to, information (Lievrouw and Farb 2003). Acquiring potentially useful climatic information may prove too difficult or expensive—even the cost of batteries for listening to the forecast by radio may be prohibitive for some subsistence farmers.

The formidable amount of human, technical, and financial resources currently dedicated to improving climatic forecasts and impact assessments is not sufficiently coordinated with efforts to increase preparedness to act on the availability of this information, or strategies to reduce susceptibility to climate variability among the most vulnerable sectors of the global population. This is a necessary component for implementing the Hyogo Framework for Action, particularly considering the evidence in favor of integrating forecast communication in participatory workshops (Patt et al. 2005).

Processes that create vulnerability need to be identified, examined, and confronted, going "beyond redistribution to identify and nurture countervailing processes" (Ribot 1995, 121). They range from lack of enforcement of local zoning regulations (Kreimer and Munasinghe 1992) to global trade policies unfavorable to developing countries (Thrasher and Gallagher 2008). An analysis of all the current and future forces creating differential patterns of vulnerability is beyond the scope of this paper. Nonetheless, there are several long-term trends shaping vulnerability and resilience that exhibit complex overlaps with climate risks. As highlighted by the 2009 World Disasters Report (IFRC 2009), early action works best when it spans a range of timescales, not just providing a more rapid response to a disaster, but also anticipating it days, hours, months, years, and even decades in advance, and over time reducing the risk of a range of hazards.

III. CHANGING PATTERNS IN VULNERABILITY AND KNOWLEDGE-BASED DECISION CAPACITY

Two kinds of ongoing processes will dramatically affect whether natural hazards become disasters. On one hand, patterns of vulnerability are shifting steadily due to rapid urbanization (Parnell et al. 2007), demographic changes (Lutz et al. 2008), and the acquired immune deficiency syndrome (AIDS) pandemic (UNAIDS 2008). On the other hand, sustained progress in areas such as remote sensing, information management, communication platforms, and even financial instruments will continue to enable us to devise innovative ways to better prepare for and respond to climate-related threats.

Key Trends Affecting Vulnerability

Of the many stressors identified by the report of the Feinstein Center (2004), urbanization and HIV/AIDS deserve a deeper look because of their interactions with climate risks.

With rural livelihoods deteriorating, many farmers are pushed into urban areas that are already overcrowded. More than half of the global population is now living in cities. Between 1950 and 2005, the urban population in Africa grew from 33 million to 353 million (Yousif 2005). The poor have been urbanizing more rapidly than the population as a whole: according to Ravallion et al. (2007), during 1993–2002, the count of the "$1 a day" poor fell by 150 million in rural areas but rose by 50 million in urban areas. Unplanned growth modifies hydrological attributes such as imperviousness and speed of runoff, increasing flood volumes and therefore the likelihood of severe flooding in shantytowns—often located in hazard-prone areas.

Humanitarian organizations, and the vulnerable communities they serve, are already dealing with the life-threatening consequences of poor design and planning in urban areas. Additionally, climate change is not only taking place, but quite literally "*taking places*", imposing more frequent and intense extreme events such as floods, hurricanes, droughts, and heat waves on built environments where people are not prepared to deal with the changing conditions. Staff and volunteers working in disaster management are at the forefront of the current climate crisis, but the complex relationships between place and climate require that humanitarian organizations rethink their future (Suarez et al. 2008a). From hazard-resistant residences and affordable flood shelters to disaster-resilient, inclusive urban planning policies, the challenges of climate risks can motivate practitioners and scholars shaping the future of cities to integrate humanitarian concerns into their work.

The effect of HIV/AIDS on the population of southern Africa and other regions with high incidence rates poses an unparalleled humanitarian crisis (Harvey 2003). The pandemic has been responsible for increased death and disability, a breakdown of social safety nets, high costs to the health care system, loss of productivity, and food insecurity at household, community, and national levels. Average life expectancy at birth has declined by more than 20 years in the most affected countries (UNAIDS 2008).

Climate-related hazards and HIV/AIDS together can lead to combined negative effects greater than the sum of their separate effects. Dreadfully synergistic mechanisms can create new, severe problems among vulnerable communities, therefore increasing the workload of humanitarian organizations. There are three main mechanisms of concern: (1) some disaster coping strategies accelerate the spread of HIV, (2) AIDS amplifies the impact of extreme events on communities with high HIV prevalence, and (3) the pandemic reduces organizational capacity to manage climate risks.

Climate, HIV/AIDS, and the Declining Capacity of Disaster Management Organizations

While the combined effects of HIV/AIDS and a changing climate are increasing the demand for disaster management services, the pandemic is profoundly eroding the ability of organizations to meet such demand. From planning processes in central government to agricultural extension programs at the village level, a multiplicity of tasks may not be completed appropriately because of deaths, disease-related absenteeism, increases in workload, low morale, loss of institutional memory, and other undesirable mechanisms that weaken institutional capacity. Evidence about this problem can be found in an analysis of six Malawian disaster management institutions (Suarez et al. 2008b).

