Towards forecast-based humanitarian decisions: Climate science to get from early warning to early action

Pablo Suarez
Red Cross / Red Crescent Climate Centre *and* Boston University Pardee Center for the Study of the Longer-Range Future

Arame Tall
The Johns Hopkins University School of Advanced International Studies *and* Red Cross / Red Crescent Climate Centre

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Summary

Why do people continue to suffer and die due to entirely predictable natural hazards? The remarkable progress in science and technology over recent decades allows us to anticipate future conditions, communicate early warnings and take early action to avoid losses, yet many recent disasters are evidence of a dreadful gap between science and the humanitarian sector. Can forecasters and risk managers build common ground, designing smart forecast-based decisions as well as simple decision-based forecasts?

The humanitarian sector needs to restructure its relationship to *predictable* climate-related threats. One option is to evolve towards knowledge-based entities that can rapidly absorb and act upon information about risks: routinely taking humanitarian action before a disaster or health emergency happens, and making full use of scientific information on all timescales. Two successful instances of collaboration between forecasters and the Red Cross illustrate this concept of "Early warning à Early Action": The 2008 emergency appeal launched by the IFRC West and Central Africa Zone to improve flood management based on a seasonal rainfall forecast (the first of its kind), and a workshop that convened scientists, humanitarian workers and vulnerable people in Senegal, which enabled a constructive dialogue through innovations such as participatory games and video-mediated approaches to risk management.

This paper proposes a framework based on four key four attributes of science-based forecasts: *location* (where is the event likely to happen?), *magnitude* (how big?), *lead time* (how far into the future?), and *probability* (what are the chances of it happening?), linking them respectively to *vulnerability*, *expected loss*, *range of plausible actions*, and the *decision of whether or not to act*. It is not easy to compare failure to prevent losses (e.g. fatalities due to inaction) and false alarm (e.g. expenses related to actions that prove unnecessary). While it will inevitably involve subjective criteria, the choice to act or not to act should be informed by a rigorous assessment of possible outcomes. Stakeholders need to jointly identify the constellation of means, relationships, and processes that can enable forecast-based decisions to save lives.

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Too many people suffer and die nowadays due to entirely predictable natural hazards, despite the remarkable progress in our ability to anticipate and address the potential occurrence of extreme events. The number of people killed by disasters had been decreasing since the 1970s, mostly due to risk management tools developed in recent decades, from satellite imagery and computer models to communication technologies and community-based disaster preparedness plans. These tools continue to improve, yet in the past years the decrease in disaster casualties has been tapering off and even reversing (Red Cross / Red Crescent Climate Centre 2007). As a result, many humanitarian practitioners are experiencing excessive workloads - precisely when they should be thinking about how to better prepare for changing risks. The combined effects of climate change, urbanization, environmental degradation and other stressors might be counterbalanced by emerging opportunities such as more reliable short-term predictions, affordable communication devices, and new climate risk financing instruments (Suarez 2009). The links between disaster risk management and development are irrefutable, and neither can be accomplished unless undertaken in an integrated manner (Schipper and Pelling 2006).

When it comes to health, shelter, water, food security, conflict and other areas of humanitarian work, many future decisions and their outcomes will be affected by climate-related events that, in many cases, can be forecasted with reasonable levels of skill. 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)[1]. Three key 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 a predicted event in order 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 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), all anticipated by science-based early warning systems. There are numerous reasons why some decision makers fail to do what it takes between the time of the forecast and the actual event in order to avoid losses. Anticipating those reasons can help save lives.

Patt and Gwata (2002) identify six key constraints limiting the usefulness of forecasts among people at risk: *credibility*, *legitimacy*, *scale*, *cognitive capacity*, *procedural and institutional barriers*, and *available choices*. Drawing on fieldwork in Zimbabwe and evidence from behavioral sciences, Suarez and Patt (2004) describe the errors of judgment that can be systematically found among forecast producers (such as a non-rational bias towards caution due to overestimating what might go wrong). It is reasonable to assume that these and other obstacles stand between science-based forecasts and humanitarian action.

