Climate and Society No. 3

A better climate for disaster risk management

IRI

The Climate and Society series provides authoritative and accessible information on climate risk management research, practice, and policy in support of sustainable development.

The series is a program of the International Research Institute for Climate and Society (IRI). IRI contributes to sustainable living and poverty reduction through the integration of climate information into management strategies for climate-sensitive sectors such as agriculture, food security, disaster risk management, water resources, and health. IRI is a member of The Earth Institute at Columbia University, New York.

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The CGIAR Research Program, Climate Change, Agriculture and Food Security (CCAFS) is a strategic partnership of the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership (ESSP). CCAFS seeks to overcome the threats to agriculture and food security in a changing climate, exploring new ways of helping vulnerable rural communities adjust to global changes in climate. The program is supported by the European Union, the United States Agency for International Development (USAID), Canadian International Development Agency (CIDA), New Zealand Ministry of Foreign Affairs and Trade, the Danish International Development Agency (Danida) and the UK Department for International Development (DFID), with technical support from IFAD.

The International Federation of Red Cross and Red Crescent Societies (IFRC) is the world's largest volunteer-based humanitarian network, reaching 150 million people each year through its 186 member National Societies. Together, they act before, during and after disasters and health emergencies to meet the needs and improve the lives of vulnerable people. They do so with impartiality as to nationality, race, gender, religious beliefs, class and political opinions.

The Red Cross/Red Crescent Climate Centre (RCCC) is a reference center on climate risk management. The Climate Centre supports the Red Cross and Red Crescent and its partners to understand and address the rising risks related to climate change, climate variability and extreme weather events.

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A better climate for disaster risk management

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Front cover
Seasonal forecast maps can be used to inform disaster preparedness activities, including floods.

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Foreword

Advances in communication technology have broadcast in vivid detail the impacts of disasters in all corners of the world, increasing global awareness of the devastating suffering caused by these events. The number and cost of climate-related disasters has been steadily increasing over the past few decades. Lives and livelihoods are increasingly at stake, as well as economic growth and national development.

In close partnership with governments and many other international and national non-governmental actors, the humanitarian community has responded to this increasing challenge by complementing response and relief efforts with preparedness and prevention measures. Climate change poses an additional challenge, with more intense and frequent extreme events expected. Although this does not mean that there will necessarily be more disasters everywhere, it does mean that increasing disaster preparedness and prevention efforts are paramount to avoid more human and economic suffering.

More recently, the urgency of climate change and advances in climate science have motivated a shift in the climate science community towards the provision of user-oriented climate services. The potential of recent developments in climate science, including the production of climate forecasts for a few months through to decades into the future, can to be extremely useful for disaster prevention, preparedness and response efforts. In May this year I presented the report of an international expert group to the World Meteorological Congress on how a Global Framework for Climate Services can provide knowledge for action by the most vulnerable.

However, as is illustrated throughout the cases presented in this important book, ensuring improved disaster outcomes goes beyond the provision of better and more tailor-made information. It requires close and active collaboration between different groups of professionals involved in disaster risk management, in order to build trust, capacity and truly useful information.

The book describes how building new capacity, climate information tools and partnerships results in better disaster preparedness and response, ultimately saving lives and protecting the livelihoods of vulnerable people. Ever stronger relationships between disaster risk managers and climate information providers are growing around the world. The food security community is leading the way in many aspects, creating multi-disciplinary processes and groups where climate information and expertise is one important strand amongst many others, to be taken into consideration by disaster risk managers.

Climate scientists are beginning to understand the real needs of disaster risk managers, leading to new research innovations and products, such as forecasting of extremes and the development of easy-to-understand thresholds and triggers to enable action.

Working together, these diverse groups are working towards the achievement of a common goal – reducing the suffering of millions of vulnerable people. Together we can learn from these innovative practices, and in so doing, be better prepared for what is to come. Too many lives and livelihoods are at stake to refrain from taking concrete action now.

Jan Egeland
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During 2009–10, the publication partners hosted Technical Advisors at different regional and national offices in Kenya, Haiti, Malaysia, Tanzania, and South Africa, in order to capture the state of the art regarding the use of climate information to inform practice. In collaboration with the International Federation of Red Cross and Red Crescent Societies, the Red Cross/Red Crescent Climate Centre, the UN Office for the Coordination of Humanitarian Affairs, and the World Food Programme, the Technical Advisors also helped develop tailored tools to inform humanitarian decision-making.

The Technical Advisors and the Climate and Society publication team would like to acknowledge the input of the many stakeholders from development partners, relief organizations, universities, research institutes, the private sector, civil society, and non-governmental organizations and meteorological agencies, which were present at the following workshops and consultations:

- A humanitarian climate risk management workshop, bringing together humanitarian practitioners, climate specialists and researchers in Nairobi, Kenya, 23–24 February 2010.
- A climate information consultation and workshop with representatives from the Tanzanian Red Cross and Tanzanian Meteorological Agency in Dar es Salaam, Tanzania, 11 March 2010.
- A climate information consultation and workshop with members of the Regional Inter-Agency Coordination Support Organization in Johannesburg, South Africa, 27 May 2010.
- A consultation session to develop a climate information monitoring framework with the IFRC Asia Pacific Zone in Kuala Lumpur, Malaysia, 5 July 2010.
- Consultations with members of the OCHA Mitigation Task Force on the use of weather and climate information for improved preparedness and response. Port-au-Prince, Haiti, July 2010.
- Consultations with members of the Kenya Food Security Steering Group, Nairobi, Kenya, September and October 2010.

The team gratefully acknowledges the financial support of OCHA, the Red Cross/Red Crescent Climate Centre, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), and the US National Oceanic and Atmospheric Administration (NOAA) for the preparation of this report.

Contents

Executive summary

Climate-related disasters are by far the most frequent natural disasters, exacting a heavy toll on people and economies. Their frequency and economic losses have steadily increased over the past few decades, stretching the response capacities of governments and humanitarian organizations. One of the many ways this challenge can be addressed is by making more effective use of the increasing wealth of climate information and tailoring it to the needs of those who could use it, to better predict and prepare for such disasters before they occur.[1]

Written in partnership with a range of humanitarian organizations, A Better Climate for Disaster Risk Management is the third in the Climate and Society Publication series. This issue highlights recent advances in the use of climate information to manage risks and improve livelihoods, such as new partnerships and user-designed information platforms. It draws together and analyzes experiences from 17 case studies that capture the current state of knowledge. It also highlights research innovations in technical boxes throughout the publication. A problem-solving framework is used to demonstrate the challenges and opportunities facing disaster risk managers in using climate science with a three step approach: indentifying the problem, developing tools, and taking action, reflected in the chapter titles.

The case studies and experiences presented in this book draw on a wealth of practical experience from within the humanitarian community. They acknowledge the enormous effort and investment by very many national and local governments, international organizations, and an increasing range of other actors in the field of climate information for disaster risk management. This publication adds to the growing body of knowledge, focusing on the experiences of a number of mostly non-governmental actors, especially the International Federation of Red Cross and Red Crescent Societies, and how through partnerships, they have helped to integrate state of the art climate science and information into improved decision-making.

Exploring the use of climate information for disaster risk management, it identifies both the achievements and the obstacles associated with this endeavour. From them are distilled the lessons learned, and a series of recommendations. Of these, effective partnership is highlighted as the single most critical ingredient for success. Climate information that can be acted upon is best created in dialogue between the users and providers,

1 Note that improving the use of seismic and geological knowledge for predicting other disasters such as volcanic eruptions, earthquakes and tsunamis is not the focus of this publication.

and partnerships between climate scientists and disaster risk managers should promote knowledge sharing, trust, and the development of innovative solutions.

Efforts to better apply climate information in disaster risk management should first focus on immediate opportunities and potential 'quick wins'. Practical engagements can be fostered by initially concentrating on countries and regions with relatively good seasonal forecast skills, and where humanitarian decisions can be influenced to provide large and immediate returns on investment. Disaster risk managers must, however, improve their understanding of the potential as well as the limitations of climate information, as the development of realistic expectations is vital to maintaining trust in the information and those who provide it.

Cases demonstrate that when climate information can be integrated into existing decision-making support tools or systems, it becomes an important piece of the information that is considered and taken up in the routine activities of disaster risk managers. The relative contribution that seasonal, decadal, and long-term trends make to current and future climate also needs to be better understood. To achieve the goal of providing relevant climate services to support disaster risk management, climate information providers such as national meteorological services must tailor their information to the problem at hand, either by refining products through iterative interaction with partners or by simplifying the presentation.

Although there have been many achievements and advances, much potential remains to be realized. Herein lies the opportunity: to build trust and improve the sharing of knowledge between the providers of climate services, and those who can use those services to enhance disaster risk management, jointly reducing human suffering and achieving more sustainable development.

Introducing climate-informed disaster risk management

Globally, climate-related disasters including floods, droughts, cyclones, heat waves and mudslides cause tens of thousands of deaths, hundreds of thousands of injuries, and billions of dollars in economic losses each year. Losses have risen steadily over the past decades, primarily as a result of an increase in the value of exposed assets in hazard-prone areas. Climate change is expected to exacerbate these rising costs due to a higher expected frequency and intensity of extreme events. In order to help meet these challenges, more investment in disaster risk reduction is needed, including in capacity to anticipate risks well ahead of when a hazard strikes. By drawing out the successes, opportunities, and continuing challenges in a series of cases studies, this book illustrates how the better use of climate information is informing risk reduction strategies and actions. This chapter introduces underlying concepts – including how climate information can be integrated into disaster risk management, the different types of climate information, and the difficulties ahead. It stresses the importance of partnerships as a means to address and overcome these challenges, and to facilitate the scale-up of these types of efforts. Terminology is defined, and the three-step problem-solving approach used in this book is explained.

Managing climate risk

The ability to manage climate risk is fundamental to disaster prevention and preparedness. Climate information can improve prevention and preparedness, but it must be readily available and understandable to those who need it. The International Federation of Red Cross and Red Crescent Societies (IFRC) first employed a seasonal forecast to trigger an emergency appeal for preparedness for a rapid-onset disaster before the 2008 West African floods (see box). This was not the first time a humanitarian organization had used climate information to mitigate, prepare for, or respond to a disaster, but it did highlight the specific opportunities of using this information more systematically. However, given that this remains an isolated example, it also shows that more remains to be done to explore how such an approach can be applied more widely.

This book considers ways that climate can be better integrated into disaster risk management practice, building on the findings drawn from 17 case studies from across the world which focus specifically on weather- and climate-related disasters and the humanitarian community. These are analyzed under three progressive chapter-based themes, identifying the problem and possible solution, developing

Advanced warning of impending storms and other climate-related hazards can help people prepare accordingly; Christopher Schoenbohm

the tools, and taking action, before concluding with the lessons learned and resulting recommendations.

Changing concepts and adapting approaches

Increased sophistication in the use of climate information for disaster risk management has tracked other changes in both the climate and disaster risk management communities. One such change was the shift in focus from disaster response, toward a more balanced approach including disaster risk reduction, officially recognized when the United Nations General Assembly declared the 1990s the International Decade for Disaster Risk Reduction. Importantly, this decade also saw a shift from an era in which disaster risk managers primarily sought technological solutions to disasters, to one with a greater emphasis on identifying and reducing the underlying causes of vulnerability.

In recent years, the Indian Ocean tsunami[1] in 2004 and the signing of the Hyogo Framework in 2005 (UN, 2005) have sharpened the resolve of governments and the international community to improve the use of prevention and preparedness strategies to reduce the loss of life, property, and the social and economic disruption caused by natural disasters. Of course, response is still an essential part of disaster risk management – no matter how hard the humanitarian community works to mitigate disaster impacts

1 Note that tsunamis are not climate related, though sea-level rise as a result of climate change can affect wave characteristics.

Improving disaster response and cost savings – the first Red Cross appeal based on seasonal climate forecasts

In 2008, the IFRC issued its first-ever flood emergency appeal based on seasonal climate forecasts (Tall, 2008; 2010). The forecasts, issued in May, indicated a heightened chance of above-normal rainfall during West Africa's July-to-September rainy season. Concerned about climate change, and having been caught off guard by devastating floods in West Africa the year before, the IFRC and the national Red Cross societies in the region were eager to respond early. To this end, the IFRC West Africa office consulted the International Research Institute for Climate and Society (IRI) for help with interpreting forecasts and developing contingency plans for the potentially serious flooding that above-normal rainfall could bring.

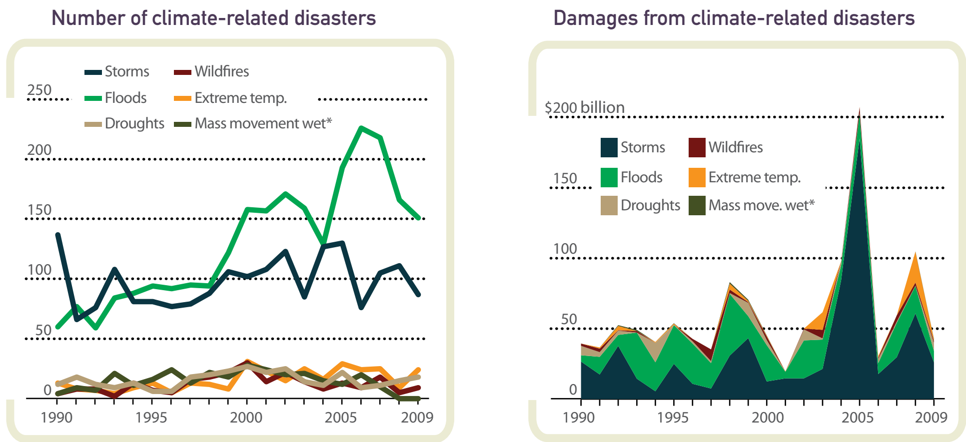
To prepare for impending impacts, the Red Cross also held training events throughout the region beginning in June. Then, as the rains began, the IFRC requested funding for preparedness activities in four West African countries (IFRC, 2008). Though donor funds did not materialize until August, the IFRC was able to make use of internal disaster funds to initiate work.

As a result, communities were better prepared when the flooding began. The prepositioning of stocks allowed the national Red Cross societies to meet beneficiaries' needs for shelter, cooking supplies, water, and sanitation within 24–48 hours – as opposed to the 40-day wait between disaster and response when flooding occurred in West Africa in 2007. Prepositioning also allowed the Red Cross to reduce the cost per beneficiary of their response to one-third that associated with 2007 flood relief (Braman *et al.*, 2010).

Disaster risk managers use weather and climate information to inform contingency plans, such as the prepositioning of relief supplies before roads are cut off by floods.

the world will still experience disasters – but recent events have pushed an increasing interest in disaster risk reduction.