For example, the Malawi Red Cross reported that it is increasingly difficult to mobilize communities facing climate risks because too many farmers are either attending funerals or caring for the sick—if they themselves are not sick. Additionally, AIDS-related attrition of staff and volunteers results in delayed and poor quality delivery of disaster response services, increased workload for remaining staff and volunteers leading to poor quality performance, failure to make timely decisions to respond to emergencies, and inability to attend national and international events (which can have an effect on the ability to fundraise for humanitarian work). This makes it very difficult to attract and retain new staff and volunteers to boost the capacity appropriately to meet the ever-increasing demands of humanitarian assistance to the affected communities.

The pandemic negatively affects organizational performance at various levels in surprising ways through the loss of experience and institutional memory. A study by Dominguez et al. (2005) highlights the loss of knowledge about locally adapted seeds and varieties, and the increasing difficulty in acquiring new knowledge. Such changes severely limit the ability of southern Africa to prepare for the changing climate, and increase the demand on institutions dealing with risk reduction and disaster response. Given the need to create and manage knowledge in a changing climate, this aspect of HIV-related staff attrition may have profound consequences. In order to better address the challenges posed by the combined effects of HIV/AIDS and climate change, humanitarian organizations need to improve their understanding of the impacts of the pandemic on organizational capacity, and the evolving nature of the demand for their services under a changing yet increasingly predictable climate.

Changing Patterns in Knowledge-based Decision Capacity

The frontiers of decision capacity are expanding thanks to the rapid rates of innovation in methods for obtaining, processing, transmitting, and using information. However, this progress is in many cases outpacing the capacity of humanitarian organizations to take advantage of a range of growing opportunities, including new technologies, financial instruments, and academic innovations.

Information and Communication Technologies (ICTs). The potential of ICT and related technologies such as remote sensing, geographic information systems (GIS), and global positioning systems (GPS), for monitoring and managing disasters is, of course, nothing new (Alexander 1991). Satellite data and efficient image analysis may successfully be used to conduct rapid-mapping tasks in the domain of crisis-management support. Voigt et al. (2007) describe various examples of disaster response involving Earth-observation experts, public authorities, humanitarian relief organizations, satellite operators, and other agencies. Outside of times of crisis, satellite imagery can also be used for assessing natural hazards and the physical aspects of human vulnerability (Sanjal and Lu 2005). Mobile telephony is playing an increasingly important role in climate risk management, including through the rapid deployment of communication capabilities by organizations like Télécoms Sans Frontiers and Ericsson Response (see for example TSF

2007). Still, while these and other tools make information more accessible and easier to disseminate, disaster management operations systematically underutilize the information we can gather from above and from the field before the crisis.

Even for simple community-based risk management measures requiring no modern technology, a major challenge for the humanitarian sector is how to scale up successful adaptation pilots. Clearly it is not feasible to dispatch technical experts to every location with poor people threatened by climate risks, so the diffusion of innovations can prove challenging. As a critical step towards improving resilience, it is necessary to ensure that a wider range of users can access and use the information available for climate risk management (Ziervogel and Downing, 2004).

Audiovisual technologies are increasingly affordable for capturing, processing, storing, and disseminating information. Videos and other communication tools, if combined with participatory approaches, may help extend the benefits of available information on climate-related threats and risk management options in a way that is sufficiently tailored to local needs and constraints (Suarez et al. 2008c). While other disciplines, such as the health sciences, have been dedicating considerable efforts to developing and evaluating intervention strategies that involve the use of video tools, climate risk management research and practice has yet to take audiovisual tools into serious consideration. Over a decade ago, a systematic review of 175 studies of video-based projects for health promotion and education by Eiser and Eiser (1996) concluded that audiovisual tools can generate the desired changes in attitudes and knowledge, and outlined the key elements for successful initiatives. Given the similarities in how information format and content can shape decision making, it is reasonable to assume that the findings from the health sector are applicable to climate risk management.

Videos and other communication tools, if combined with participatory approaches, may help extend the benefits of available information on climate-related threats and risk management options in a way that is sufficiently tailored to local needs and constraints.

New Financial Instruments. The field of microfinance is booming, and offers enormous potential for humanitarian organizations. For example, in early 2008 Kenya became the first country in the world to use cash transfers through mobile phones for emergency response (Datta et al. 2008). M-Pesa is a cash transfer service that does not require users to have bank accounts: once registered, the user can send electronic cash to any other mobile phone user in Kenya by short message service (SMS). Recipients can either redeem this for conventional cash at agent outlets, or buy airtime for themselves and other subscribers. During the post-election crisis in the Kerio Valley, the NGO Concern Worldwide decided to use M-Pesa instead of the usual approach of carrying and distributing food. A total of about $50,000 was disbursed to beneficiaries in 570 households; they were able to locally buy food and other necessities, therefore supporting the local economy. Mobile-enabled cash transfers allowed the NGO to overcome the challenges posed by the terrain and the security situation in timely, safe, and cost-effective ways. The evaluation of this pilot (Brewin 2008) highlights valuable lessons for scaling up this approach.