Redefining emergency appeals in West Africa

During the 2007 floods that swept across 20 African countries from the Atlantic coast to the Red Sea, as is usually the case, most of the establishment of temporary shelters, prevention of water-borne diseases and other humanitarian work was implemented during and after the flood. Just one year later, the threat of flooding again loomed over West Africa. But this time, a new approach was to be tested.

By May 2008, scientists observed unusual conditions that suggested a highly enhanced probability of extreme precipitation in parts of West Africa (see Figure 1). In previous years, when climate scientists issued seasonal rainfall forecasts, the humanitarian sector had difficulty making sense of the technical language and graphs. In the words of one practitioner, “if an image is worth a thousand words, 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 inaction, as usual. This time, 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), enabled the IFRC West and Central Africa Zone to understand the danger signals provided by science – and to make decisions accordingly.

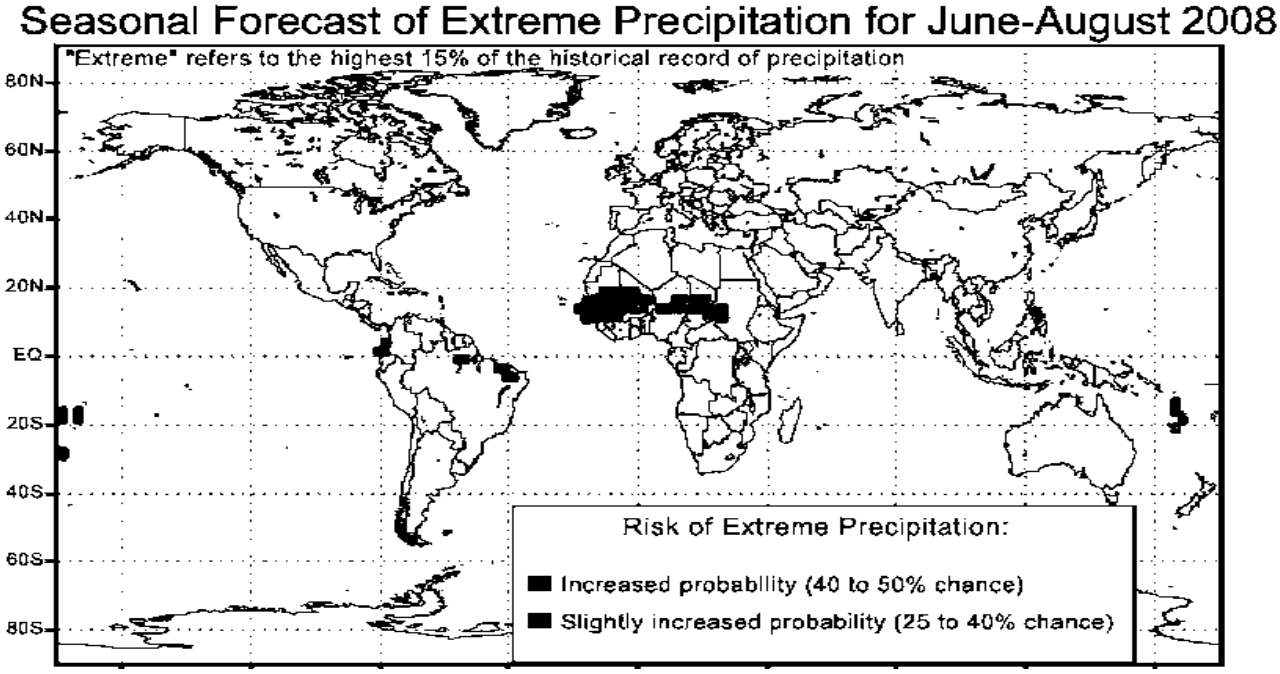

Figure 1: Seasonal forecast for June–August 2008, issued May 15th 2008, showing enhanced risk of extreme precipitation for part of West Africa (Source: IRI 2008)

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, and gained skills in mobilizing human resources and dealing with logistical, financial and administrative procedures. Two masters students familiar with climate science became interns in the IFRC Zonal office in Dakar, helping humanitarian staff understand the available 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[2], 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 a disaster that has not yet struck based on a seasonal precipitation forecast, did not respond until late August once flooding was already underway.