One reason for this is the rising cost and number of climate- and weather-related disasters (IMF, 2010). As evidenced by the International Disaster Database (CRED, 2011), the number of climate-related disasters has steadily increased from an annual average of 224 in the 1990s, costing a total of US$50 billion, to an annual average of 347 in 2000–09, costing US$72 billion (see Figure 1). This 50 percent increase in number and cost from one decade to the next is the result of a confluence of factors, including population growth in flood-prone areas and an increase in the value of exposed assets. The increasing economic cost and toll of disasters



*Includes landslides, subsidences, rockfalls and avalanches
Source: EM-DAT: The OFDA/CRED International Disaster Database

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Source: EM-DAT: The OFDA/CRED International Disaster Database

Figure 1: The rising number of climate-related disasters per year in 1990–1999 and 2000–2009, and damages in US$ billons (CRED, 2011).

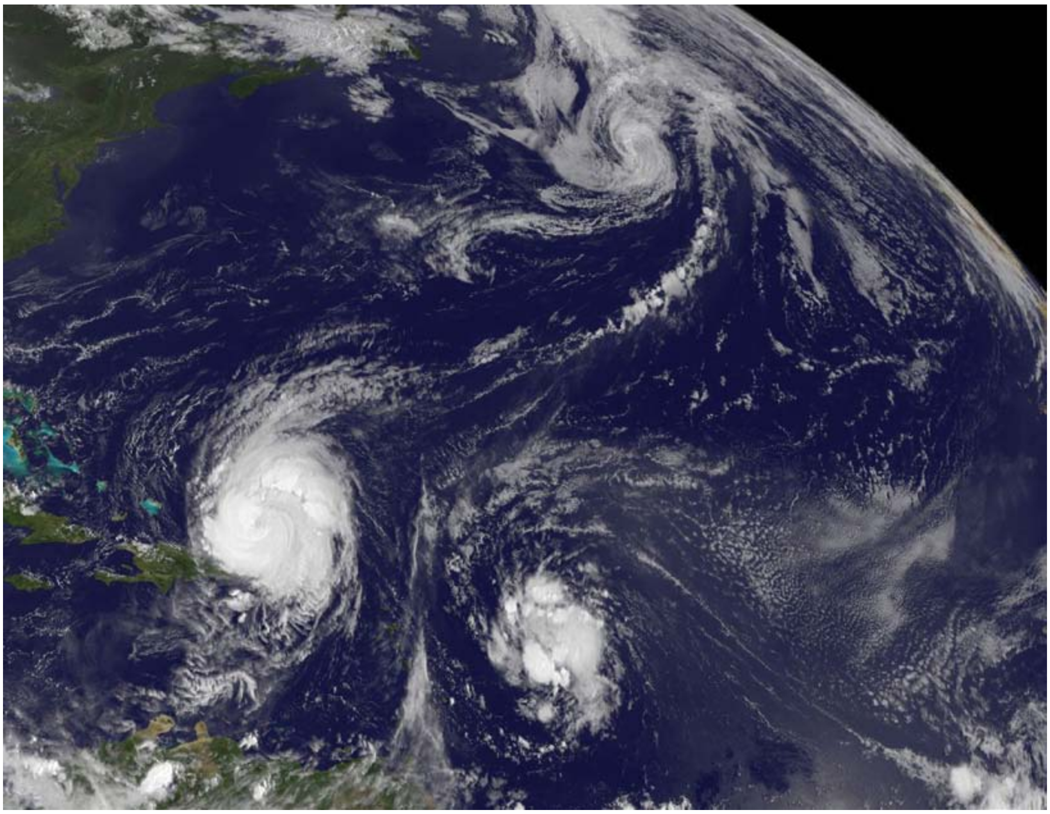
should be a significant incentive for governments and humanitarian organizations to focus more of their attention on preparedness, prevention, and on addressing the root causes of vulnerability. However, in spite of increased donor interest in disaster prevention and risk reduction, this has not been matched by substantive amounts of new funding or new projects (Martin *et al.*, 2006).

The increase in the number and cost of climate- and weather-related disasters has taken a toll not just on individual lives and livelihoods, but also on national development. Disasters pose both direct costs such as damage to buildings, crops, infrastructure, etc., and indirect costs, i.e. losses in productivity, increased investment risk, indebtedness, etc. Between 1990 and 2000, the World Bank estimated that in several developing countries, natural disasters had caused damage representing between 2 and 15 percent of their annual GDP (World Bank, 2004). In addition, a growing body of evidence, much of it captured in the United Nations 2007–2008 Human Development Report, points to the direct effects of climate on economic and human development, particularly in low-income countries (UNDP, 2008; Mutter, 2010).

The shift toward preparedness and prevention is also in part motivated by concern regarding climate change. Scientific consensus suggests that this will bring more intense and more frequent extreme events (IPCC, 2007). Although this does not necessarily mean that there will be more disasters everywhere, it does mean that it is prudent to increase disaster preparedness and prevention efforts.

The rapidly increasing demand for easily accessible and timely climate information that can help government, non-government, private sector and community actors make better-informed decisions in light of climate variability and change has motivated global and national efforts to develop climate services. Climate change presents new and greater challenges for disaster risk managers already struggling to manage climate variability. For example, the assumption that past climatic conditions will continue into the future is no longer valid. There is increasing demand for new and better climate information to allow decision makers and resource managers to better anticipate and plan for the potential impacts of climate variability and change.

At the same time, recent advances in climate science, including the production of climate forecasts at different time scales, can help to fill this information void. Cases throughout this book illustrate how seasonal



Early warning can lead to early action and risk reduction, but satellite and other weather data must be made available, understandable and actionable to people on the ground who can make use of it; NASA/GOES Project climate forecasts can help governments and/or humanitarian organizations improve their disaster preparedness. Climate scientists, including meteorological agencies, are also increasingly interested in advancing the use of climate information through the development of climate services.

Building on the idea of weather services, climate services seek to improve decision-making in a variety of sectors, including health, food security, agriculture, water management, and disaster risk management, through targeted support and provision of climate information. The implementation of comprehensive climate services is still in its infancy, but a few initiatives are leading the way. These include the Global Framework for Climate Services, and AfriClimServ, which seek to prioritize effective partnerships between climate information providers, and the potential users of climate information – communities with very little history of interaction.

The shift toward climate services comes at a time when it is increasingly recognized that the ability to manage climate risk is fundamental to disaster prevention and preparedness. By adopting a climate services approach, the climate community hopes to be better positioned to add value to disaster risk management decision-making and outcomes. Although it is clear that climate services cannot address all the constraints to reducing disaster risk, and that not all disaster-management decisions rely on climate information, such information can make a very important contribution in many cases.

Incorporating climate information into disaster risk management

Paradigmatic changes in the climate science and disaster risk management communities have led to an increased interest in climate services. The increased sophistication of climate information for disaster risk management is based both on advances in climate science and on the development of a deeper understanding of how climate information can be used in disaster-related decision-making. As a result, in many cases, disaster risk managers are now able to use information across timescales – i.e. from days to decades – to inform decisions and improve prevention, preparedness, response and recovery.

Disaster risk managers are also increasingly aware of the value of climate information. A range of governmental and humanitarian organizations now actively recognize the role that climate information can play in risk reduction, early warning and early action (Haile, 2005; GIZ, 2007; IFRC, 2009). Although more quantitative evidence is needed, it is clear that climate information can be used to reduce critical response times, particularly when information is used to mobilize and direct donor resources. Early action saves not just lives but also livelihoods, the loss of which severely impedes economic growth and sustainability (Haile, 2005).

Valuing climate information

Policymakers and practitioners, such as disaster risk managers, make choices to use and/or invest resources in ideas and technologies that will provide benefits to society. One reason that they have not invested significantly in climate information is that the benefits and impacts of the information have not been well estimated and/or articulated (Hansen *et al*., 2006).

The value of climate information – for example in climate products such as seasonal rainfall forecasts – is now beginning to be evaluated. However, quantitative cost–benefit evaluations are still lacking in many cases. This is perhaps not surprising considering that forecasts have not been widely used for disaster risk management, so large data sets that could be used for comparative estimates do not yet exist. Another challenge for calculating the benefits of using climate information in private or public decision-making is the establishment of suitable criteria and indicators that allow researchers to distinguish between the effects of improved information and the effects of other measures taken to reduce the impact of weather-related disasters.

The added value of climate information is hard to disaggregate because it is often one of many factors used in decision-making. In this sense, the central challenge, as with any evaluation, is to understand what effects can be ascribed to the use of climate information as opposed to other factors. For example, the lives saved due to early warning and action in advance of a particular flood, though based in part on climate information, cannot be solely attributed to the use of the information. In other words, the challenge is to properly define the counterfactual – what is the outcome in the absence of climate information, and does the comparison identify the impact of climate information alone? Though this is a serious challenge, well-designed data collection can significantly improve the understanding of causality.

An added complication is that it is difficult to predict one single effect of the use of any particular type of climate information. Rather, the effect of the use of climate information is likely to vary for different sectors of the population, as some people will benefit more than others. Effects will also depend on various conditions, as the same piece of climate information applied to the same problem will be effective in some places and not in others. At this point, researchers assessing the value of climate information need to understand who benefited from the use of such information, how, and under what conditions.

Despite the lack of quantitative studies of the use of climate information for disaster risk management, the observed increase in the demand for such information illustrates its value. By this measure, what is useful will be valued. It is clear that investments in climate services are being made, and that climate information is increasingly being used by those involved in disaster risk management. Some information (including the forecasting of extreme weather) is particularly in demand by disaster risk managers and energy suppliers, suggesting that this information is more valuable than other types. Until more comprehensive evaluations can be completed, the available evidence suggests that climate information is certainly valuable, though the actual extent and benefits are yet to be accurately ascertained.

Disaster-related definitions

A **disaster** is a serious disruption in the functioning of a community or society, causing widespread human, material, economic, or environmental losses that exceed the ability of the affected society to cope using its own resources. Disasters come in all shapes and sizes, and have origins that range from natural to artificial (UNISDR, 2009).

Risk is the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Disaster risk is a function of hazards, elements at risk (i.e. population, infrastructure, and property), and their vulnerability; disaster risk management requires an understanding of the social, political, geographical, and climatological factors at play.

Disaster risk management (DRM) is a systematic approach to avoiding, transferring, and reducing the adverse impacts of hazard events. It includes a range of activities that are frequently presented as a cycle including prevention/mitigation, preparedness, response, and recovery (see Figure 2).

Disaster can be caused by physical hazards that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. This book concentrates primarily on climate-related disasters caused by **hydrometeorological hazards**, being natural processes or phenomena of atmospheric, hydrological or oceanographic nature. These include tropical cyclones, storms, floods, storm surges, blizzards, droughts, wild fires, temperature extremes, landslides, avalanches and sand or dust storms. Climate-related disasters also include some biological disasters, such as cholera and malaria outbreaks.

The chances of being affected by a hazard depends on **vulnerability**, determined by physical, social, economic, and environmental factors or processes which affect the susceptibility of a community to the impact of hazards.

Disaster **prevention** can be thought of as taking measures to reduce overall vulnerability to natural hazards. These include measures taken to detect, contain, or forestall events or circumstances that, if left unchecked, could result in a disaster. As it is often impossible to completely avoid losses, disaster risk managers also try to mitigate adverse impacts by updating buildings and/or building codes, improving environmental policy, and increasing public awareness of potential vulnerabilities.

Another essential part of the disaster risk management cycle is **preparedness**, which is also an effort to reduce vulnerability, though recognizing that impacts cannot be prevented entirely. Preparedness includes those strategies, activities, and actions taken before hazard events occur in order to lay the groundwork for effective response. For instance, contingency planning and the stockpiling of supplies can help disaster risk managers respond quickly to protect people and property when a disaster strikes. Once a disaster has occurred, the focus changes to **response**, which includes the mobilization of emergency services during or after a disaster situation, in order to reduce impacts on the population.

Finally, **recovery** involves the restoration (or improvement, in some cases) of the facilities, livelihoods, and living conditions of disaster-affected communities. This includes repairing or upgrading physical infrastructure, ensuring appropriate social services, and the provision of food and other resources. Recovery describes rehabilitation and reconstruction activities that save lives, address immediate needs, restore normal activities, and reduce future disaster risk.

Climate-related definitions

Weather represents the state of the atmosphere at a specific time and place, including the temperature, humidity, cloud cover, rainfall, wind, etc. **Weather forecasts** give specific indications of what conditions are expected for precise locations and times, for example, forecasts will indicate the actual temperature that is expected on a specific day.

Weather services seek to provide information for the benefit of society (private and public sector), including providing weather forecasts, issuing storm warnings, gauging and reporting on river levels and flooding, providing information on frost, heat- and cold-waves and providing drought forecasts and assessments.

Climate represents the statistics of weather, estimated over some (preferably long) period of record, typically 30 years or more. **Climate forecasts** are usually expressed in less precise formats. For example, climate forecasts are for average conditions over periods of weeks, months or seasons. In addition, rather than indicating specific temperatures or amounts of rainfall, the forecasts will indicate probabilities of the temperature or rainfall being within some range of values, e.g. the probability of warmer- or wetter-than-average conditions. **Climate change** represents any change in climate over time, whether due to natural variability or as a result of human activity.

Climate services seek to improve decision-making in a variety of climate-sensitive sectors, including health, food security, agriculture, water management, and disaster risk management, through targeted support and provision of climate information.

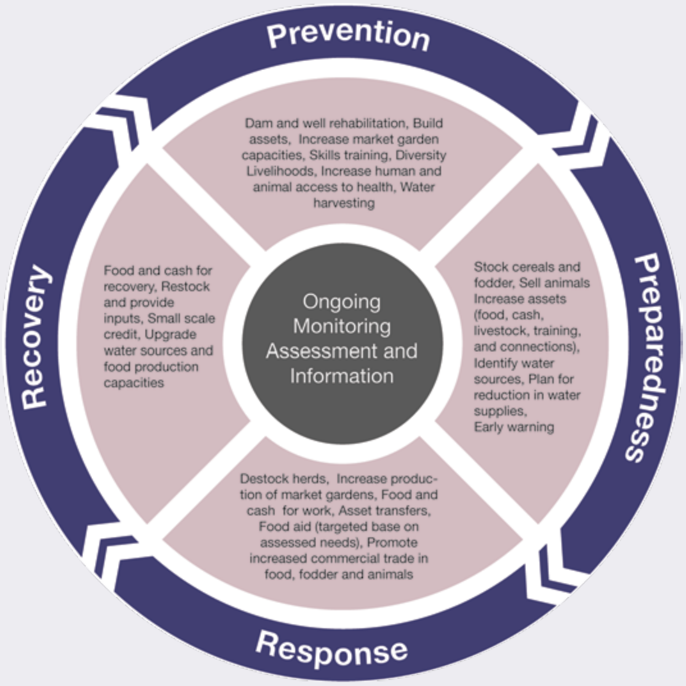


Figure 2: The disaster risk management cycle in the Sahel, where frequent droughts lead to famine and food insecurity (adapted from Kelly and Khinmaun, 2007).

The disaster risk management cycle is a diagrammatic representation of disaster prevention, preparedness, response and recovery, and is designed to show what types of interventions can be undertaken at each stage for a particular disaster, including fires, tsunamis, avalanches, earthquakes, and volcanic eruptions. This publication focuses solely on climate-related disasters, including tropical cyclones, storms, floods, landslides, droughts, heat waves, blizzards, and some outbreaks of epidemic diseases.