Recent developments at the interface between the fields of finance and climate science have allowed for a very promising set of new approaches to risk-transfer instruments, such as weather derivatives, catastrophe bonds, and index-based weather insurance (Hellmuth et al. 2009). While conventional indemnity-based insurance is written against actual losses, index-based weather insurance is written against a physical trigger, such as insufficient cumulative rainfall during the germination period for a certain crop. In other words, index-based insurance is against *events* that cause loss, not against the loss itself (Turvey 2001). Index-based contracts as an alternative to traditional insurance allow for objective and transparent triggers that can be used to determine when and to what extent assistance may be required. They have the advantages of greatly limiting transaction costs and eliminating moral hazard. Importantly, they allow disbursement of payouts as soon as the weather event is measured—in the case of droughts, expedient payments reduce the need for farmers to sell their assets in order to cope with the disaster.

Three recent pilot schemes illustrate the value of this approach:

- In central Malawi, through a project promoted by the World Bank, index-based drought insurance was bundled with microcredit to successfully enable smallholder farmers to access improved agricultural inputs (Suarez et al. 2007).

- In Ethiopia, the World Food Program established a macro-level index insurance program to manage drought risk. With donor support, the national government paid a premium, so that if weather stations across the country detected rains so poor as to require substantial food aid, the insurance scheme would release funds for activating the relief operation (Hess et al. 2006).

- The Caribbean Island States, supported by the World Bank, have recently formed the world's first multi-country catastrophe insurance pool, an index-based scheme reinsured in the capital markets, to provide governments with immediate liquidity in the aftermath of hurricanes or earthquakes (Ghesquiere et al. 2006).

These pilot programs present compelling evidence that index-based insurance schemes can provide vulnerable people, poorer governments, and humanitarian organizations with access to affordable means to spread risks spatially and temporally. Most importantly, as argued by Linnerooth-Bayer et al. (2005), pre-disaster assistance can reduce the human and economic toll that natural hazards impose on the poor by making insurance-based assistance contingent on requirements or incentives for prevention as part of a comprehensive risk-management program. Even at extra cost, pre-disaster donor aid through index-based insurance schemes can thus be an efficient strategy if it reduces the long-term need for humanitarian disaster aid.

Oxfam America, Swiss Re, IRI, and a variety of Ethiopian organizations are piloting insurance in Northern Ethiopia. The project allows very poor farmers to purchase drought index insurance through in-kind contributions of labor on climate risk reduction projects. The pilot's rollout in 2009 demonstrated that the model can reach families generally seen as "uninsurable." About 65 percent of the enrolled farmers are chronically food-insecure, and 38 percent were female heads of household.[3]

3. For more information, see www.oxfamamerica.org, search on "weather insurance" to find all resources on topic.

Insurance instruments that spread and pool risks are emerging as important candidates for supporting adaptation to climate-related disasters in developing countries (Warner et al. 2009). Article 4.8 of the United Nations Framework Convention on Climate Change (UNFCCC) and Article 3.14 of the Kyoto Protocol call upon developed countries to consider actions, including insurance, to meet the specific needs and concerns of developing countries in adapting to climate change. The humanitarian sector would have an important role to play in implementing the billions of dollars per year for insurance-based mechanisms to support climate change adaptation currently under consideration by the UNFCCC (2009), yet there is very little familiarity with this issue among key stakeholders.

Global Academia: A Resource for the Future. The recent and ongoing transition in higher education from discipline-based to integrated approaches (Hudson and Tonkin 2004) is allowing humanitarian issues to become part of the learning, teaching, and research experience of scholars. This direct connection between academic institutions and humanitarian organizations facilitates the transfer of knowledge about current research that is applicable and helpful to humanitarian efforts.

For example, since 2007 the Red Cross/Red Crescent Climate Centre has engaged dozens of students in fields ranging from climate science and environmental management to public health and even film studies. These students helped change the way newly available tools are used by humanitarian staff and volunteers, all while fulfilling academic requirements and improving students' curriculum vitae.[4] They have contributed substantially to the "Early Warning > Early Action" framework outlined in IFRC (2008b). Some of them are now employed by humanitarian organizations.

4. For more information, see www.climatecentre.org/site/young-scholars.

Advanced students in fields such as health, communication, environment, business, engineering, international relations, foreign languages, decision sciences or anthropology have skills that could support climate risk management work in the field, and academic requirements could reasonably be aligned with projects from humanitarian organizations. By 2005 there were over 130 million students enrolled in higher education programs worldwide (Gürüz 2008, 24). This constitutes a vast, under-leveraged pool of potential contributors to the knowledge-intensive tasks that humanitarian organizations need to tackle. A vigorous effort to recruit young scholars for humanitarian work can help nurture a new generation of staff and volunteers better equipped for the challenges ahead.

IV. TOWARDS A NEW RELATIONSHIP WITH KNOWLEDGE ABOUT THE FUTURE CLIMATE: TWO CASE STUDIES

Flood-resistant Poultry in Bangladesh and Filmmaking Farmers in Malawi

The humanitarian organization CARE has piloted a community-based approach to climate change adaptation in 16 vulnerable communities in southwestern Bangladesh. During participatory workshops on climate risks, one of the problems discussed was the challenge of poultry: families reared chickens for meat and eggs, but when floods hit, the chickens would often drown. People surviving the flood were left without their main source of protein, precisely at the time when flooded roads made food aid delivery more difficult. Eventually relief would arrive and, with support from relatives outside the village, families would slowly reconstitute the poultry stock.