Nevertheless, the IFRC West and Central Africa Zone began to act right away, making use of the IFRC's Disaster Response Emergency Fund (DREF), which had been recently modified to allow funding for action *in advance of a possible disaster*. Visas and medical insurance were secured for RDRT members to expedite their deployment to a country in need. By mid-July, early warning systems were created or strengthened in many flood-prone areas, 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, soaps, water and sanitation kits, cholera kits, tents and other non-food items) from a logistics unit in Dubai to distribution warehouses in Senegal, Cameroon and Ghana. By anticipating the need and moving supplies ahead of time, up to 50,000 potential beneficiaries could be assisted within 24-48 hours. Reducing the time that flood victims are without clean water, food, shelter, and sanitation substantially reduces the chance they will become ill, increasing their chance of survival.

Figure 2 shows the three locations where relief stocks were prepositioned, as well as observed rainfall for the region – a reasonable match to the forecast from Figure 1. It should be noted that, despite these efforts, in many cases the relief items arrived too late or were insufficient. On September 10, in response to floods in Togo and Benin, the IFRC launched a revised appeal for about $1 million to support 2,025 families over two months. Braman (2009) offers an overview in more detail of the sequence of early warnings and early actions, as well as an analysis of impacts, challenges, and concrete recommendations.

Much needs to be done to address continuing bottlenecks impeding more effective forecast-based action. Scientific organizations are currently unable to provide more reliable predictions, particularly for decision makers at the community level: weather station density is too low, staff and computer power is insufficient. Humanitarian staff and volunteers lack the capacity to fully understand the implications

Prepositioned relief stocks and observed rainfall extremes

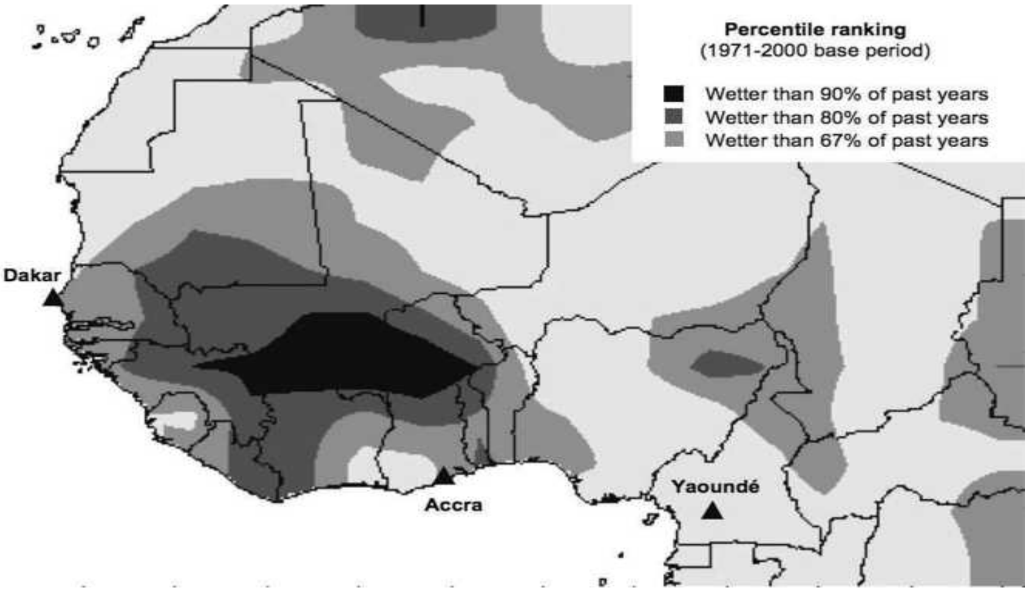

Figure 2: Areas with observed rainfall anomalies during July–August 2008. (Source: IRI Data Library 2009). The excessive rains present a reasonable match to the seasonal forecast from Fig 1, which was used by IFRC to preposition flood relief stocks in warehouses in Accra, Dakar and Yaoundé. Faster delivery of aid substantially reduces the chances of post-flood illness or death.

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", a problem not exclusive to climate risks). 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 is pivotal, and remains unacceptably weak.