Climate information is explicitly incorporated into the disaster risk management cycle in order to demonstrate the types and timing of information that can help disaster risk managers prepare for and respond to climate-related events (see Figure 3). This includes short-term weather forecasts, seasonal forecasts, and information on longer-term trends including decadal variability and climate change. Figure 3 also shows the kinds of actions that disaster risk managers can take based on different types of information. For instance, seasonal forecasts can be used in preparedness efforts including training volunteers and prepositioning of stocks. Information at longer timescales can be useful in strategic planning and risk assessments, though scientific understanding of decadal variability and processes is still evolving.

Disaster risk managers are learning to use climate information across time scales to improve prevention, preparedness and response; SALTBONES; Olav A./Røde Kors

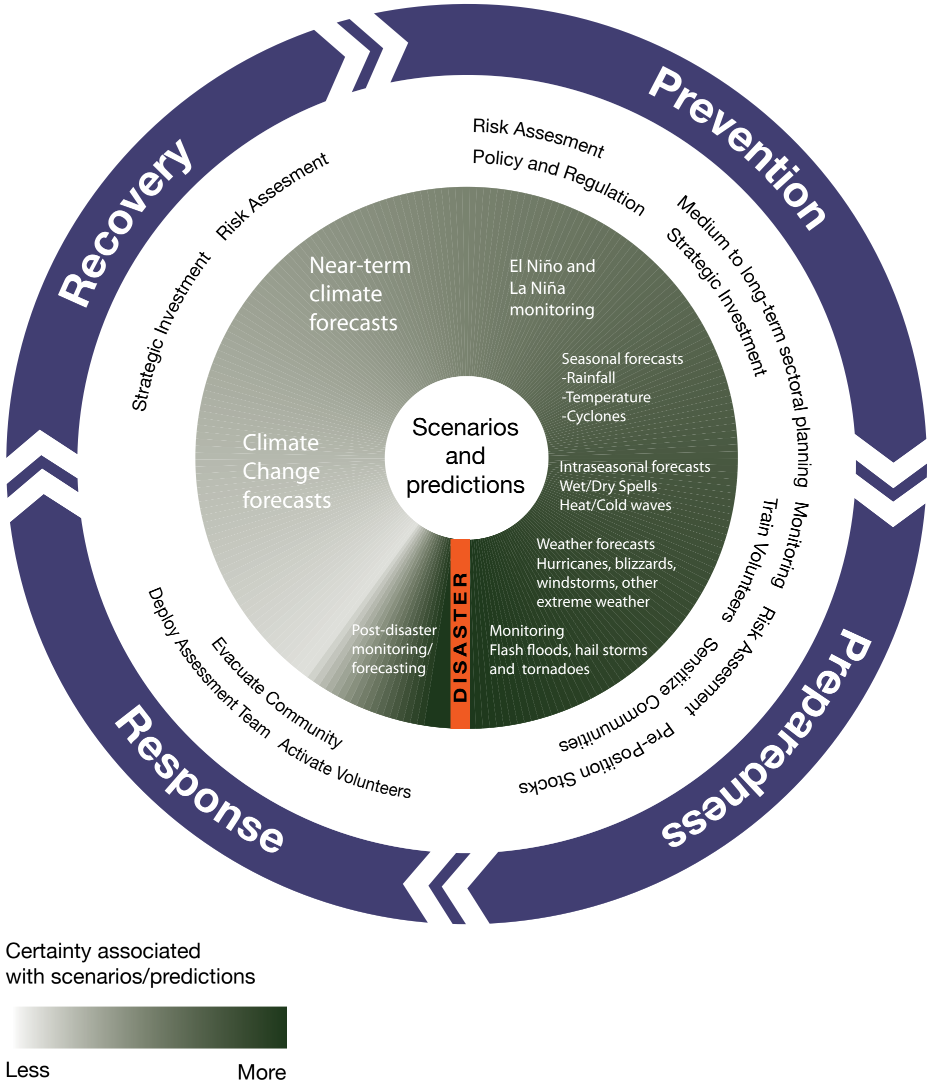


Figure 3: Incorporating climate information into the disaster risk management cycle illustrates the kinds of information that can inform specific decisions (adapted from Kelly and Khinmaun, 2007).

Understanding different types of climate information

With varying levels of precision and skill, scientists are able to produce climate information at a range of different temporal scales. This is useful to disaster risk managers, though each type of information fits into the disaster risk management cycle in different ways. Understanding the differences between, and the different uses of, these various kinds of information is an important step in effectively incorporating them into disaster risk management.

Historical climate information

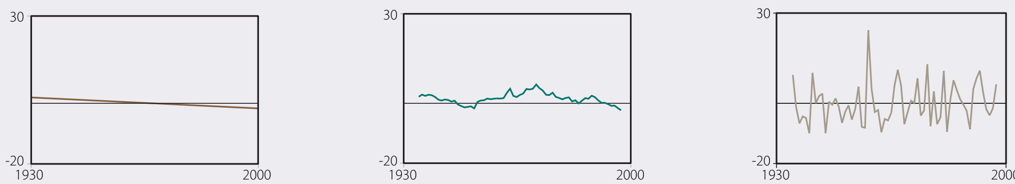
One of the most important types of climate information is historical. Disaster risk managers use historical information to assess baselines

Looking to the past to understand the future

Though climate change predictions are generally made over large geographic areas, the impacts of climate change will be felt by local communities, including farmers and urban dwellers. A careful look at the past climate in a particular community can help to understand how local climate has evolved in the past, and how it may vary in the future.

Climate scientists look at climate records to try and understand how local rainfall, for example, has varied by day, month, year, decade and even century. This knowledge is important to a farmer or disaster risk manager because it may mean that despite climate change scenarios predicting less rainfall over the next 100 years, rainfall could still increase on timescales of years to a few decades over the course of the century.

As such, disaster risk managers may have to adjust their expectations regarding climate change, and adjust their strategies accordingly. This is especially true in arid and semi-arid regions such as the Sahel (see Figure B1), where rainfall variations in a particular year or decade dwarf those at the century time scale. Where data are available, knowledge of how climate has varied in the past can help disaster risk managers get a sense of the way the climate-related risk faced by their region has changed and may continue to evolve over time.



a) The variation in observed precipitation that can be explained through long-term change.

b) The variation in observed precipitation that can be explained through decadal variability.

c) Seasonal variability, subtracting long-term and decadal variability from overall variability.

Figure B1: Seasonal, decadal and long-term variability in rainfall in the Sahel.

or 'static risks', i.e. the maximum flood level expected over a 50-year period. It is important to understand that the selection of the time interval or length of the historical record can drastically affect the risk assessment. For example, the risks of a major drought may be small over the next 20 years, but significant over the next 200 years. Disaster risk managers should thus be especially cautious when estimating extreme values from short time series.

Historic climate information gives indications of how risk is constantly changing based on seasonality, inter-annual climate variations, changes in population and the built environment, etc. Population, economic and environmental trends can significantly affect risk within any single decade for example, and with the prospect of global climate change, some climate-related hazards may become more frequent over the next few decades.

Historical climate information also provides a context for interpreting climatic conditions and trends. Once disaster risk managers understand how climate has varied in a particular place across seasons, years, decades, and centuries, and the magnitude and frequency of past droughts, floods, and heat waves, they are better able to contextualize current climate and weather forecasts. In many cases, historical information can also provide disaster risk managers with a sense of the potential consequences of a particular forecast, and the types of actions that can be taken in response.

Historical information continues to be valuable despite human-induced changes to our climate. Although climate change is already impacting present-day climate, historical information is still valuable to help inform strategic investments such as in infrastructure and long-term livelihood measures. A sound analysis of historical climate also aids in the understanding of how climate may evolve in both the near and long-term future. Unfortunately, reliable time series of historical climate information are not always readily available in many developing country settings.

Long-term drying is one factor, for example, that is likely to impact the quality and availability of water, and by extension, a range of issues related to agriculture, food security, health, and social relations. Tracing the exact impacts of such distant climate change is impossible, but scientists have developed a range of approaches that help them evaluate the economic, environmental and social risks of long-term variability and change. By feeding available climate information into these tools, disaster risk managers can weigh the pros, cons, costs, and benefits of different long-term investment strategies, revealing 'low-regret' approaches that reduce climate vulnerability at minimal cost (Callaway *et al.*, 2006). Decision makers can then decide whether investment in relatively costly infrastructure such as a large reservoir, might be justified based on the level of risk and uncertainty.

Decadal or near-term climate information

Scientists have begun to focus their attention on anticipating changes in the next 10 to 30 years. Prediction at this timescale is still highly uncertain and a major topic of research for the fifth IPCC report. Whereas the forecasting of decadal variability still poses significant challenges, it is clear that some parts of the world experience stronger decadal variability than others. Projections for this time period, referred to as near-term climate change, can be valuable for informing strategic decisions regarding infrastructure and long-term livelihood strategies. Where natural oscillations in the climate systematically reduce long-term climate change trends, making decisions based on climate projections for 2100 for example may not be the most adaptive approach. In such regions, information about near-term climate change would help determine more appropriate strategies.

Seasonal climate information

Disaster risk managers use seasonal climate information to help develop appropriate risk management strategies, as is exemplified in many of the case studies presented in this book. Seasonal rainfall and temperature forecasts issued at least a month in advance, provide probabilities as to the chances of below-, near-, or above-normal conditions in the forthcoming three-month season. Although there are challenges associated with incorporating such probabilistic information into decision-making, disaster risk managers can use seasonal climate forecasts as a starting point for preparedness measures, such as prepositioning and resource planning, and to inform agricultural management decisions such as crop or variety choice (Haile, 2005; Patt *et al.*, 2005; Hellmuth *et al.*, 2007).

In developing seasonal forecasts, scientists pay particular attention to the El Niño Southern Oscillation (ENSO). ENSO involves changes in sea surface temperatures in the tropical Pacific Ocean, and related atmospheric circulation patterns. El Niño is used to describe warmer temperatures; La Niña cooler ones. ENSO is the most significant source of seasonal climate variability globally, with rainfall in many parts of the world being strongly influenced by it. Where the connection between ENSO and seasonal climate is stronger, seasonal forecasts give a more accurate prediction of seasonal climate.

Since the 1980s, disaster risk managers have incorporated seasonal climate forecasts into food security early warning systems. For example, the Famine Early Warning System, now FEWS NET, was established in response to a series of intense droughts that ravaged the Sahel in the 1970s and 1980s. It uses seasonal climate information, environmental monitoring and derived agrometeorological data to produce food security updates that disaster risk managers use to anticipate, prepare for, and manage food insecurity.

The migration of the inter-tropical convergence zone (ITCZ) in Africa affects seasonal rainfall patterns across that continent. This moving equatorial belt is where northern and southern trade winds meet, and is a key component of global circulation system. The timing of the advance and retreat of the ITCZ determines the length and characteristics of the rainy season at a given location. Food security managers have exploited that knowledge, by mapping the progress of the rains, to determine their stock prepositioning strategy (see box).

Disaster risk managers later began to use seasonal climate forecasts for flood preparedness. One such example is from Mozambique, where a flood early warning system was developed in 1999. By incorporating seasonal forecasts developed by the Southern African Regional Climate Outlook Forum into hydrological models, the system in Mozambique was designed to allow disaster risk managers to issue warnings and activate appropriate disaster-management responses. Just one year after the system was developed, the country experienced the worst flooding it had seen in a century – and whereas the system performed relatively well, warnings were not sufficiently communicated to populations at risk, underscoring the need for community involvement, education, and awareness (Hellmuth *et al.*, 2007).

In the Atlantic basin, disaster risk managers also use seasonal hurricane forecasts to inform preparedness and prevention. As the Atlantic Ocean is characterized by large year-to-year variability in climate, disaster risk managers benefit from an improved understanding of the forthcoming season. Unfortunately, hurricane forecasts issued in early April for the Atlantic's June-to-November hurricane season tend to show only limited levels of accuracy, and as a result are not frequently used for disaster preparedness. Forecasts issued in June and August exhibit modest improvements and can be more useful, as the peak of the season is still some months away (generally from September to October). However, even with accurate forecasts of the number of storms, anticipating the impacts of the hurricane season at specific locations remains a major problem. Even in a below-average season

Using the ITCZ to help plan logistical operations in Darfur

By 2004, hundreds of thousands of people in the Darfur region of Sudan and neighboring eastern Chad were displaced by fighting. Most of these fled to internally displaced people (IDP) and refugee camps, and were almost entirely dependent on humanitarian assistance for their survival. However, during the rainy season in Darfur, roads become impassable and communities were completely cut off for several months. This posed a significant challenge for humanitarian organizations including the World Food Programme (WFP), charged with providing life-saving supplies to the camps. Initial efforts to preposition food in camps were undertaken, but as the rain approached, food security experts realized that prepositioning adequate supplies would be difficult.

To assist in planning these operations in Darfur and Chad, FEWS NET and the UN Joint Logistics Centre operated by WFP on behalf of the humanitarian community, developed the Darfur Rain Crisis Timeline. This product combined climate information with logistical information, including the locations of refugee and IDP camps and transport infrastructure. A seven-day rainfall forecast was overlaid on this information to support convoy planning. Most significantly, it provided the current and projected position of the inter-tropical convergence zone (ITCZ) which affects the rainy season. Mapping the progress of the rains on their northward march allowed logistics planners to shift their prepositioning strategy to fill warehouses in the south where the rains would arrive first, leaving time to preposition in the northern areas until later in the season's onset.

The Darfur Crisis Rain Timeline provided disaster risk managers with a new and tailored understanding of the nature of the climate in Darfur. In doing so it allowed a significant improvement in the performance of logistical operations, both at a strategic seasonal level and on a weekly basis for planning convoys. Without a clear understanding of the climate system that drives the rains in the region and the needs of disaster risk managers, this simple product would not have been possible.

for example, there can still be significant losses with only one major hurricane landfall (Camargo *et al.*, 2007). This was the case in 1992, a season with a very low level of activity but when Hurricane Andrew caused extensive damage in the Bahamas and parts of the southeastern United States.

Furthermore, current seasonal forecasts do not yet include reliable information regarding possible sites of landfall, and without that, the level of impact is unknown. Nevertheless, there are examples of hurricane forecasts being used directly by the disaster risk management community. The IFRC has developed recommendations for early action based on seasonal hurricane forecasts (IFRC, 2009). The Red Cross Pan-American Disaster Response Unit also presents the hurricane forecast at their annual planning meeting (Kopcik, 2009; Braman *et al.*, 2010). Hurricane forecasts are also used by the World Food Programme to inform decisions regarding the prepositioning stocks and for contingency planning (Klotzbach and Gray, 2010).

Although seasonal hurricane forecasts have limited utility, shorter-term tropical cyclone forecasts – made a week or two in advance – are frequently used by disaster risk managers for early warning and early action. These provide relatively accurate information on the likely trajectory and strength of specific storms, allowing time for communities to prepare and/or evacuate. The Red Cross used such forecasts to help with evacuation efforts in Mozambique in 2000 and Bangladesh in 2007.