In the past, many years would elapse before the next flood again killed all the chickens. However, in recent years, community members reported that with flooding happening more often, their chickens were being wiped out again and again before they could ever regain pre-disaster levels of poultry stocks. When presented with information about climate change and sea level rise, they understood that frequent flooding may become the new state of normalcy, and discussed what to do differently. One woman expressed a brilliantly simple idea: “how about replacing chickens with ducks?”

Figure 1: Ducks Replace Chickens

Poultry rearing is common in southwestern Bangladesh, where chickens often drown during floods. When participants in a CARE project gained knowledge about climate change, they proposed to replace chickens with ducks, reducing the impact of more frequent flooding on food security. Photo by A. Dazé.

This adaptive change requires a low initial investment and is easy to implement. According to the examination of pre- and post-project coping mechanisms, duck rearing was adopted by more than 1,300 women (Patt et al. 2009).

Halfway across the globe, the Malawi Red Cross and Malawi Meteorological Services had received support to advance climate change adaptation among subsistence farmers, piloting participatory video methods in the village of Mphunga (Salima district). Food insecurity due to flood and drought is becoming more severe, with failed crops and drowned chickens among other impacts, causing many families to become chronically dependent on relief. People involved in vulnerability assessments indicated that they didn't know why the rains had been so bad in recent years, and suspected that it could be either bad luck or divine punishment (both theories leading to the assumption that things should soon go back to "normal"—and therefore no need for new action). As one of the farmers put it: "If god wants to punish me, I will be punished—there's nothing I can do about it. Why should I do things differently?"

Then these Malawian farmers heard the story of the Bangladeshi women and they saw the photo of the ducks shown in Figure 1. They also saw a short video about an Argentinean shantytown that is also experiencing more frequent and intense extreme events. Seeing helps believing: they instantly understood—and trusted—that what Mphunga had been experiencing lately was indeed part of something bigger. If the global climate is changing, then they *can* do something about it. These Malawian farmers agreed to start by replacing some chickens with ducks.

Through a series of workshops, Mphunga villagers learned more about the changing climatic risks, and discussed additional options for adapting to expected future conditions. Then, with support from filmmakers and university students versed in participatory video methods (Lunch and Lunch 2006), a smaller group of farmers, along with some Red Cross volunteers, learned the basics of how to operate camera equipment, develop a script, shoot, and contribute to the editing process. Farmers became filmmakers, and made a video[5] to help other farmers prepare for more floods and droughts.

Figure 2: Farmers Become Filmmakers

Subsistence farmers from Mphunga, Malawi became filmmakers using participatory video methods during a project involving the Malawi Red Cross and Malawi Meteorological Services. Their short film on climate change was screened in neighboring communities and accelerated the dissemination of climate adaptation measures.

5. The 7-minute film can be seen with English subtitles at www.youtube.com/watch?v=2PcVn4oy3NI.

They chose six adaptation strategies for their film, including duck rearing, diversification of crops, flood warnings with whistles, and storing harvested grains in 50-kg bags to take the food to higher ground just before floods. The Malawi Red Cross organized screenings of the film in neighboring villages during July 2008. Through surveys and video interviews, Baumhardt et al. (in press) assessed how the video influenced perceptions and understanding, and found substantial increase in willingness to embrace climate risk management strategies.

Mphunga villagers are now selling ducks to neighboring communities. When floodwaters were rising in January 2009 in the neighboring village of Kasache, Alick Malunje and other farmers who had watched the Mphunga video managed to get their bagged harvest to high ground, whereas those still using loose storage in granaries saw their harvest ruined, and needed food aid.

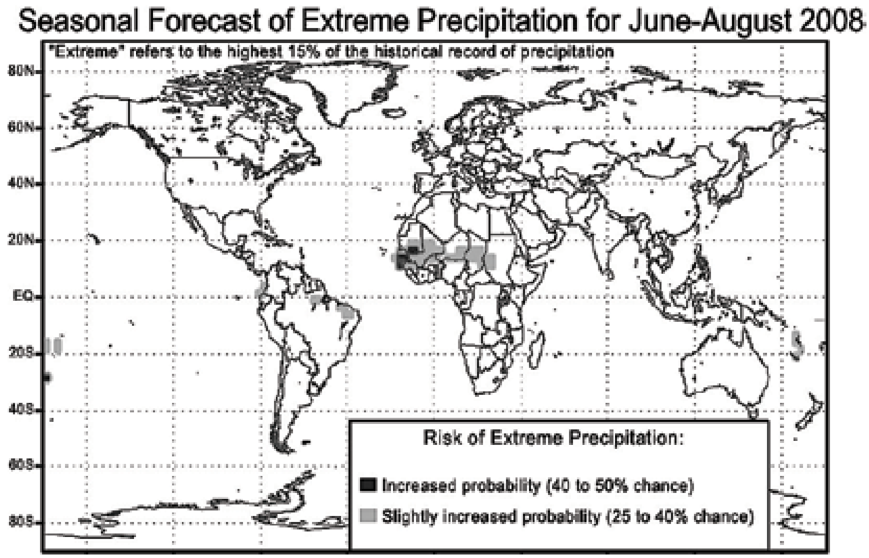
Scaling up this video-enabled approach to climate adaptation makes sense—especially in regions like sub-Saharan Africa where the illiteracy rate is nearly 60 percent (UNDP 2007)—but the challenges are enormous. Lack of equipment and lack of personnel trained in both filmmaking and climate change are major obstacles to using video for awareness raising, training, advocacy, and community planning. In addition, there must be a well-developed method for ensuring that the featured adaptation techniques will actually work in different national and local cultures before they can be successfully disseminated.