Innovative dialogue between forecasters, humanitarian workers and people at risk

Located a few kilometers upstream from the mouth of the Senegal River, the island of Doune Baba Dièye had soil so rich that it became the main source of vegetables for the nearby city of Saint-Louis, former capital of French colonial Africa. Over the past decades, a combination of deforestation and changing rains has resulted in more severe flooding in both the city and the village. Following the 2003 floods, the Senegalese government decided to make an opening in the 'Langue de Barbarie', a thin, sandy peninsula separating the ocean from the final section of the river. This opening, a canal created 7 km south of Saint-Louis to accelerate river drainage and therefore protect the city from future floods, measured 4 meters in 2003. It has now become 2 kilometers wide. Doune Baba Dièye is the island in front of this opening.

Since 2003 Doune Baba Dièye has been affected by a new type of flooding, caused by coastal storms. Residents report going to bed in fear of being caught by giant waves at night.

Fishing has been impacted by changes in currents and waters' salinity. The soils in their plots have become so salty that vegetable farming has been drastically reduced, strongly affecting the food security and income of the 750 inhabitants. Villagers now suffer and even die for two reasons: *climate change*, and *bad decisions*.

During December 1-4, 2009, the IFRC West and central Africa Zone organized a workshop that convened about 40 people who would not normally talk with each other:

- Red Cross staff members covering Senegal from global, continental, regional, national, provincial, district and village level, as well as Red Cross colleagues from Mali, Togo, Benin and Burkina Faso
- Fishermen and community leaders from the village of Doun Baba Dièye
- Scientists from Pan-African, Regional, National and Provincial entities who research and make predictions on climate change, meteorology, hydrology, fisheries and other fields

This workshop, unprecedented in the context of Senegal and probably of the developing world, had as its main objective the exploration of options for using science to support people at risk. The event was carefully designed to create an atmosphere of collaboration without hierarchies - as opposed to the usual sequence of unidirectional presentations from decision-averse scientists to decision-oriented practitioners. This powerpoint-based approach to workshops often leads to a very frustrating experience for both sides, in part because of the excessive reliance on complex graphs and text-packed slides that can cause utter confusion or simple boredom among non-expert audiences. (For a useful review of why bad presentations happen to good causes, and what can be done about this, see Goodman 2006).

The workshop used innovative ways to enhance fruitful collaboration, such as:

- *Small dialogue tables* of about 4-6 people where first an expert would explain, in simple language and without a computer, what a certain prediction tool can and cannot do, and why it is important for decision-makers, then practitioners and community members would have time to ask questions, and finally all together explore options for turning plausible predictions into concrete action
- *Video-mediated approaches* to community-level climate risk management (Suarez et al. 2009)
- *Participatory games*[3] specifically designed to (a) broker a constructive dialogue without hierarchies, (b) reveal key insights about obstacles to forecast communication and use in a changing climate, and (c) elicit concrete ideas for forecast use.
- *Visit to Doun Baba Dièye*, hosted by over a hundred community members who shared their experiences, insights and questions with humanitarian staff and scientists (who in turn shared with the vulnerable community the main ideas derived from the previous three days of the workshop). Games, video tools and facilitated discussions with islanders resulted in two main requests from the community to the visitors: (a) a science-based warning to alert them of incoming coastal or riverine flooding, and (b) a place to go to when they have to evacuate the island.

As a result of this workshop, the Red Cross and partners from knowledge centers are now beginning to formulate concrete ideas for science-based action at different time scales: from evacuation based on flood forecasts, to mangrove planting in the coast, to collaboration with Mali Red Cross for afforestation in the upper Senegal River Basin to reduce peak flow downstream, and a follow-up workshop is being planned for July 2010. Unfortunately these dialogue processes take time and perseverance, while risks keep rising (six residents of Doune Baba Dièye died during a storm in late February 2010, less than three months after the workshop participants' visit). It is imperative to accelerate the connection between those who know climate science and those who can act to save lives and livelihoods.

Building common ground: smart forecast-based decisions plus simple decision-based forecasts

Scientists produce complex probabilistic forecasts (like Figure 1), and their outputs can be conceived as a signal that reaches decision makers. Regrettably, scientific outputs do not always become inputs into people's choices. Part of the problem is that 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 (maps, numeric tables or technical statements that are often incomprehensible for non-specialists); whereas the optimal input signal from the humanitarian perspective is binary (i.e. "act" versus "do nothing").