Weather forecasts

Weather forecasts provide information on immediately approaching events. As the lead-time is much shorter than with seasonal forecasts, the accuracy is greater. Also, although they do not provide disaster risk managers with a great deal of advanced warning, weather forecasts still enable measures including the early coordination and mobilization of human resources and supplies, the activation of contingency plans, informing populations at risk, providing instructions on precautionary measures, and setting up shelters or evacuating communities (Braman *et al.*, 2010).

Across timescales

By monitoring climate information across timescales, disaster risk managers can get a sense of the overall likelihood of various climate-related risks. For instance, a seasonal forecast can predict the likelihood that a coming rainy season will be wetter or drier than normal, and thus be a helpful guide to anticipating impacts. When an alert for a particularly wet season is issued however, disaster risk managers must continue to monitor forecasts on shorter timescales (such as monthly, ten-day, weekly, and daily weather forecasts) in order to determine where and when extreme weather events might occur (IFRC, 2009; Braman *et al.*, 2010).

It is important to realize that in order to effectively use climate information for disaster risk management, government

Collecting meteorological data is important for characterizing climate risks at a given location; UK Department for International Development

and humanitarian organizations must also understand the timing of climate-related impacts, and use this timing to guide the logic of their decision-making. For instance, an early end to the rainy season in southern Africa in February will have its main food security impact the following October when the region's hunger season begins. In order to meet the needs of the affected population, food security actors will need to prepare six months in advance – that is, in April. Climate hazards must be scheduled and mapped out in order to effectively use climate information in disaster risk management.

Challenges to climate-informed disaster risk management

There are many challenges to improving disaster risk management – both as a whole and specifically with respect to hydrometeorological hazards. Even when confronting such hazards, improving the relevance and use of climate- and weather-related information is only one part of a range of important efforts. So while the humanitarian community has clearly benefited from integrating weather- and climate-related information into disaster risk management decision-making, the use of this information to date has been limited in scale and scope. Several challenges help to explain this. Decision makers are first and foremost limited by their awareness of the information. Furthermore, decision makers are not always sure how to interpret climate information, or how to integrate it into decision-making processes. Additionally, they often face political, social and communication constraints that impede their ability to make use of such information.

For instance, the world's poorest people face severe resource constraints that leave them vulnerable to climate risk, even in cases in which they know and understand this risk (UNDP, 2008). They may know what to do to protect themselves from climate-related risk, but be unable to take action. For example, even in cases in which drought conditions are predicted farmers may not be able to change the crops they plant. Alternatively, when good rains are forecasted, they may not have ready cash for livestock restocking. The situation is compounded when humanitarian agencies are unable to access funds to help these poor farmers until the effects of the disaster have already been felt. However, all people, rich or poor, underinvest in measures that reduce future risks, thus indicating that access to wealth is not the only constraining factor.

In some cases, disaster risk managers may also decide not to incorporate climate information into their decision-making process even if it is available. One reason for this is a lack of quantified evidence that proves the added value of climate information in decreasing suffering, mortality and/or economic damage. Another reason is that disaster managers have historically been exposed to an often-daunting mass of largely unfiltered, irrelevant and even conflicting information. To date, the climate community has lacked a specific mandate to tailor information to specific needs, and to act as a trusted partner and source of information to the humanitarian community (Williams, 2005).

There are also challenges to acting on early warning information. Humanitarian relief operations are primarily funded by voluntary contributions from the donor community. Donors are less likely to be prompted by preemptive early warning systems, but rather by harrowing pictures once a famine or other disaster is well underway (Broad and Agrawala, 2000; Haile, 2005). Other determining factors include: the political will of donors and donor countries, capacity, level of emphasis on disaster risk reduction, and the availability, quality, and communication of early warning information (Haile, 2005; Tadesse *et al.*, 2008; IFRC, 2009).

Ongoing research may improve forecasting skills still further in the near future through improved understanding and forecast systems (NRC, 2010) – though longer-range forecasts are always going to be more uncertain than those made at shorter ranges. As a result, decision makers will always have to weigh the trade-off between better preparedness made possible by longer lead-times on one hand, and the greater probability that preparations made on the basis of better information will prove to be justified, on the other. This is particularly difficult to judge where resources are very limited, as in many developing countries.

Disaster risk managers may also have difficulty interfacing and integrating climatic uncertainty into decision-making. In their regular operations, they deal with huge complexities, relying on good information to help them understand possible hazards. Climate-informed disaster risk management often involves the development of strategies and contingency plans (Choularton, 2007), but they are sometimes difficult to mesh with probabilistic climate information.

Unfortunately, overcoming the challenges highlighted above is not straightforward. Information about past and present climates is not always available, and when it is, it may be uncertain, confusing, or difficult to understand. At the same time, there will always be a significant amount of uncertainty about our future climate. Challenges may be even greater in countries most vulnerable to climate-related disasters, many of which are also less developed and lack both the resources and the data required to produce quality climate information tools. Given these constraints, the most efficient pathway to integrating climate information into disaster risk management is to focus on the 'quick wins', rather than starting to promote the use of climate information everywhere for every single decision.

Partnerships for better disaster risk management

Overcoming challenges to the use of climate information is not impossible. However, enhancing disaster risk management by better use of climate information can be achieved only if there is stronger dialogue between a chain of experts, including disaster risk managers and climate scientists (Goddard *et al.*, 2010). Then, the former can understand what is possible in terms of information supply, and the latter can understand in what decision-making context their information can be applied and so tailor it to those needs.

Partnerships that link humanitarian actors with climate practitioners, for example, will allow knowledge and information to be exchanged and mutual capacity to be developed. Extended interactions in partnerships helps to ensure that climate information users and providers learn to better speak and understand one another's language. This may require scientists ensconced in their field to learn to discuss climate-related hazards without relying on the associated esoteric jargon. It may also require that humanitarian actors learn new terms and concepts in order to effectively understand and communicate climate risk.

Partnerships also ensure that the information provided by climate scientists is salient and relevant to the problems and decisions faced by humanitarian actors. In the past, scientists used a supply-driven approach that tried to solve problems with information and/

or tools at hand. To increase relevance, the needs of stakeholders and decision makers must be understood, to inform tool development and research priorities (Meinke *et al.*, 2006; 2009; Dilling and Lemos, 2011).

Partnerships can also help to enhance the credibility and legitimacy of the information provided by climate institutions (Cash *et al.*, 2003; Meinke *et al.*, 2006). This can be achieved by linking to national or regional organizations with a track record of good stakeholder engagement. Humanitarian and government organizations often play a significant role in translating information into something people need and understand, providing it in the right place at the right time, and in a way that is trusted. At the same time, partnerships help to overcome unwarranted expectations of the value of the information, by helping to build capacity and correct interpretations of the information provided.

Examples of partnerships in action are found throughout this book. These have brought disaster risk managers, government and private-sector actors, and climate information providers together, in order to build trust and capacity and increase understanding of each other's needs and limitations. Through consultation with humanitarian and government organizations, information providers have been able to tailor the provision of information and to open up new, more relevant research that applies directly to the needs of humanitarian organizations. At the same time, disaster risk managers have been able to take advantage of often-complicated climate information to add value to their decisions.

Getting the climate right: case studies in climate-informed disaster risk management

Efforts so far to enhance disaster risk management by the improved use of climate information have met with mixed results. While some have worked extremely well, others have been restricted by a range of obstacles. This book offers evidence from a series of case studies that highlight good practice, explore challenges, and from the lessons learned, point the way forward. The cases are presented by way of a problem-solving framework, using a three-step approached mirrored in the following chapter titles.

Identifying problems and possible solutions (Chapter 1) is the first step to gaining a clearer understanding of the situation and the problem. This book specifically considers how climate information can better enable disaster risk managers and climate scientists to identify risks and vulnerabilities, monitor changing risks, and investigate the relationship between climate and socioeconomic impacts. It also necessarily involves communication and partnerships between climate information users and providers. This may involve processes of education and dialogue between the two groups, in order to understand where, when and what types of climate information can be useful to problem identification.

Where there is a lack of available climate information, innovative climate research may be necessary to help bridge the gap.

Developing the tools (Chapter 2) is the second step, and involves identifying how climate information can be integrated into strategies to plan for and respond to climate-related disasters. This can include the tailoring of information to the precise needs of disaster risk managers, or the integration of climate information and knowledge into existing disaster risk management decision-making processes and tools. In many of the presented cases, climate scientists and disaster risk managers work together to create tools that increase the capacity to interpret and use climate information, understand probabilistic forecasts, and identify thresholds for action.

Taking action (Chapter 3) is the third step, once disaster risk managers have developed tools and methods. Even in the best of cases, barriers to action will remain, including untimely access to information, a poor understanding of the connection between climate information and associated climate impacts, and lack of timely donor funds. Despite these obstacles, improved disaster mitigation, preparedness and response can be achieved, when disaster risk managers are provided with clear and actionable climate information, particularly when the two communities of practice work together.

This book highlights some examples of how disaster risk managers in the humanitarian community and climate scientists are working together to integrate climate information into humanitarian decisions, though there is a much greater potential than is currently being realized. There is a strong need to replicate and learn from these cases and processes at regional, national and local scales, to further improve them, and to ensure they are taken up by others.

Chapter 1: Identifying problems and possible solutions

Disaster risk managers can use climate information to help characterize risks. But while climate information has an important role in informing disaster risk management, it is just one of many pieces that must be taken into consideration by disaster risk managers. Also, the degree to which climate information is actually integrated into a better understanding of the problem is heavily dependent upon the strength of the partnerships between disaster risk managers and climate information providers and scientists. Through six interlinked case studies, this chapter explores a range of different problems faced by disaster risk managers that have tried to incorporate climate information into their activities. It also highlights a number of associated problem-identification strategies and possible solutions. Some involve scientific analysis, others involve communication between climate scientists and disaster risk managers. This chapter reveals both the problems surrounding the use of climate information for disaster risk management and the methods to address them.

Dealing with droughts in Syria

Disaster risk managers in Syria are facing a dilemma. They are concerned with perceived trends of increasing drought and want to know whether the trend is a result of climate change, and if so, should they be planning for a drier future? Analysis considers the influence of different forces, including inter-annual, multi-decadal and climate change, concluding that climate change has an influence in Syria and they should plan for more frequent droughts.

In August 2009, Syria was deep into its third consecutive year of drought. Like many of its neighbors in the Middle East, Syria continually struggles to cope with dry conditions, but suffers particularly when the short rainy season fails. When 2008's dry conditions persisted into 2009, more Syrian farmers lost their harvests, herders struggled to feed and water their animals, and safe drinking water became even scarcer. By then, hundreds of thousands of people had already abandoned their farms and rural livelihoods and moved to the growing cities on the desert margins.

The Syrian Red Crescent had been monitoring drought conditions along with the government and other national and international organizations, and were concerned that persistent dry conditions might be a result of climate change (see Figure 4). In 2008, in cooperation with local authorities, the Syrian Red Crescent participated in the distribution of 29,000 food baskets in the east of the coun-

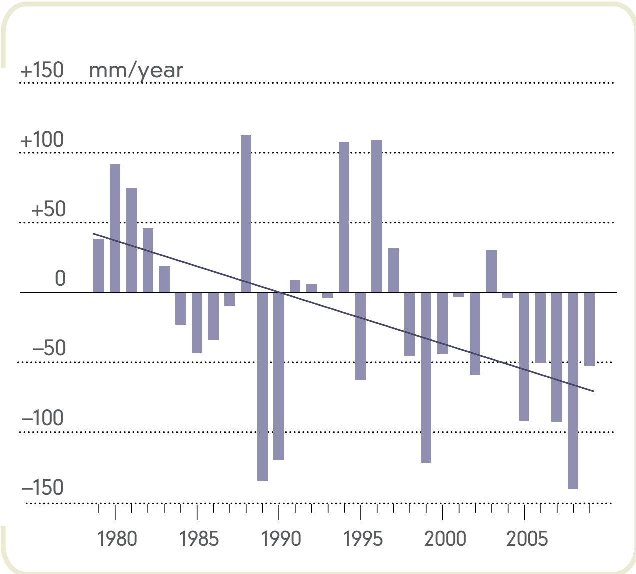


Figure 4: Annual rainfall anomalies in Syria, 1979–2009 (NOAA).

try where the impacts of the drought were the most severe. It also participated in coordination meetings with the United Nations Development Programme (UNDP), the Food and Agricultural Office of the United Nations (FAO), and the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (IFRC, 2009).

At the request of the Red Cross/Red Crescent Climate Centre, the International Research Institute for Climate and Society (IRI) investigated the factors contributing to drought conditions in Syria. A better understanding of Syrian climate could help better anticipate future weather to better inform strategic planning.

Rainfall and temperature in the region are influenced by decades-long variations in Atlantic Ocean temperatures. The El Niño Southern Oscillation in the Pacific Ocean has little effect in the region. Warmer temperatures in the Atlantic are associated with an enhanced chance of drought in much of the Middle East, including Syria, whereas lower ocean temperatures are associated with an enhanced chance of improved growing conditions. In 1995, the Atlantic switched from a cooler to a warmer phase, contributing to current drought conditions. Phases typically switch every 25 to 50 years. It is unknown when the next switch will occur, and although understanding is improving, there is currently

Syrian farmers are accustomed to drought. But do the trends indicate that they should plan for them more often? And what does this mean for humanitarian organizations?; Martin Talbot

no means of predicting drought conditions based on Atlantic Ocean temperatures.

The influence of Atlantic temperature does not fully explain Syria's recent drought, but the recent four years of drought are symptomatic of a decades-long drying trend. Based on the findings of the Intergovernmental Panel on Climate Change (IPCC), it seems likely that this trend will continue. Indeed, the panel's Fourth Assessment Report indicates that Syria is likely to experience more intense and more frequent drought events in the coming years.

Drought in Syria can therefore no longer be considered as an exceptional event. Drought should be managed using sound risk management principles, anticipating the effects of extended periods of below-average rainfall, and to lessen its impacts on productive economic activities, social well-being and the natural environment (El Hassani, 2002).

This information on long-term changes to Syria's climate prompted the Syrian Red Crescent to strengthen links with the national meteorological agency to help them better prepare for future climate-related events. As a result, they developed better mechanisms to access weather- and climate-related information and are working to incorporate this information into their own operations. The International Federation of Red Cross and Red Crescent Societies (IFRC) began to better integrate climate change and water-use considerations into their own wider disaster risk management preparations. At hygiene-promotion workshops for women, for instance, disaster risk managers included climate change in conversations about coping with drought. Disaster risk managers also looked to longer-term risk reduction strategies such as tree-planting campaigns.

While IPCC projections indicate that a strong climate change signal may result in more frequent drought conditions in Syria, it is not clear as yet how the cycle of Atlantic Ocean temperatures will moderate or enhance

Where is decadal climate variability in rainfall significant?

Figure B2 provides an at-a-glance indication of where the proportion of variability in rainfall explained at the decadal (ten-year) time scale is large, as compared to inter-annual and climate change signals. The map represents a seasonal composite of the highest proportions of variability attributable to decadal variability. The higher the explained proportion, the larger the influence of decadal processes as compared to inter-annual and climate change trends. Based on this information, disaster risk managers can decide whether or not decadal scales are worth monitoring. For instance, in places where there is a high proportion of decadal variance (i.e. greater than 20 percent), the signal could be considered strong enough for disaster risk managers to take into consideration when making strategic investments and planning decisions.