In a review of Red Cross video projects for climate risk management in Argentina, the Bahamas, Indonesia, and Malawi, Suarez et al. (2008c) pointed to three main areas of urgent future work: developing guidelines for design and implementation, developing rigorous assessment methods, and developing sustainable multidisciplinary teams. Toolkits and technology partnerships would also be needed.

Redefining Emergency Appeals in West Africa

During 2007, some of the worst floods in decades swept across 20 African countries stretching from the Atlantic coast to the Red Sea. As is usually the case, most of the work involved in dealing with the crisis was implemented during and after the flood, including evacuations, establishment of temporary shelters, and prevention of water-borne diseases. Just one year later, the threat of flooding was again looming over West and Central Africa due to wholly predictable monsoon rains. But this time, a new approach was to be tested.

Figure 3: Example of Seasonal Forecast Map



Seasonal forecast for June–August 2008, issued May 2008, showing enhanced risk of extreme precipitation for part of West Africa (Source: IRI 2008)

By May 2008, scientists observed a combination of conditions in the world's oceans, including the Tropical Atlantic, that suggested a highly enhanced probability of extreme precipitation in parts of West Africa, as illustrated in Figure 3.

In previous years, when climate scientists issued seasonal precipitation forecasts, the humanitarian sector had a difficult time making sense of the technical language and graphs. In the words of a practitioner, "an image is worth a thousand words, but a graph about a seasonal rainfall forecast is worth a thousand incomprehensible words." Thus, when the forum for seasonal prediction in West Africa launched its consensus forecast, it would have been natural to expect the usual inaction or misunderstandings. Yet, in this case a recently established partnership between the International Federation of Red Cross and Red Crescent Societies (IFRC) and the International Research Institute for Climate and Society (IRI), and interactions with regional science organizations like the African Centre of Meteorological Applications for Development (ACMAD), allowed the IFRC West and Central Africa Zone to be better prepared to understand the signs provided by science—and to make decisions accordingly.

Because of this collaboration, a few humanitarian workers better understood changing climate risks, new science-based predictive capabilities, and options for forecast-based action. A five-day training of Regional Disaster Response Team (RDRT) leaders was held in June. Participants from 12 countries learned how to interpret seasonal forecasts and six-day precipitation predictions, as well as skills in mobilizing and managing human resources and dealing with logistical, financial, and administrative procedures. Two graduate students familiar with climate science became interns in the IFRC Zonal office in Dakar, and helped the humanitarian staff understand the available scientific information and use it to formulate action plans.

A wholly pre-emptive emergency appeal for regional flood preparedness was issued on 11 July 2008—the first of its kind[6], based on a seasonal rainfall prediction (IFRC 2008a). For nearly US$750,000, the emergency appeal would turn early warning into early action for better humanitarian intervention before and during the likely floods. However, most of the donor community—not used to receiving requests for funds for a disaster that has not yet struck—did not respond until late August once flooding was already underway.

But the IFRC West and Central Africa Zone did start to act right away, making use of the IFRC's Disaster Response Emergency Fund (DREF),

6. Seasonal forecasts have been available for over a decade, and during strong ENSO years there would have been good reasons to take this kind of preventive action before 2008. It is unfortunate that the first forecast-based emergency appeal had to wait so long—a sign of the gap between climate science and humanitarian work.

which was recently modified to allow funding for action *in advance of a possible disaster*. Visas and medical insurance were secured for RDRT members so that their deployment to a country in need could be expedited. By mid-July, early warning systems were created or strengthened in many flood-prone locations, and flood contingency plans were prepared for Benin, Burkina Faso, Gambia, Niger, Nigeria, Senegal, and Togo. It would normally take two to three weeks to transport relief items (including blankets, kitchen sets, soaps, water and sanitation kits, cholera kits, tents, and other non-food items) from a logistics unit in Dubai to those in need. By anticipating the need and pre-positioning items in distribution warehouses in Senegal, Cameroon, and Ghana, almost 50,000 potential beneficiaries could have their needs met within 24 to 48 hours. Using forecasts to reduce the time that flood victims are without relief items like clean water, food, shelter, and sanitation substantially reduces the chance they will become ill and increases their chance of survival.