Translated into words, the map in Figure 1 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 observing precipitation that would rank in the top 15% of the historical record is now enhanced to between 40% and 50%".* With this scientifically sound but complicated information, Red Cross personnel (who are usually not climate scientists), need to answer very simple questions:

- Do we evacuate or not?
- Do we preposition relief items or not?
- Do we mobilize our regional disaster response teams or not?
- Do we know if the cost of acting is affordable and worth it given the chances of reducing losses?
- Do we ask for donor support or not?

Linking information to decisions is not easy… A climate scientist is obviously not equipped to answer any of these questions (which are only partially, and highly indirectly, climate questions). Most of the humanitarian sector is also unable to address them with any confidence, at least at present, for different reasons. 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 likely magnitude of the natural hazard is sufficiently threatening, if there are too many people at risk, if those people are unable to manage the shock on their own, if available choices can reduce losses, if there is enough time to implement those choices, if resources are readily available or can be secured before it is too late, and so on. Yet all these factors can be examined well before an early warning: information about vulnerable communities can be mapped through remote sensing, GIS, participatory approaches and so on.

It is certainly possible and desirable to *not wait until a disaster is looming* in order to establish what constitutes unacceptable levels of risk (i.e. threats so high as to merit humanitarian action). Informed analysis of plausible forecasts must become a stronger part of 'horizon scanning'. It is possible (and certainly desirable) to implement risk reduction measures, so that hazards do not result in too much loss. Somehow, someone has to come up with criteria, protocols or other decision-support mechanisms to receive science-based predictions and recommend an adequate course of action. At present some countries do this by translating information-rich predictions into a simple code, such as "yellow alert", which does simplify decisions but at the expense of making all yellow-alert humanitarian actions alike, missing the opportunity to tailor interventions based on the foreseeable details of the likely losses.

At a fundamental level, for any given event, science-based forecasts can be boiled down to four attributes: ***location*** (where is the event likely to happen?), ***magnitude*** (how big is the event that scientists say may occur? This is usually defined by a physical variable such as millimetres of rain, kilometres per hour of wind, or river elevation in meters), ***lead time*** (how many hours/days/weeks/years expected to elapse between issuance of the forecast and occurrence of the event?), and ***probability*** (what are the chances of the event happening?)[4]. It should be noted that, on a normal day, the probability of a damaging event should be relatively low - relevant forecasts are the ones that indicate an unusually high or low chance of something bad happening in the foreseeable future). Each of these four forecast attributes is linked to an aspect of reality that can help determine whether or not it is desirable to trigger humanitarian decisions:

- The vulnerability of those threatened by the event can be derived from the forecast's *location*
- The expected loss caused by the event can be estimated based on the forecasted *magnitude*
- The range of plausible actions that could be taken to reduce losses is determined not only by available human and financial resources but also by the *lead time*, which needs to be longer than the time it takes to carry out loss-reduction measures under consideration (including time needed for proper institutional channels to decide, plus time to mobilize people and materials and get things done)
- The decision of whether or not to act will necessarily be a subjective call, and should be based on the *probability* of the event's occurrence, and an analysis and comparison of the four possible outcomes:
    a. *worthy action*: decide to act, then event materializes and losses are avoided
    b. *worthy inaction*: decide to not act, then event does not materialize
    c. *failure to prevent losses:* decide to not act, then event materializes - leading to avoidable losses
    d. *false alarm*: decide to act, then event does not materialize - often resulting in perceived waste of resources and loss of trust in forecast.

How to compare these four scenarios, weighing not just the probabilities but also the different kinds of losses in scenarios (c) and (d)? It is more complicated than apples and oranges: it requires comparing and assigning relative values to number of fatalities, health outcomes, economic costs, people's loss of trust in forecasts, donor fatigue, present versus future possibilities and risks, and more. Decision makers are going to find it hard to evaluate risk management options, particularly when considering the opportunity costs: in a resource-constrained world, a lot could be done with limited resources to address *other* problems beyond the hazard being forecasted. Predictable climate-related threats must be examined alongside other current and future risks, from global pandemic to the consequences of insufficient investments in girls' education. The issue of weak comparability is not new, and available tools such as multi-criteria evaluation can support decisions under conditions of complexity (Funtowicz et al 1999).