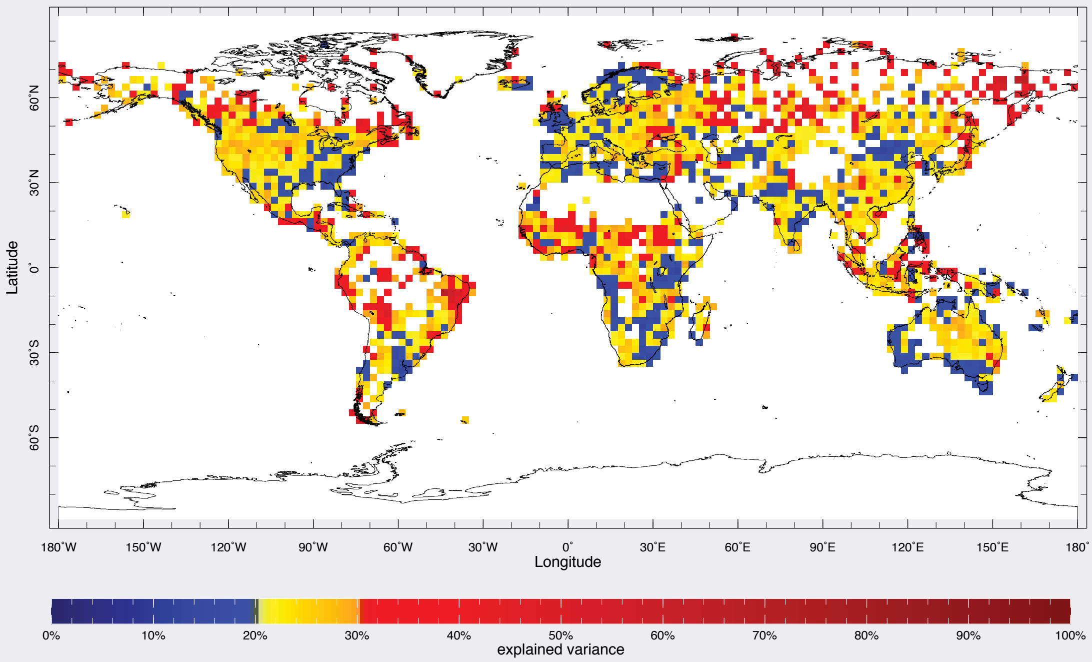


Figure B2: The global significance of decadal rainfall variability.

this trend. This investigation of the nature of climate variability observed in Syria underscores the importance of careful problem identification. Understanding the drivers of recent drought in the region gives disaster risk managers a better understanding of the implications for planning.

Climate science can provide disaster risk managers with information on trends to help them prepare for future impacts. This example illustrates how careful scientific analysis helped inform preparedness, though climate science is not always the limiting factor for disaster risk management.

Identifying risks and vulnerabilities in Haiti

After the recent earthquake in Haiti, concern that the impending rainfall and hurricane season may threaten a large and vulnerable population led to demand for information on climate and the potential for hurricanes, landslides, and floods. An initiative to gather information, make it understandable and easily accessible in a 'one-stop shop' website was undertaken. This one-stop shop helped disaster risk managers identify emerging climate-related risks and so take preparedness actions before events occurred. Through the UN Office for the Coordination of Humanitarian Affairs (OCHA), disaster risk managers were also able to make use of vulnerability data collected and presented by the Earth Institute Task Force on Reconstruction on Haiti. Creating a mechanism to help disaster risk managers quickly and easily identify the risks and vulnerability of Haiti's new reality helped them to prepare for and mitigate impending climate impacts.

The poorest country in the western hemisphere, Haiti suffered a 7.0-magnitude earthquake on 12 January 2010. It was the strongest earthquake to hit the country in 200 years, and a mere 35 seconds of shaking caused a disaster of almost unprecedented scale and complexity. Some three million people were affected, nearly a third of the population. At least 230,000 people lost their lives, and 300,000 more were injured. The earthquake crippled the capital and economic heart of the country, Port-au-Prince, destroying more than 60 percent of the housing. More than 1.3 million people took shelter in makeshift settlements in and around the city, and half a million more sought refuge with friends and family in other parts of the country. Damage and economic losses were estimated at US$7.9 billion, more than the country's entire GDP in 2009.

It was not the just power of the earthquake that killed so many people – chronic poverty and extreme vulnerability also played a role. Haiti was still recovering from the impact of four hurricanes that struck the country in a single 30-day period only 18 months earlier. Confronted with such strong forces of nature, the country's weak infrastructure crumbled and its deforested hillsides gave way, magnifying Haiti's pre-existing vulnerability. Shelters and camps for inter-

Victims of one disaster are much more vulnerable to climate-related hazards, as was the case after the 2010 earthquake in Haiti; Eric Holthaus

nally displaced people became vulnerable to thunderstorms, strong winds, landslides, the threat of hurricanes, and disease outbreaks. The destruction of social networks meant that people had fewer informal resources to draw on, and the collapse of government agencies meant that the authorities were extremely restricted in their ability to prepare for and respond to follow-on disasters. In this context, humanitarian organizations stepped in to help. Haitian and international organizations helped search-and-rescue teams identify survivors, establish shelters, and dispense food and medicine. They also began preparations for the rains.

Haiti's main rainy season and hurricane season coincide, and in 2010 the forecasts for both were near record highs. Operationally the two are linked, as preparing for one is preparing for both. The difference is that while individual storms during the rainy season are basically unpredictable – they can devastate any place at any time – hurricanes can be predicted days in advance. This gives humanitarian organizations more time to prepare for hurricane events.

In Haiti, hurricanes rarely cause much wind damage, as the country's rolling hills and mountains reduce the wind's effect. The biggest threat by far is extreme rainfall, and flooding kills more people in Haiti than nearly any other natural hazard, also causing devastating mudslides. So after forecasts for an active 2010 hurricane season were released, disaster risk managers began to worry about what would happen if a mudslide hit one of Haiti's many camps for internally displaced people.

Along with the main rainy season, forecasts for an active hurricane season brought the potential for more tragedy, with 1.5 million people living in camps as the season entered full swing in August and September. Before these efforts, there was very little formal use of weather and climate information in the country, with a staff of only three meteorologists in the Haitian Meteorological Service and most UN agencies (including camp managers) sourcing weather information from public Internet websites. Very few sufficiently large hurricane shelters were identified before the season began in June.

In its role as coordinator, the UN Office for the Coordination of Humanitarian Affairs (OCHA) worked to synchronize efforts and distribute information useful both to survivors and to humanitarian groups. As one of their biggest responsibilities, OCHA was particularly concerned with insulating relief efforts and the local population from the impending rainy season. One way they addressed this issue was to work with groups capable of characterizing Haiti's new vulnerabilities. The Earth Institute Task Force on the Reconstruction of Haiti provided technical advice to the UN team in Haiti in the days immediately following the earthquake, gathering satellite images, highlighting vulnerability hotspots and assessing landslide risks. This information helped inform day-to-day operations and whether camps were at risk.

The team at OCHA also sought out information on the outlook for Haiti's rainy season, approaching in March. They wanted disaster risk managers to have ready access to forecast information, particularly for rainfall and hurricanes. OCHA sought help from the Red Cross/Red Crescent Climate Centre and from IRI, who also involved the National Oceanic and Atmospheric Administration (NOAA), the World Meteorological Organization (WMO), the Red Cross/Red Crescent Climate Centre, the Caribbean Institute for Meteorology and Hydrology (CIMH), the Center for International Earth Science Information Network (CIESIN), the Caribbean Catastrophe Risk Insurance Facility (CCRIF), and Risk Managers to the Caribbean (CaribRM).

The group worked together to sort through available information and determine which sources were credible and useful. They created a website (http://iri.columbia.edu/haiti/), which included only the information most relevant for disaster risk planning and management (see Figure 5), filtering out overly technical products and providing explanatory text when needed.

The ultimate goal was to provide a 'one-stop shop' of information to help disaster risk managers monitor forecasts and changing risks without having to spend hours sorting through less relevant information. Ideally, disaster risk managers monitor different

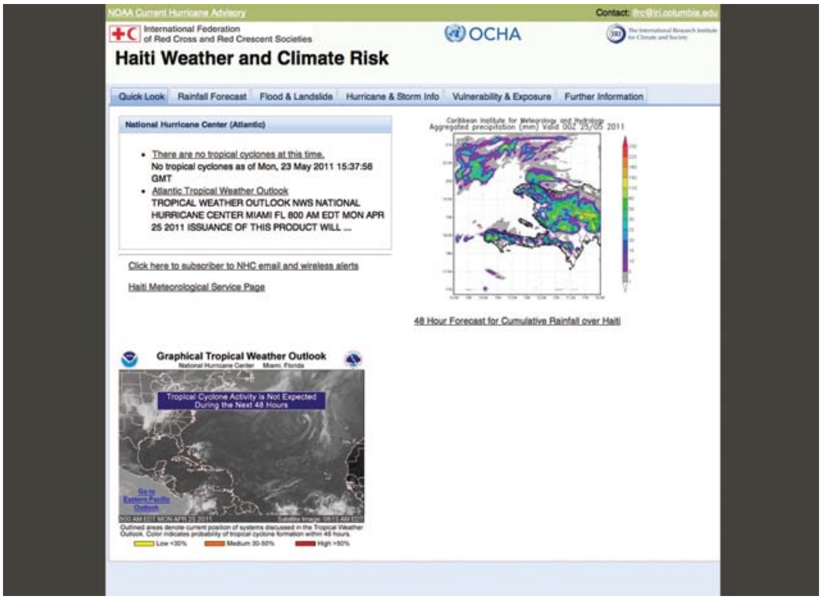


Figure 5: The Haiti Map Room, developed with a range of partners.

sources of information, piecing together conflicting forecasts of varying credibility, but in the midst of Haiti's unique disaster, time and technical constraints made this impossible. The main role of disaster risk managers is to estimate the related impact and damage in the given location. In the run up to and during the rainy season, the site was used internally by OCHA and more widely by IFRC, to prioritize actions such as the prepositioning of supplies.

This website included information on both present and future conditions. Forecasts gave disaster risk managers early warning and allowed them to take preparatory measures including updating contingency plans. As individual storms approached, disaster risk managers were able to use the site to shift their attention from seasonal forecasts to weather forecasts. With maximum lead-time, this allowed them to anticipate the location, severity, and timing of extreme weather events.

Once the forecast for above-normal rainfall in Haiti's April-to-June rainy season was issued, preparations began. In hundreds of camps, cash-for-work programs built drainage ditches to divert water away from tents. Extra supplies – tarps, tents, food, and water – were prepositioned throughout the country. Many of these activities then began to happen independently, as the rainy season grew closer and the above-normal forecast became common knowledge.

In the end, however, the rainy season turned out to be slightly below normal. Still, sporadic storms occurred and large areas of the capital reported flooding after rain showers lasting only 15 minutes, worsened by poor drainage and rubble piles throughout the city. Advanced preparations proved useful. Prepositioned supplies not used to mitigate storm impacts were used in earthquake relief or for the upcoming hurricane season. The deployment of extra staff and the training of volunteers also proved invaluable once the hurricane season began. Disaster risk managers began to change their focus from protecting camps from rainstorms to using what they had learned in the rainy season to help the country better survive the hurricane season.

As the hurricane season approached, many organizations became increasingly worried about the potential for further devastation. Slow progress in rebuilding facilities and institutional capacity meant that significant risks remained. Flooding was the primary risk especially in and around Port-au-Prince. The earthquake had severely reduced effective drainage throughout the city, public spaces had become temporary shelters, and evacuation plans – if they existed at all – were far from adequate.

OCHA again turned to their partners for assistance, and helped coordinate discussions between the government and the humanitarian response, led by the UN. As the season approached, OCHA focused this effort on redirecting, prioritizing, and supporting the government's own initiatives, largely through the Haitian Department of Civil Protection with responsibility for disaster preparedness, coordination and response.

Engineers from Haiti's Ministry of Public Works did a remarkable job immediately following the earthquake – for example, by color coding every building in Port-au-Prince according to its structural integrity (green/yellow/red). OCHA determined that more than 100 shelters were ready for the hurricane season, with a total capacity of about 6,000 people. However, in a city with 1.5 million homeless people, this was clearly not enough to house even the most vulnerable people in need of shelter from a hurricane, even overnight. Meetings were immediately organized to address this problem, and a plan for constructing 'temporary shelters' began.

OCHA also instituted a mitigation task force that supported the International Organization for Migration (IOM), the Haitian Red Cross (HRC), and others, as they designed an innovative SMS-based warning system called the 'Noula platform' to provide information based on weather forecasts for those living in displacement camps in advance of the hurricane season. The system was able to quickly and efficiently warn the public in specific parts of the country about flooding risks by targeting selected mobile telephone towers with text messages, and preparedness messages were distributed in the local Creole language as well as French. Through a partnership with Voila – one of Haiti's largest service providers – the system also allowed the general public to call a short code (177) for more information, or to report an emergency situation. Additional partnerships with Haitian radio stations quickly spread further critical information.

Humanitarian actors, most of which had no formal meteorological training, were also supported through OCHA. In addition to the official Haitian Meteorological Service short-term weather forecasts, the task force also recruited IRI to contribute 'plain English' descriptive text to accompany the official information – allowing those working for humanitarian organizations to quickly interpret and make even better use of complex weather information in times of crisis. Regular email updates by trained meteorologists were circulated during hurricane watches and warnings, with a question-and-answer capability for those needing more precise decision support for preparedness activities.

A near-miss by Hurricane Earl at the end of August solidified a mindset of preparedness in Haiti. When Hurricane Tomas arrived, Haiti was as prepared as it could be, given the still-fragile post-earthquake environment. Despite never officially making landfall, the Category 1 storm brought days of heavy rain to the southern peninsula, though no major flooding was experienced in the earthquake zone as a result. The primary impact was an increase in standing water, worsening the ongoing cholera epidemic. The IFRC used the SMS-based warning system to coordinate with the government. They alerted populations, and moved emergency supplies ahead of time to Les Cayes near where Tomas was expected to strike, helping to limit the loss of life.

Intermediate-term solutions over the next few years should focus on building national capacity to produce and use weather and climate information, and to use this to prioritize transitional shelters before permanent housing is rebuilt. The ultimate goal of 'forecast-based decisions' is to encourage a culture of preparedness in a country with a history of vulnerability and poor disaster response.

There were challenges associated with the use of the website described above. It was revised in June, based on feedback from disaster risk managers in Haiti and those within OCHA. Disaster risk managers requested more localized and timelier information; which were met by providing access to locally downscaled coarse-resolution forecasts and by supplying more frequent updates throughout the season. Also, despite efforts to ensure that the language on the original website was non-technical, disaster risk managers still found the information and the list of potential responses needed to be further simplified.