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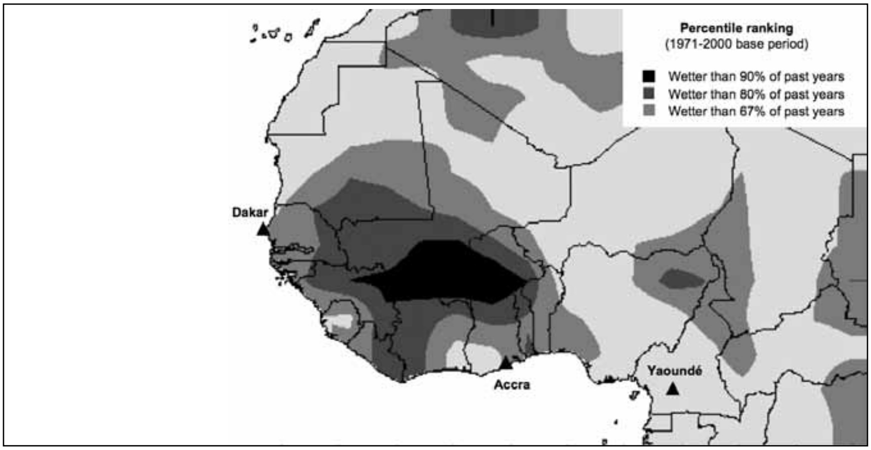
Despite these efforts, in many cases the relief items arrived too late or were not sufficient. On September 10, in response to the floods in Togo and Benin, the IFRC launched a revised appeal for $1 million to support 2,025 families over two months. Figure 4 shows the locations where relief stocks were pre-positioned, as well as observed rainfall for the region—a reasonable match to the forecast from Figure 3. Braman (2009) offers a detailed overview of the sequence of early warnings and early actions, as well as an analysis of impacts and challenges. The first-ever regional flood preparedness meeting, convened in June 2009, engaged about 70 humanitarian and government representatives from 18 West African countries and made extensive use of the seasonal forecast to guide discussions.

Figure 4: Pre-positioned Relief Stocks and Observed Rainfall Extremes



Areas with observed rainfall anomalies during July–August 2008. The excessive rains present a reasonable match to the seasonal forecast from Fig. 3, which was used by IFRC to pre-position flood relief stocks in warehouses in Accra, Dakar and Yaoundé. Faster delivery of aid substantially reduces the chances of post-flood illness or death. (Source: IRI Data Library 2009, with data from Precipitation Reconstruction for Land—NOAA/NCEP.)

Numerous lessons were learned in this disaster management experience based on a seasonal rainfall forecast. It is easy to argue that the measures taken saved lives; though about 50 lives were lost, this number could have been much larger without the preparedness efforts triggered by the seasonal forecast. It should be noted that the IFRC emergency appeal was essentially destined to no-regrets interventions (i.e., they would still have paid off over the years even if flooding had not happened in 2008). Of course, ideally we would like to be perfectly prepared for everything, but we can't. The forecasts helped prioritize and mobilize efforts for the most urgent options from the large palette of no-regret risk reduction and preparedness measures available.

However, much needs to be done to set up systematic procedures for rigorously estimating the number of lives saved by early action and, more importantly, to address the key bottlenecks to more effective use of early warnings. Scientific organizations at the regional and national level are currently unable to provide more reliable predictions, particularly for supporting informed decision making at the community level in places where predictability could be improved (weather station density is too low, staff and computer power is insufficient). Humanitarian staff at the national and local level lacks the capacity to fully understand the implications of seasonal and short-term predictions. We know that, due to the probabilistic nature of forecasts, some preventive actions in response to early warnings will eventually prove unnecessary for specific events that do not materialize, potentially leading to loss of trust if uncertainties are inadequately communicated (i.e., "crying wolf"). Even if information were perfect and perfectly understood, the challenges of operationalizing forecasts would continue to be enormous. Still, the connection between early warning and early action remains unacceptably weak.

V. DEVELOPING A SYSTEMS-ANALYSIS APPROACH: LESSONS FROM CIVIL AVIATION

The field of systems analysis offers a readily applicable model for thinking about next steps for integrating climate and knowledge into the future of humanitarian organizations, building on the concepts of *sensor*, *actuator* and *transfer function*.

- A *sensor* measures a physical quantity and converts it into a signal which can be read by an observer.
- An *actuator* is a device or other entity that transforms an input signal into motion.
- A *transfer function* is a representation of the relation between the input and output of a system.

Science-based institutions are analogous to *sensors*: they can measure aspects of climate and weather, and send information about observed or projected conditions as an output signal to humanitarian organizations and people at risk.

Humanitarian organizations are analogous to an *actuator*: if they receive a signal that clearly indicates an observed or projected disaster, they are expected to have the capacity to convert that information into action (for example, by evacuating people from a floodplain in advance of a flood).

The *transfer function* is what should mediate between the early warning from the scientific organization and the timely, 'smart' action of humanitarian organizations and the people they serve. This is the missing piece: as of now, the humanitarian actuator doesn't know whether or not any science-based signal of predicted conditions should be transformed into motion. How can they translate the output from the sensor (e.g., a forecast for an impending flood) into a simple "Yes/No" output that can trigger action on the part of humanitarian organizations?