Because of the probabilistic nature of weather and climate predictions and related forecasts (hydrological, food production, etc), there is no way of knowing, ahead of time, whether deciding to act will avoid losses or waste scarce resources. Therefore, it is not fair to accuse a forecast-based decision of being wrong: If there's a 90% chance of thousands of people dying within 24 hours due to an incoming hurricane, it is advisable to persuade people to seek shelter, even if one out of ten times the hurricane changes its trajectory and people act in vain.

There is of course the issue of "crying wolf". Dow and Cutter (1998) examined the evacuation behaviour of residents in communities that experienced two hurricane evacuations that turned out to be false alarms. They found that the role of official communiqués was more limited than previously assumed, as people sought information on more diverse sets of concerns affecting their choices. They concluded that, during the period when people do not find that officials are "crying wolf", residents are searching elsewhere for information to assess their own risk—what does it mean to me if there is a wolf? Forecasters could improve their outreach to authorities, humanitarian workers and the public if they worked with other experts to contextualize climate information alongside other existing and emerging risks. This can involve information from vulnerability assessments to behavioral science – not a simple task.

An answer to rising climate risks: Early warning → Early action

In the face of a changing climate, it will not be enough for humanitarian organizations to simply train existing staff on new tools, or expand the staff and volunteer base: it 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 risks. One option is the concept of "Early Warning à Early Action", defined as "routinely taking humanitarian action before a disaster or health emergency happens, making full use of scientific information on all timescales" IFRC (2008b).

The humanitarian sector, in collaboration with scientists, donors, governments and people at risk, needs to establish processes of dialogue that can help not only understand predictions, but also establish criteria for smart forecast-based decisions that can save lives and livelihoods: link early warning with early actions. University students can be invited to align their academic work with humanitarian needs to help set the foundations of science-based risk management decisions at different temporal and geographic scales[5].

In order for the outputs of their computer models to be translated into simple decision-based forecasts, scientists also need to better understand the *thresholds in physical systems*, such as natural hazards big enough to cause significant but avoidable damage, as opposed to the relatively irrelevant thresholds (such as the probability terciles in seasonal rainfall forecasts), as well as the *thresholds in humanitarian decision-making*. The design of forecast communication processes and products must address the diverse set of concerns that determine people's actual choice under uncertainty: what do people need to weigh, beyond the physical aspects of the hazards, before deciding whether to act or not based on the forecast?

Dinku (2010) proposes that governments create national centers for climate and development: small teams of experts within a relevant ministry mandated to ensure availability of decision-relevant climate information, facilitate mainstreaming of climate issues into development activities, and lead in the design and implementation of national climate policies. While disaster management would clearly benefit from such centres, humanitarian practitioners can neither wait for them to become operational, nor assume that once they exist they will properly address humanitarian concerns. Agile, tailor-made approaches are needed. In terms of monitoring and evaluating any such approach, outcome indicators (such as reduction of lives lost in disasters), while desirable, are insufficient. There should also be a set of *process* indicators, aimed at ensuring that the interventions designed to reach the outcome are robust and optimally smart given the availability of climate science. While eventually all efforts should be forecast-smart, interim targets could be used to measure progress on mainstreaming science-based predictions; for instance on the degree to which measures listed in a national flood contingency plan are to be implemented (or not) depending on the location, magnitude, lead time and probability of hydrological forecasts.

Information about a possibly harmful event in the future can and must serve both for preparing to cope with the hazard and to identify the constellation of means, relationships, and processes that enable the relevant actors to derive benefits from climate-related predictions at all timescales. The Humanitarian Futures Programme offers a first step.

End Notes

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

2. 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

3. See 4-minute video about the "Early warning →early action" game at http://www.youtube.com/watch?v=Mpj_EbKdwEo, and rules of a simple game to explain probability-based decisions and climate change at http://petlab.parsons.edu/redcross/2009/12/a-simple-card-game-illustrating-probability-climate-change. Both games were created with the Parsons School for Design.

4. Note that there are other forecast attributes such as source, skill, geographic scale of applicability, comparison to average conditions, and even graphic design, that may deserve attention at a finer level of early action design

5. See for example the "Young Scholars for Humanitarian Work" program at http://www.climatecentre.org/site/young-scholars

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