After revision and as the hurricane season approached, the website was used frequently by key decision makers in OCHA and in government departments. It was widely publicized within IFRC via its internal intranet, after an in-person IRI demonstration. The webpage now works across forecast timescales for different risks, including 48 hours for floods, 5 days for hurricanes, 14 days for rainfall, seasonal outlooks, and long-term risk mapping, to better capture the suite of risks that Haiti faces from weather and climate disasters.

However, use of the website revealed that bypassing the existing national government risk structure – which seemed to be a necessity in the days after the earthquake – marginalized the ability of the government to play a leading role. In the months after the initial disaster, UNDP and WMO had already begun to build capacity within the National Meteorological Service, which will eventually host the website, and the Ministry of Agriculture, to provide climate services and manage climate risks.

In practice there remains a huge gap in accessing, understanding, and acting on climate information in Haiti, including at the shorter timescale, especially at the 'pre-emergency/early warning' stage such as flash-flood forecasting during the rainy season and hurricane preparedness, etc. OCHA could consolidate 'best practice' climate information and supply it in such a one-stop shop as the website, until the National Meteorological Service has the capacity to fulfill this role. Unfortunately, there has been little initiative for such in the post-earthquake environment. Actions based on this information six months after the earthquake are still mostly reactionary, i.e. relocating a camp after it has already been flooded, and only most recently is a focus on preparedness emerging.

Climate information was used to motivate demands for additional supplies from the international community. One NGO even established a 'Beat the Rains' fundraising campaign. (http://jphro.org/). Unfortunately, even with the additional priority from knowing that an above-normal rainy season was looming, institutional, governmental, financial and logistical constraints restricted effective action taking place.

Gaps in preparing for the rainy season, both in plan and in practice, motivated steps to address similar issues in preparing for hurricane season. OCHA organized and managed preparedness efforts by consensus through the Mitigation Task Force, fully involving government departments and the humanitarian community. Additionally, the World Food Programme as the leader of the Logistics Cluster in Haiti conducted extra staff training.

The climate information one-stop shop website was one tool that did help, developed after a problem had been identified. Created from a partnership between users and providers of climate information, it provided information in a form helpful to disaster risk managers that helped save lives and reduce suffering. Nonetheless, problems and significant challenges still remain, particularly related to improving national capacity.

Monitoring climate and weather changes in the Asia-Pacific region

There are a disproportionate number of weather-related disaster impacts in the Asia-Pacific Region. The Disaster Management Unit (DMU) of the IFRC Asia Pacific Zone office, in partnership with IRI, developed a prototype-monitoring framework to help staff to identify months in advance areas at higher risk of climate-related hazards. As a result, the DMU staff has a better sense of which areas require continued climate and weather monitoring as the season progresses and to alert the national Red Cross or Red Crescent to changing risks. This information can help staff determine where and whether to provide supplementary support for preparedness activities, including replenishing stocks, mobilizing staff, and conducting refresher trainings.

The Asia-Pacific region is exposed to a wide variety of hazards, including earthquakes, tropical cyclones, floods, droughts, heat waves and cold periods, volcanoes, and forest fires. Weather- and climate-related disasters take a particular toll on the region. Between 2000 and 2010, such events accounted for almost 70 percent of disasters reported in the region (CRED, 2011). Between 1999 and 2009, they accounted for 85 percent of all people impacted by disasters, and 79 percent of global disaster-related fatalities (IFRC, 2009). These high numbers are partially attributable to the region's large population and high population densities, but high poverty rates also play a role.

The region has responded to this vulnerability by taking significant steps to mitigate the effects of climate-related impacts: Since

Advanced warning of flooding gives people time to stock up on essential food and water, and allows humanitarian organizations the opportunity to preposition relief aid; Alex Wynter/IFRC signing the Hyogo Framework of Action in 2005, Asian governments have held three Ministerial Conferences on Disaster Risk Reduction (AMCDRR, 2005; 2007; 2008). Both the Asia-Pacific Economic Cooperation and the UN Economic and Social Commission for Asia and the Pacific have also recently created avenues for regional cooperation on disaster risk reduction (APEC, 2008). These efforts increased development of early warning systems allowing governments and disaster risk management agencies to warn and mobilize at-risk communities before disasters strike. For example, the Mekong River Commission provided a multinational framework to provide localized flood forecasts as well as a Flash Flood Guidance System in Cambodia, Lao PDR, Thailand and Viet Nam.

Eager to make more systematic use of available climate information to improve local early warning systems, the DMU of the IFRC Asia Pacific Zone office developed a monitoring framework to help them quickly analyze changing risk scenarios. It was designed to streamline the use of climate information and help disaster risk managers focus on information most useful to them in different places and at different points in time.

To develop the framework, the DMU, the Red Cross/Red Crescent Climate Centre and IRI identified, consolidated, and organized the climate information resources most relevant for disaster risk management activities in the region. The result was a systematic matrix to help DMU staff strategically navigate through the range of climate information they receive at various geographic and temporal scales in order to identify and monitor changing risks (see Table 1).

Disaster risk managers at the Asia-Pacific DMU first consult a range of baseline information to provide the context for seasonal forecasts and assess areas at risk. This includes El Niño (or ENSO – El Niño Southern Oscillation) events, which exert a powerful influence on the Asia-Pacific region. Impacts typically associated with this include floods, droughts and tropical cyclones. The second layer of information includes specific ENSO forecasts, available up to nine months in advance, giving disaster risk managers a rough indication of future conditions. For instance, El Niño events are associated with late-onset and below-normal rainfall during Indonesia's November-to-March rainy season. La Niña in contrast, generally brings an early onset to the rains and particularly heavy rainfall from December to February. Disaster risk managers are then better informed when they review contingency plans, check stock inventories, and more closely monitor shorter-term forecasts for more specific warnings.

Three to six months in advance, the third level of information including seasonal rainfall and cyclone forecasts, help disaster risk managers to understand the conditions to expect over the coming season. Based on these forecasts, disaster risk managers become aware of risks of drought, storms or floods, and

Table 1. A climate monitoring framework, developed for the IFRC's Asia-Pacific Zone Disaster Management Unit.

Layer	Information provided	Potential action
Baseline information	e.g. for typical La Niña impacts – "La Niña is associated with higher than average rainfall in Indonesia from December through February."	• Monitor ENSO forecasts. • Crosscheck with other baseline information, such as vulnerability indicators.
ENSO forecasts	e.g. for IRI probabilistic ENSO forecasts – "There is a more than 70 percent chance of La Niña conditions through to the end of February 2011."	• Communicate with the Indonesia Red Crescent (PMI) regarding enhanced risk of above normal rainfall. • Prepare guidance for contingency planning inputs that could be provided by the Indonesian meteorological services. • Check inventory of available regional stocks.
Seasonal forecasts	e.g. for IRI probabilistic ENSO forecasts – "There is a more than 70 percent chance of La Niña conditions through to the end of February 2011."	• Consult relevant climate information providers. • Provide support as necessary to the Indonesian Red Crescent (PMI) to update flood contingency plan. • Assist with volunteer training, simulation exercises and community sensitization. • Mobilize regional disaster response support staff. • Refresh or increase regional stocks as necessary.
Sub-seasonal and real-time forecasts	e.g. for the Indonesian Meteorological and Geophysical Agency's three-day forecast – "There is an 80 percent chance of extremely heavy, sustained rainfall over the next two days."	• Evacuate vulnerable communities. • Mobilize impact assessment teams.

can make plans for how their organizations will respond. In the context of other baseline information, this information may prompt them to take actions including the updating of contingency plans, training of volunteers, or the prepositioning of stocks.

The final layer of information comprises weather and hazard-monitoring information, and the vast majority of information currently used by disaster risk managers falls into this category. This is useful in helping them assess flood- and cyclone-related risks but as it is available mostly at the national and local level, regional disaster risk managers find it time-consuming to monitor. With the monitoring framework, the Asia-Pacific DMU uses the first three layers of information to target potential problems areas. Once these hotspots are identified, disaster risk managers can use short-term information to anticipate potential disasters.

This monitoring framework allows the tracking of changing risks. For example, a forecast indicating the high probability of a La Niña event and knowledge of its general impacts might lead to concerns about flooding in parts of the Philippines. This would prompt the Asia-Pacific DMU to more actively review contingency plans and to monitor local weather more closely.

If the seasonal forecast then also predicts above-normal rainfall, the regional DMU could alert the national Red Cross or Red Crescent, who would then review their own preparedness planning and – in the case of high risks and low capacities – suggest appropriate actions to take in advance. This may include the prepositioning of supplies, training additional volunteers, or in some cases, an early appeal for funding. The national Red Cross or Red Crescent may also liaise with the meteorological office, and possibly pass some of the information on to the branch and/or community level. This would create a wider circle of people more aware of the need to follow weather forecasts, and if heavy storms were predicted, the entire community would be better prepared.

Several challenges to implementing the framework have been identified, however. The first two are associated with a need to combine various kinds of information on exposure and vulnerability to assess potential impact, and the range of types of weather and climate information available. It may be conceptually convenient to group climate information according to spatial and temporal scales, but different forecasts do not always fit together cleanly. Seasonal forecasts may be issued by different agencies, at varying lead-times, for different seasons, or on different geographic scales. Reviewing this varied information at the same time can create informational gaps and overlaps and confuse disaster risk managers. There are also challenges associated with deciding what information resources should be used. There are more than 20 tropical-cyclone forecasting resources in the region, and given this wide array, it is hard for the Asia-Pacific DMU to decide which is best suited to their needs, further complicated when overlapping forecasts do not agree.

There are ongoing obstacles to taking action even when information is clearly presented and disaster managers have a good understanding of forecasts at different time scales. For instance, users are sometimes uncertain as to how likely an outcome must be before they should take action. Regarding 'trigger' thresholds for initiating preparedness activities based on seasonal climate forecasts, DMU staff preferred to have relatively high probabilities before taking action, such as a 65 percent chance of above-normal rainfall. For other decisions such as closer monitoring, the threshold can be set much lower. However, a forecast probability of 65 percent is rare. Of all the seasonal rainfall forecasts produced by

IRI for the Asia Pacific region since 2002, probabilities above 50 percent have been reported only five times.

In many places, forecasts above 50 percent are even less frequent. In some cases this reflects forecasting skill – which varies

Mapping seasonal forecast skill

Disaster risk managers have frequently complained that climate information is difficult to use. Forecasts are often provided in technical probabilistic terms or by way of abstruse color-coded maps. Disaster risk managers also frequently take issue with the timing of forecasts, which do not always provide them with the lead-time they would like for preparedness or prevention. In some cases, the forecasted information is itself not useful. In these cases, disaster risk managers who want to know whether or not their region will experience flooding are forced to settle for a shift in the odds regarding overall seasonal rainfall.

One way to address these issues is to simplify the information and its presentation. This involves identifying the questions most important to users, removing unnecessary information, and indicating suggested actions. The example of global skill maps illustrates how good presentation can make climate information easier to use.

Skill maps provide a quick indication of where seasonal forecasts can be used for early warning. While forecast skill should be incorporated into the forecast itself – that is, a higher shift in the odds should represent a greater level of skill – Figure B3 based on IRI's forecasts since 1997, indicates areas where seasonal forecasts may rarely ('little or no skill'), sometimes ('some skill'), or often ('good skill') provide useful information about rainfall for the next three months. Based on this information, disaster risk managers can decide whether or not seasonal forecasts are worth monitoring. For instance, in places where there is little to no skill, any shift in the probabilities is likely to be small and early warning opportunities will thus be very limited.

Precipitation forecast skill: best of all seasons

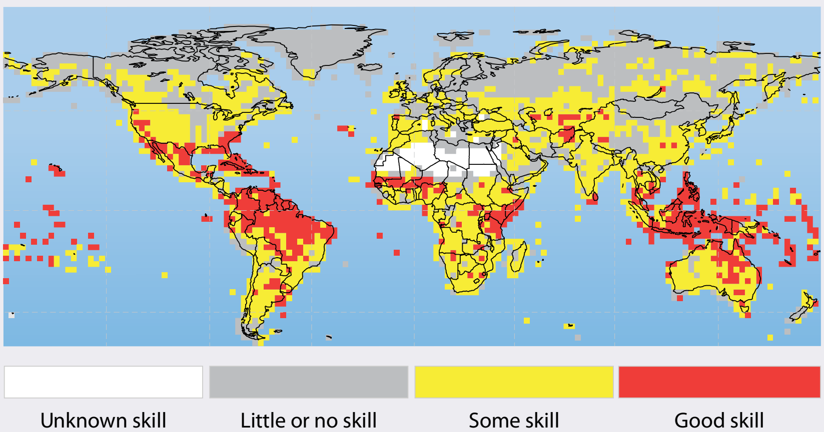


Figure B3: Skill map indicating areas where rainfall can be predicted with little or no skill, some skill and good seasonal rainfall forecasting skill (composite of all seasons).

depending on our understanding of the factors that contribute to local climate in particular areas. Recognizing this, IRI developed a 'predictability' map in collaboration with the Red Cross/Red Crescent Climate Centre. This map highlights regions that are more likely than others to receive high confidence forecasts. Seasonal forecasts innately reflect the level of skill via shifts in probability, and the higher the probability, the higher the skill for that location and time of year. So, these maps are not a direct indication of skill, they indicate where strong forecast 'signals' (i.e. large probabilities) are more likely to occur on a more frequent basis. The map is thus an initial filter, helping to determine where to initiate humanitarian action based on climate forecasts.

A final challenge stems from the presentation of the information. In the same way that the vast quantity and varying kind of information in the monitoring framework makes it difficult for disaster risk managers to use, those trying to present information, for example, on tropical cyclone seasonality, rainfall seasonality, and ENSO impacts, are also challenged to make the information easily understood and actionable. To overcome this, the Asia-Pacific DMU is working with design specialists to identify the best ways to present the layers of information to disaster risk managers.

Though there are challenges associated with both the use and further development of the Asia-Pacific DMU monitoring framework, successes to date show an improved understanding of the nature of the risks facing the region. The framework will increase the efficiency of their efforts – saving precious time and protecting lives and livelihoods. Armed with this framework, disaster risk managers are now better equipped to respond quickly and appropriately to climate-related events and, hopefully, minimize the losses associated with them.

Incorporating climate information into user-led processes in Kenya

An innovative, well-planned and well-managed steering group led by the food security community in Kenya has been successful in integrating climate information into processes that mitigate food insecurity. As seen during the drought of 2008 and 2009, this approach engages a wide range of decision makers and experts in interagency collaboration, which is key to the effective application of early warning information and timely action. Although challenges remain, this decision-making process shows itself to be flexible enough to incorporate climate information at different levels and timescales, and to meet the needs of various user groups.

When a user community seeks to incorporate climate services into their planning processes, and actively works with the meteorology community to do so, climate information can provide an essential contribution to disaster risk management. A good example of this kind of cooperation is from Kenya, where interagency collaboration has facilitated improved access to, understanding and use of climate information in the food security sector.