Part of the problem is that the optimal signal from the perspective of humanitarian staff and volunteers is binary (i.e., "get into motion" or "do nothing," which necessarily needs to be partially based on subjective criteria of what constitutes acceptable risk), whereas the optimal output signal of an impending threat, from the perspective of scientists, is a set of complex and precise data about objective physical variables in the form of maps, numeric tables, or technical statements that are often incomprehensible for non-specialists.

Scientists produce complex probabilistic forecasts such as the seasonal forecast map from Figure 3. These maps are designed to communicate things that, unfortunately, come across as incomprehensible. Translated into words, the maps says: *"Given what we know as of May 15, 2008, we can say that, for the period June–August 2008 in the areas of West Africa highlighted in the map, the probability of seeing precipitation that would rank in the top 15 percent of the historical record is now enhanced to between 40 percent and 50 percent."* With this scientifically sound information at hand, humanitarian staff and volunteers (who are usually not climate scientists), need to answer very simple but important questions for the communities at risk:

- Do we evacuate or not?
- Do we pre-position relief items or not?
- Do we mobilize our regional disaster response teams or not?
- Do we ask for donor support or not?

Linking information to decisions is not easy. The proper answer to the list of questions above is: "it depends on many factors." Action should be taken only if the probability of hazard occurrence is deemed high enough, if the natural hazard is sufficiently threatening, if there are too many people at risk, if those people are unable to manage the disaster on their own, if there are interventions that can eliminate or mitigate losses, if there is enough time to implement those decisions, and so on. The climate scientist is obviously unable to answer those questions, and so is most of the humanitarian sector—at least at present. Yet all these factors can be examined well before an early warning: information about vulnerable communities can be mapped regularly with the tools described earlier in this paper, and we do not need to wait until a disaster is looming to establish thresholds for action. Somehow, someone has to come up with criteria, protocols or other decision-support systems that can receive science-based predictions and recommend an adequate course of action—or, at a minimum, examine whether or not a red flag should go up based on the early warning to indicate that early action is needed. We need smart, forecast-based decisions as well as simple, decision-based forecasts.

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Much can be learned from the field of civil aviation, where the *sensor-actuator* approach has been set in place for an enormous variety of plausible problems of a mechanical, human, or meteorological nature. Pilots and airline personnel are the actuators, and they can count on a multiplicity of sensors about the aircraft and its present and expected environment. As actuators, they have clear protocols in place (i.e., transfer functions) to deal with a very wide range of possible crises, which facilitates their decision making when threats become real, be it a small electrical malfunction, a flock of geese disabling all the airplane's turbines (*New York Times* 2009) or an unruly passenger who had too much to drink *(The Independent* 1999).

Crews and ground personnel undergo regular simulations and trainings to ensure that the protocols will be implemented smoothly if needed, and the industry is constantly learning and improving its detection equipment, safety protocols, and mechanical designs to reduce the risk of disasters. Situational judgment tests, which typically consist of scenarios depicting an often-complex situation and a range of alternative solutions, have been used to quantitatively evaluate the training of pilot judgment in response to warning signs (Hunter 2003). Failure analysis of complex aviation systems of communication and surveillance identify the potential consequences if a particular component underperforms, and ensure that the effect and/or its probability of occurrence will be acceptably safe after adequate system redundancy or revised operational procedures (Asbury and Johannessen 1995). Even with regards to weather predictions, the airline industry is exemplary in its use of available information for reducing fuel consumption to take advantage of trade winds (Houghton 1998), or to reroute flights with respect to a specified probability threshold of encountering severe weather (McCrea et al. 2008).

In order to save lives and assets, airline crews, like nuclear plant operators and other professionals facing potentially life-or-death situations, are part of a system with (a) very good monitoring systems that send early signals when problems are looming, and (b) very detailed protocols that establish a relationship between a wide range of plausible warning signals (which describe the risk) and the corresponding decisions and actions (which should lead to the desired outcome). Nowadays, climate science can offer very good monitoring systems to humanitarian workers and communities at risk, but such information is not always accessed, understood, trusted, and used for optimal results.

We know that subsistence farmers, coastal fisherman, or shantytown dwellers can find themselves threatened by events with causal vectors that are, fundamentally, no less predictable and preventable than those encountered by aircraft. Of course, in civil aviation the range of plausible disastrous events and intervention measures are more limited than in the humanitarian sector, to a large extent because an aircraft is a much less open system than the global population—and its life-sustaining systems on the ground. While the civil-aviation analogy has its limitations, it could be argued that the lives of vulnerable people deserve to be protected with a systematic approach to risk management as well thought-out as the approach used to protect frequent fliers. The humanitarian sector, in collaboration with the scientific community, donors, governments, and people at risk, needs to define sets of transfer functions that can save lives and livelihoods by linking early warning with early actions. Information about a possibly harmful event in the future can and must serve both for preparing to cope with the hazard and identifying the constellations of means, relationships, and processes that enable the relevant actors to derive benefits from climate-related predictions at all timescales.