Over 95 percent of Kenya's cropland depends on rainfall (FAO, 2011). A failed season has significant and widespread impacts especially in marginal arid and semi-arid areas of the country where the most food insecure people live. National systems for responding to climate risks have been developed, but they require time to put into operation, especially to manage a large-scale drought such as that in 2005–06 which affected over a million people. The sooner that mitigation of and response to an impending drought or flood can begin the more effective the actions can be in terms of saving lives and livelihoods and protecting household assets (Broad and Agrawala, 2000; Haile, 2005).

In Kenya, a network of organizations led by the Government of Kenya and the World Food Programme (WFP), work together to facilitate climate-informed food security efforts under the auspices of the Kenya Food Security Meeting (KFSM). This is the nation's main food-security forum where government ministries, UN agencies, the Kenya Meteorological Department (KMD), NGOs and donors meet monthly to exchange information, debate options, and formulate

Dryland farming is hard work, and a risky business. When enhanced rainfall or drought are more likely, seasonal forecasts can help both farmers and humanitarian organizations to prepare; Curt Carnemark/World Bank interventions. The meeting is advised by the Kenya Food Security Steering Group (KFSSG), a core of participants including the WFP, the Food and Agriculture Organization of the United Nations (FAO), the Famine Early Warning Systems Network (FEWS NET) and the government, that act as a technical think-tank on drought management and food security issues.

This government-led framework creates active partnerships, linking the climate and food security communities through a unified approach to addressing drought and food security (Akilulu and Wekesa, 2001). It is more transparent and efficient than earlier emergency response efforts having several parallel structures.

Early in 2009, reduced food security resulted from three consecutive poor rainy seasons, and the situation risked slipping into a humanitarian crisis. In February, the Steering Group members led a multi-agency assessment to evaluate conditions and guide intervention strategies. This regular biannual process helps food security experts gather data from a range of sources and characterize the food security situation, and account for early warning information (e.g. seasonal forecasts) and trends. These processes also help to estimate how food insecurity may progress over the following six months, and interventions and refinement of ongoing programs are proposed.

During the 2009 assessment, FEWS NET provided early warning information indicating that the current drought was likely to continue through to the next rainy season. FEWS NET is a USAID-funded activity that collaborates with international, regional and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. FEWS NET professionals monitor and analyze relevant data and information in terms of its impacts on livelihoods and markets, to identify potential threats to food security, working closely with partners such as WFP's Vulnerability Assessment and Mapping team in Kenya.

The assessment revealed that as a consequence of consecutive seasons of drought, food reserves and savings had been depleted, eroding the ability of households to meet basic food needs. In addition, a number of factors – including high food and commodity prices (80–120 percent above normal), increased incidence of animal diseases, and resource-based conflicts – converged to exacerbate food insecurity in many areas. An estimated 2.5 million drought-affected people, including 850,000 children, were expected to be highly food insecure during the 2009 April-to-September season (KFSSG, 2009).

In response to the deteriorating conditions, the assessment report proposed a wide range of recommendations, from improved rainwater harvesting to additional training for nutritionists to better manage acute malnutrition. Advanced preparation of WFP's Protracted Relief and Recovery Operation was also encouraged – a planned emergency operation expected to expand coverage of humanitarian food aid starting in May. By initiating fundraising activities early in the season, the WFP could access and stock necessary resources prior to the rollout of the program, allowing timelier implementation of assistance.

In early March, a Climate Outlook Forum for the Greater Horn of Africa region was held to integrate national, regional and international climate predictions into one consensus rainfall forecast for the upcoming season. The resulting forecast indicated an increased likelihood of below-normal rainfall in March, April, and May over much of the region including most of Kenya (KFSSG, 2009).

FEWS NET is the primary link between this Forum and Kenya's food security institutions, translating and disseminating the consensus forecast for easier application, and also representing the food security sector at the conference. The Steering Group works with FEWS NET to use these seasonal rainfall forecasts along with other monitoring data to create food security outlooks that better inform decision-making (see also Chapter 2). However, in 2009, these outlooks were delayed until April due to the already ongoing crisis in the region.

Immediately following the Forum, the Kenya Meteorological Department issued a national-level forecast developed specifically for Kenya. Forecasts at this level are a valuable addition to regional forecasts because they better capture small-scale features including topography, which affect local climate. The national forecast was also tailored to the food security community as it provided potential sector-specific impacts, as well as forecasts for onset and cessation periods by location. This forecast indicated that most of the country was likely to experience below-average rainfall, except in the extreme west and some coastal regions. The rainfall was predicted to start in mid-March, first in western Kenya before progressing eastward as the season continued. As the meteorological department participates in the Steering Group, a channel for rapid dissemination already existed. Information was immediately communicated through an open consultative forum, and bulletins were emailed to Steering Group members and posted online.

Although the timing of the regional and national forecasts prevented them from being integrated into the February assessment process, they were incorporated into the Steering Group's monthly updates and biannual outlook. These bulletins were used to prioritize areas for additional monitoring and possible intervention. This process for continuously incorporating new information into food security analyses allows for updates in planning and response to be made throughout the season.

When the Steering Group issued their monthly update in April 2009, observed rainfall data were used to highlight the delayed onset of the long rains in the southeast, and the need for continued monitoring of seasonal progress. Given the length of time before the next major harvest, if the long rains were to continue to fail, recommendations were proposed to mitigate food insecurity. These initiatives included increased general food distribution, livestock off-take, and supplementary feeding for children under the age of five.

Later in the month, the Steering Group issued a food security outlook, using monitored and forecasted climate information to develop the most likely food security scenarios for April to June and June to September. Despite the bad start to the rainy season, and the fact that the season was forecasted to be below normal, the outlook indicated that planned emergency operations would prevent further deterioration of the food security situation. Specifically, the WFP's Protracted Relief and Recovery Operation which had been in planning stages throughout the early part of 2009, was expected to increase humanitarian aid coverage to meet the projected needs.

The food security assessment report, updates and outlook by the Steering Group encouraged the pre-positioning of food even before WFP's new program was officially underway. In April, WFP working with UNICEF and Kenya's Ministry of Public Health Services, delivered food to health facilities in drought-affected regions where delayed onset of the long rains had been observed and undertook training for the implementation of supplementary feeding programs for children under five and for pregnant and nursing mothers. This preparation helped lay the foundation for effective scaling-up of supplementary feeding programs in areas projected to face increased food insecurity due to potential drought conditions.

By the end of May, it was clear that seasonal rainfall was indeed below average (see Figure 6), and the upcoming harvest was expected to be poor. To mitigate food insecurity, humanitarian organizations continued to roll out interventions that had been planned and reviewed earlier in the year by members of the Steering Group. In this way, climate information helped Kenya's food security institutions improve planning and timely response during this evolving food security crisis.

Throughout the 2009 rainy season, it is important to note how a variety of climate information was used for early warning. The seasonal forecasts combined with on-going food security assessment and monitoring provided the first wave of early warning information, helping to set the initial scope of intervention programs and response. Once the rains began, seasonal monitoring data provided a second wave, and combining these allowed for continuous revision of the initial assessment based on what actually occurred on the ground.

This case study demonstrates how the collaborative food security framework in Kenya enables various sectors to work together

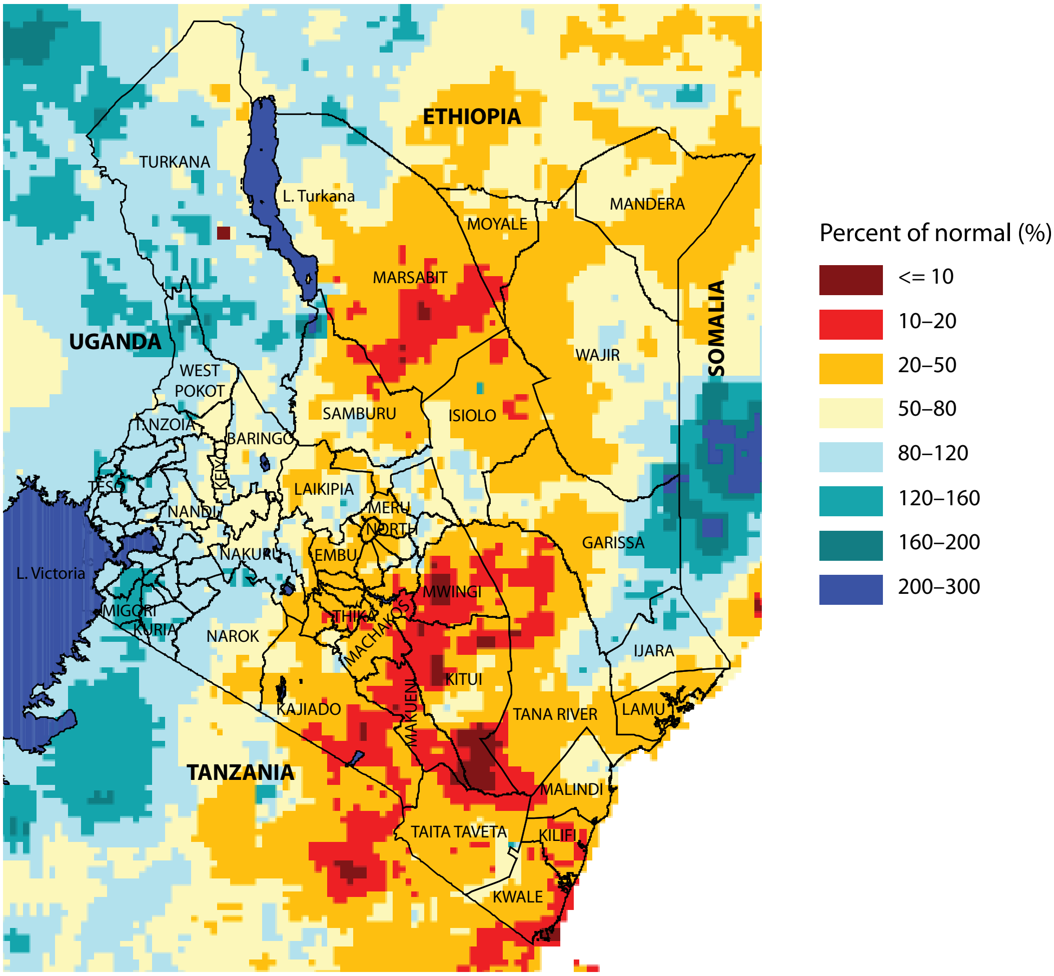


Figure 6: Rainfall anomalies in Kenya from 11 March to 31 May 2009. Notice below normal conditions in most of the country especially the south-east, in line with what was forecasted (FEWS NET-USGS).

continuously and gather and disseminate information as well as revise and improve intervention strategies. It is also important to note that this user-led structure incorporates climate information that is specifically targeted to facilitate decision-making in the food security sector. Assessments, updates and outlooks are all tools through which climate information is presented in a user-friendly format, tying it to implications for food security (see also Chapter 2).

The inter-agency efforts of the Steering Group play a key role. Food security actors such as WFP highlight the context in which the food security community operates, so that information providers can better address their needs. The Steering Group works with partners such as FEWS NET and the Kenya Meteorology Department to determine the best ways to integrate and apply climate information. As cooperation is critical to meeting the food-related needs of millions of people across the country, only by incorporating climate information into this kind of network is it made truly useful.

In the coming years, this ongoing collaboration will remain critical as a strong user-led food security process continues to develop, designed to access and use relevant climate information. Moving forward, it will be important to address two primary challenges in applying seasonal forecasts in Kenya's food security sector, the first being dealing with the uncertainty of the seasonal forecasts, and the second ensuring suitable timelines of forecast availability and need for action.

Uncertainty in climate information limits the ability of disaster risk managers to take preventative action to reduce the impacts of climate hazards. The Steering Group uses probabilistic seasonal forecasts to prepare for action, while monitoring the situation further to determine if a real hazard emerges. However, the forecasts are rarely used for mitigation approaches prior to the onset of the rainy season. For example, in Kenya, while forecasts allow for prepositioning of stocks, food security decision makers feel that they do not provide a concrete foundation for making decision about scaling-up provision of drought tolerant seeds. Continuous collaboration between the food security and climate communities can help facilitate the earlier application of climate information for mitigation actions.

In addition, the decision-making timeline for the food security sector also does not always align well with the output of early warning information from the climate community. The consistent provision of seasonal climate forecasts as input into the annual short and long rains assessments in Kenya would improve the food security planning and response process in the country. It is important for these stakeholders to work together to negotiate and reconcile the need for information with availability.

The first step in addressing these challenges is the continued collaboration between humanitarian and climate communities, and a better recognition of the general timeline for decision-making, in both sectors. Nonetheless, this example provides a model of how to effectively integrate climate information into processes designed to mitigate the food security impacts of drought.

Collaborating for effective malaria control in southern Africa

A range of constraints make it difficult for climate scientists to provide climate information in the precise form and/or at the exact time that disaster risk managers would like. This case highlights this problem, and an example of an instance in which the timing of the release of seasonal climate forecasts was modified to meet the needs of health practitioners concerned with managing malaria epidemics. Evidence suggests that it has substantially improved preparedness and timely response of national control programs.

Some 300–500 million people are infected with malaria each year and two million die, with more than 80 percent of deaths occurring in sub-Saharan Africa (WHO, 2003). Given malaria's heavy toll, its effective prevention and control have become a key element of global, regional and national disease-control policies. Although endemic malaria is the major burden globally particularly for children under five years old and pregnant women, epidemic malaria is also a significant problem. Importantly and rarely appreciated, endemic and epidemic malaria need different approaches to their control and prevention. Endemic malaria needs ongoing routine measures, whereas control of epidemic malaria relies on measures being applied in the right place at the right time.

Epidemic areas are often found on the margins of endemic areas where conditions are normally not favorable and malaria seldom

Climate information is important for predicting and preparing for malaria epidemics, as well as floods and droughts – but understanding the information needs of health professionals is essential; US Army Africa occurs. However, from time to time conditions change briefly and a malaria epidemic threatens. The changes typically involve higher-than-normal rainfall in desert fringes where it is normally too dry for malaria, and higher-than-normal temperatures in highland fringes where it is normally too cool for the mosquitoes that carry malaria to thrive. People in epidemic areas have little immunity and all age groups are vulnerable to severe disease outcomes, so when an epidemic occurs health services are easily overwhelmed (Worrall *et al*., 2004).

The threat of malaria epidemics makes it important to have a system that allows public health practitioners to forecast where and when malaria epidemics may occur. Temperature, rainfall and humidity are considered risk factors for transmission. Given the limited resources in many tropical and sub-tropical countries for detecting and controlling malaria outbreaks, mapping areas of climatic suitability and vulnerable populations can help targeting and preparedness. Also, as global temperatures rise and rainfall patterns change, fears are raised that conditions for malaria outbreaks may occur in locations that have normally been considered malaria-free.

Malaria early warning systems involve a number of cumulative indicators being used to plan, prepare and trigger a range of prevention and control measures in a timely manner. Vulnerability monitoring and assessment may include measures of drug and insecticide resistance, co-infection with other diseases, and movement of non-immunes into endemic areas or parasite carriers into non-endemic areas. Seasonal climate forecasts have shown advance lead-times of five months in southern Africa, whereas environmental monitoring of rainfall, temperature, humidity, vegetation condition and flooding allows more geographical focus, but lead times are shorter, often only one or two months. Sentinel case surveillance is then used to confirm when an epidemic is imminent or in its early stages, and each of these triggers pre-determined response measures.