VI. CONCLUSIONS AND RECOMMENDATIONS

Even though we know more and more about both future climate-related threats and evolving patterns of vulnerability, this knowledge remains vastly underutilized by humanitarian organizations and people at risk. Major disasters such as cyclone Nargis, the Niger famine, and hurricane Katrina illustrate the extent to which entirely predictable extreme events are allowed to become deadly disasters, mostly through failure to act. Science and technology are rapidly expanding the frontiers of decision capacity to respond to predictions, yet climate science has been fundamentally detached from the humanitarian sector. Thus, humanitarian organizations currently lack the structural ability to build institutional and stakeholder capacity to effectively use newly available tools. The changes in climate risks, vulnerability patterns, and decision capacity are, in many respects, outpacing the humanitarian organizations' efforts to adapt to the changes.

In this context, it is not enough to simply insert new information and tools into existing job descriptions and institutional structures that remain excessively compartimentalized. *A fundamentally different approach to the use of information for decision-making is needed in the humanitarian system.* Organizations need to transition, from action-based entities used to acting on minimum climate information, towards knowledge-based entities that can absorb predictions about impending threats, rapidly synthesize information, formulate decisions, and transform reality in a timely and well-thought manner.

Recommendations from previous studies that apply to this issue include reforming the culture of leadership through the education of future leaders (Lagadec 2007, 53) and nurturing the creativity, flexibility, information absorption capacity, and planning and policy-making authority to anticipate and respond (Feinstein Center 2004, 93). Yet there needs to be new thinking and new systems for adaptive action developed and specifically tailored to the growing predictability of climate-related risks.

Newly available inputs for decision capacity need to be fully integrated into humanitarian work. It would be very desirable (and perfectly feasible) to build on earlier efforts in the following ways:

Strengthen* ex-ante *disaster management systems by fully integrating predictions at all timescales. Given the massive number of vulnerable communities with very different profiles in terms of hazards and coping capacity, the process of setting up all the necessary hazard-specific early warning systems for early action requires a holistic, innovative approach that is both comprehensive and scalable. Unfortunately, this cannot be carried out easily with the current mechanisms, competencies, and mindset of the humanitarian sector. In order to scale up at the pace required by climate change, it is necessary to rapidly expand the base of technically competent humanitarian staff and volunteers, and engage more players in new ways. Advanced university students can provide support to NGOs, local communities, government agencies, and other stakeholders to establish the collaborative platforms for new approaches like the early warning case study described in this paper. Innovative cross-fertilization of disciplines and entities working at different geographic scales can combine participatory risk assessment (based on GIS and GPS, as well as conventional low-tech methods) and community-based and remotely-sensed monitoring of physical variables (e.g., rainfall, river levels) tied through mobile telephones to rapid-deployment units equipped with video tools for training and mobilizing workers, volunteers, and people at risk after early warnings have been issued with various lead times from seasonal to a few days to nowcasting. As discussed, disaster management plans should systematize the set of actions that ought to be taken by different actors in response to likely early warn-

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ings, as well as outline decision-making mechanisms for dealing with warnings that are not easy to anticipate and a monitoring and evaluation strategy aimed at constant learning. At the macro level, the donor community needs to rethink how to support the capacity of an already overstretched humanitarian sector.

Establish index-based risk management schemes to trigger timely mobilization of resources. Financial instruments can be designed to support a timely disbursement of funds when climate-related variables indicate that a humanitarian crisis is likely to happen, in time for mobilizing staff, relief items, and other options to reduce the negative impacts of the predictable hazard. Index-based microinsurance and other risk sharing schemes could be bundled with risk reduction measures such as reforestation to reduce peak flood flows, or water storage for drip irrigation in drought-prone areas. Distribution mechanisms can engage the private sector, for example via mobile-phone-enabled cash transfers, so that funds can flow to those in need as soon as the physical measurements indicate that a certain threat is impending—instead of the usual *ex-post* approach of delivering support too late at a very high cost. Donors must rethink their mechanisms for disbursement of funds for situations where early warnings warrant early action but the proposed interventions do not fit existing channels for disaster relief or development aid.

Refocus humanitarian services to address changing patterns of vulnerability. In a changing climate, familiar hazards are expanding their reach, both temporally (e.g., different seasonality of extreme events) and spatially (e.g., malaria outbreaks at higher altitude). Complex emergencies are more likely. Additionally, socially driven processes including unplanned urbanization and the AIDS pandemic are fundamentally altering the spatial distribution of the most vulnerable—and the ways in which they can be served before, during, and after disasters. Research institutions, technology developers, and other actors can supply methods and tools to better understand the new risks

From the global to the community level, relevant organizations need to think innovatively in order to design, implement, and constantly improve systems for turning early warnings into early actions.

and the best ways to address them given existing and foreseen conditions, climatic and societal. Young scholars can be a major contributing force in this process.

From the global to the community level, relevant organizations need to think innovatively in order to design, implement, and constantly improve systems for turning early warnings into early actions. There is no time like the present to think ambitiously about how we will use new knowledge to fulfill the humanitarian mission.

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