The seasonal forecast lead-time allows responders to acquire and distribute the resources needed to effectively manage an epidemic. The Malaria Early Warning System (MEWS) in southern Africa initially sourced climate information from the Southern Africa Regional Climate Outlook Forum (SARCOF), before the demand for information more tailored to the malaria control community led to the establishment of a annual Malaria Outlook Forum (MALOF) (DaSilva *et al*., 2004).

The first SARCOF was held in late September 1997, its timing set by the meteorological community to occur immediately prior to the onset of the rainy season in parts of the region. In subsequent years, however, it was held in August or early September at the latest, in response to requests from the agricultural community to provide the earliest warning possible about the coming rains. Even though the skill of the early forecasts is low at this time, the agricultural community prefers to be updated later and adjust plans accordingly.

For some decision makers such as the malaria control community, however, higher skill levels are preferred at the cost of a shorter advanced notice, partly because of the inherent time lag between the rainy season and the malaria season, which provides some advanced notice even in the absence of forecasts. As a result, WHO, the Drought Monitoring Center of the Southern Africa Development Community (SADC) and IRI have worked with the World Meteorological Organization and with ministries of health and national meteorological and hydrological services in southern Africa to conduct the pre-season Malaria Outlook Forum (MALOF) since 2004.

The forum demonstrated an opportunity for national malaria control services across southern Africa to gather and review the regional climate forecasts, examine vulnerability factors, map areas at risk, and based on these, develop action plans for epidemic preparedness over the coming season. Held in November, the forum occurred at the optimal time for maximizing seasonal forecast skill in the region and thus complemented the malaria planning-process much better than the earlier forecasts from SARCOF. In this way, the malaria control services worked with the scientific and climate communities to produce and access climate information in a timeframe and with the skill level most useful to them.

Facilitating mutual understanding in the Pacific Islands

Lack of interchange between different groups is overcome when communities understand the perspectives of the others. Since climate scientists and humanitarian actors come from such different backgrounds, capacity building and iterative engagement help build trust and lead to effective climate-related interventions, as happened with Red Cross-led initiatives in the Pacific Islands. This example explores the implications of changing climate risks with local communities by using seasonal calendars, allowing them to assess for themselves the risks they face, now and in the future.

The Pacific Islands comprise 26 independent states and territories spread across 30 million square kilometers of ocean, and that are vulnerable to a range of hydrological and meteorological hazards including tropical storms, flooding, drought, storm surges, and tsunamis. Despite uncertainties regarding the precise nature of the impacts that climate change might have on the Pacific Islands, IPCC research indicates the region can expect an increase in the number of extreme weather events (Parry *et al.*, 2007). It is likely that climate change will manifest itself in the Pacific Islands both in longer-term trends such as sea-level rise and changes to the seasonality, frequency and intensity of weather-related disasters (Parry *et al.*, 2007).

Given the humanitarian implications of climate change, the regional office of the IFRC started to support the national Red

Cross societies to assess the changing risks, and integrate that information in their efforts to support the decision-making processes of local communities. The challenge is to communicate the realities of climate change to Pacific Island communities, while helping them to explore ways to proactively respond. From as early as 2003, national societies in the Pacific region began preparing local communities to understand and respond to climate change. National societies began by recognizing the uncomfortable fact that Pacific islanders were being asked to respond to a more uncertain future. Aware that climate change was likely to have relatively dramatic impacts on Pacific island communities even in the short term, preparing local communities quickly became a priority.

For national societies, the first step was to educate themselves. Red Cross volunteers and full-time employees needed to understand relevant climate information, and transmit it effectively to local communities. An important part in building this capacity was the development of the participatory Preparedness for Climate Change Programme.

First implemented in the Pacific region in 2003, the Preparedness for Climate Change Programme required Red Cross offices to contact climate-related stakeholders, including meteorological and environmental offices, in order to develop the sort of connections necessary to ensure access to critical climate information, and to help them analyze the potential impacts of climate change at both national and local levels. As a result, societies across the region used newly created partnerships to produce climate change impact studies. The Red Cross/Red Crescent Climate Centre also provided training to ensure that officers understood the causes, consequences and threats associated with climate change.

The program also called for national Red Cross societies to gather and analyze information from local communities regarding the changes they had witnessed and how climate-related impacts were affecting them, whether they were directly related to climate change or not. As a result, Red Cross societies across the Pacific region gained a better understanding of the climate-sensitivity of their local communities. For example, in the Solomon Islands people considered how health risks such as malaria and food-borne illnesses were changing as a result of climate change.

Given the unique challenges posed by the remoteness of many Pacific Islands, national Red Cross societies also explored how community-based approaches might help them meet the challenges associated with climate change. Representatives from many of Red Cross societies in the Pacific region gathered to share their experiences at a regional workshop in Fiji in 2010. From this, a practical guide on community-based approaches was produced. This guide was based on the existing global Vulnerability and Capacity Assessment Toolkit, but tailored to the Pacific and explicitly integrating climate risk management. It describes a range of methods designed to help a community identify its own problems, and create an enabling environment to foster solutions to the problems faced.

Most prominent is the seasonal calendar, which helps communities identify and express perspectives on variations in the availability of resources throughout the year. The seasonal calendar encompasses changes in food, water and income availability, and reveals environmental changes, providing an overall picture of when different hazards and risks are present and when the community is at its most vulnerable. In this way, the seasonal calendar helps communities identify the best way to prepare for and respond to disasters. When participants visualize past patterns related to growing seasons, health issues, and the timing and extent of rainfall, and compare those to current trends, the seasonal calendar helps initiate a conversation about climate change. Even when the changes that are being observed are not directly related to climate change, the discussion helps further an understanding of how future changes may affect their lives, and helps communities develop possible solutions to them.

Education and awareness raising can help reduce the vulnerability, particularly in isolated disaster-prone communities; UK Department for International Development/Rafiqur Rahman Raqu

Importantly, the seasonal calendar helps the Red Cross to provide information about climate change within the context of local communities. This is important because in some cases providing too much information about climate change was believed to encourage a fatalistic perspective. By providing information in context, tools such as the seasonal calendar also help communities to determine where responding to climate change falls on their list of local priorities.

Once communities have identified and prioritized their vulnerabilities, the Red Cross helps them take steps to prepare for and manage disasters. This has involved building drainage systems for tidal surges, rainwater harvesting and the retrofitting of existing water collection points, or growing alternative crops to take advantage of changing conditions and moving plantations further from the coast.

Based on lessons learned during their climate change campaigns, many national Red Cross societies in the Pacific region are now working closely with communities to help them understand and use climate information in their more day-to-day plans. This is particularly important because it is seasonal extremes that produce the disasters that regularly impact the islands. Helping communities to prepare for these extremes allows them to overcome current development challenges, and effectively manage current climate variability and risk.

An example of efforts to transfer information about seasonal and inter-annual variability to local communities comes from Micronesia. In March 2010, Micronesia's meteorological office informed the national Red Cross that the country faced an increased chance of drought based on the El Niño event already underway. The Red Cross requested help from the meteorological office to interpret and respond to this information, seeing an opportunity to open a dialogue about climate risk. As a result of this interaction, the Red Cross and the meteorological office developed community-based methods to respond to threats associated with climate variability and change.

The first step in the process took place in Pohonpei in May 2010. Participants from Red Cross branches, government offices and the local humanitarian community explored the unique context of vulnerability and capacity within Micronesia. Participants developed skills needed to use participatory tools to support communities in identifying and addressing priorities regarding climate risk. Sessions on climate variability and climate change were delivered by the meteorological office, and how they could work together with the Red Cross to help anticipate and prepare for disasters was discussed. The two agencies signed a Memorandum of Understanding, and have since met monthly to discuss potential climate-related hazards. The meteorological agency has also provided Red Cross staff members with training on climate variability, and has agreed to use community-based approaches that have helped the Red Cross develop good working relationships with local people.

Importantly, the Red Cross in the Pacific has also developed relationships with seasonal forecasters including the Island Climate Update, the Climate Prediction Center, and the International Research Institute for Climate and Society. These have helped the Red Cross familiarize itself with the El Niño Southern Oscillation and with its impacts in the region, helping it develop risk reduction strategies to reduce impact. Communicating this kind of information to local communities is helping them become better prepared to manage seasonal, inter-annual and long-term climate risk

The reality of the Pacific region is that many communities are extremely isolated. To help them understand and prepare for climate risk, the Red Cross works to communicate climate information in a way that is clear and actionable. It does this both by educating its own workforce, which includes many volunteers, and by employing community-based approaches such as the seasonal calendar. The Red Cross has also worked to develop relationships with local and regional forecasters in order to ensure that they have access to, and are able to understand, seasonal, inter-annual, and regional forecast information. In this context, Red Cross national societies help communities understand and respond to climate-related risk.

Summing up

Can climate information help disaster risk managers plan for the future? While the answer to this question is very clearly yes, the extent to which climate information can be helpful depends on the specific region in question, the lead-time associated with the particular information, and how clearly the information is presented. This chapter has highlighted some of the problems and challenges that are currently facing disaster risk managers who are trying to make use of climate information; it also includes discussion of some of the solutions that have been put forward to resolve these challenges, which are summed up below.

A better understanding of climate can help disaster risk managers differentiate between what may be part of a recurring cycle and what is a long-term trend. Knowing the difference is essential for planning for the future. Such was the problem faced of the government and humanitarian organizations in Syria, when dealing with the third successive drought year in 2009. The results of the analysis revealed that drought in Syria can no longer be considered as an exceptional event, being linked to the changing climate of the region. New partnerships between providers and users of climate information developed, and improvements in future drought preparedness can be expected.

Disaster risk managers are sometimes overwhelmed by the vast quantity of information available. In Haiti, they worked together with scientists to develop an easily accessible 'one-stop shop', a platform of targeted climate-related information to help disaster risk managers better understand the situation and enable timelier decisions. Useful in complex emergencies, one-stop shops would ideally be developed and made accessible in routine preparedness, helping disaster risk managers prioritize layers of information at any time.

Monitoring frameworks like that employed by the IFRC Asia Pacific Disaster Management Unit help disaster risk managers look for changing risks, allowing them to be prepared months in advance and to consider climate information across time scales. The development of this framework relied on strong partnerships between climate scientists and disaster risk managers to identify what information would be useful at different decision-making points, but a challenge still to be resolved is how much certainty is needed in climate forecasts for different actions to be deemed reasonable and undertaken.

Efforts to mitigate food insecurity in Kenya show how effective climate information can be when integrated into existing food security decision-making processes. A process led by the food security community, but including a wide range of decision makers and experts, including the national meteorological department, is an effective way to identify areas at risk of food insecurity in part based on climate information. Seasonal forecasts also contribute to improving early warning and action when they are incorporated in a timely fashion. By working together, climate scientists can understand when and what types of information are needed, and government officials, humanitarian organizations and others can better understand why and how this information can add value.

Climate information is also required for managing aspects of human health, such as predicting and planning for epidemic outbreaks of malaria. In southern Africa, however, the timing of climate information that was being provided was not optimal given the timing of malaria epidemics and the skill level of the forecasts. Collaboration between health professionals and climate information providers led to more valuable and better targeted information. A requested delay in the release of information increased its overall value, allowing health professionals to better prepare for malaria epidemics and reduce human suffering.

Humanitarian organizations and climate scientists can work together for a fundamental understanding of the types of problems they may face as a result of climate change. In the Pacific, the Red Cross built its own capacity first, before bringing the information to the community level. The Red Cross works with local communities and meteorological services to help them better understand the implications of, and to prepare for, long-term climate change. The use of seasonal calendars familiar to the community was a useful exercise in getting communities to think about how they observe their climate changing, providing a practical context for them to consider climate change implications and proactive ways they can mitigate them.

In some cases, disaster risk managers have difficulty accessing useful information to help them understand the risk and potential problems they are facing. New research questions may arise based on the real needs of disaster risk managers. Whereas some researchers have the flexibility to address these pertinent, real-world questions, such questions are often considered a low priority for academics, who need to publish for their professional survival (Dilling and Lemos, 2011). Sometimes, such questions can lead to innovative research, whereas in other cases much simpler analysis may be all that is needed to create useful but not necessarily publishable information for practical use. To get the best minds engaged on solving problems may require more diversity in the ways researchers are rewarded, and in the way they interact with society to define real societal needs.

Chapter 2: Developing the tools

The process of integrating climate information into disaster risk management is not an easy one. It requires the commitment and support of a range of partners who can work together to develop and refine climate-informed decision-support tools, systems and platforms. In many cases these tools and platforms have already been developed by disaster risk managers, in which case collaboration can improve the integration of climate information into them to better inform action. Constant refining and improvement is the typical feature of this step of 'developing the tools'. This approach also creates a sense of ownership amongst partners, as well as building capacity in understanding the constraints and opportunities. Building on the identification of the problems and possible solutions offered in the previous chapter, this chapter illustrates examples of various processes that climate scientists and disaster risk managers have taken together, and analyzes the effectiveness of methods and tools used.

On 14 and 15 June 2010, heavy rains brought devastating flash floods and landslides to southeastern Bangladesh, causing at least 55 deaths and damaging homes, crops, livelihoods, and communication infrastructure. Bridges and culverts were destroyed and roads were washed out, leaving hundreds of thousands of people stranded (IFRC, 2010).

Four days earlier, during a routine check of global conditions, a disaster information officer at the headquarters of the International Federation of Red Cross and Red Crescent Societies (IFRC) in Geneva noticed above-normal rainfall forecasted for Bangladesh over the following week (see Figure 6). He immediately informed his colleagues of the situation. Within seconds, his email reached a number of partner organizations including Red Cross/Red Crescent national societies; a range of technical departments including health, water and sanitation, shelter, logistics and crisis management; the global operations coordinator; and the IFRC media department.

This email early alert was designed to help mobilize technical and logistical support from within the Red Cross/Red Crescent community, and an official press release describing the situation also sought to mobilize external financial support. Email alerts are one means that allow the IFRC headquarters to become aware of potential disasters before they occur, and give them an opportunity to plan and respond in a more effective manner – rather than just in a pure response mode.

In consultation with IFRC officers across Asia and in Bangladesh, the Geneva office analyzed the severity of the threat based on regional capacity and the credibility of the information. A decision was made to inform the Field Assessment Coordination Team and the Emergency Response Unit for a potential deployment.

On 22 June, more than US$100,000 was requested from IFRC's Disaster Relief Emergency Fund to support the Bangladesh Red Crescent in delivering immediate assistance to at least 6,500 people. Although the request was made a week after the disaster struck, actions in Bangladesh were taken beforehand. Stocks of non-food items available for dispatch to affected districts were reviewed and checked, and volunteers were mobilized, who were then ready and able to assist with evacuation efforts as soon as the disaster struck. Climate information, linked to effectively communications through email alerts, allowed informed decisions to be made, reducing the human suffering from this weather-related disaster.

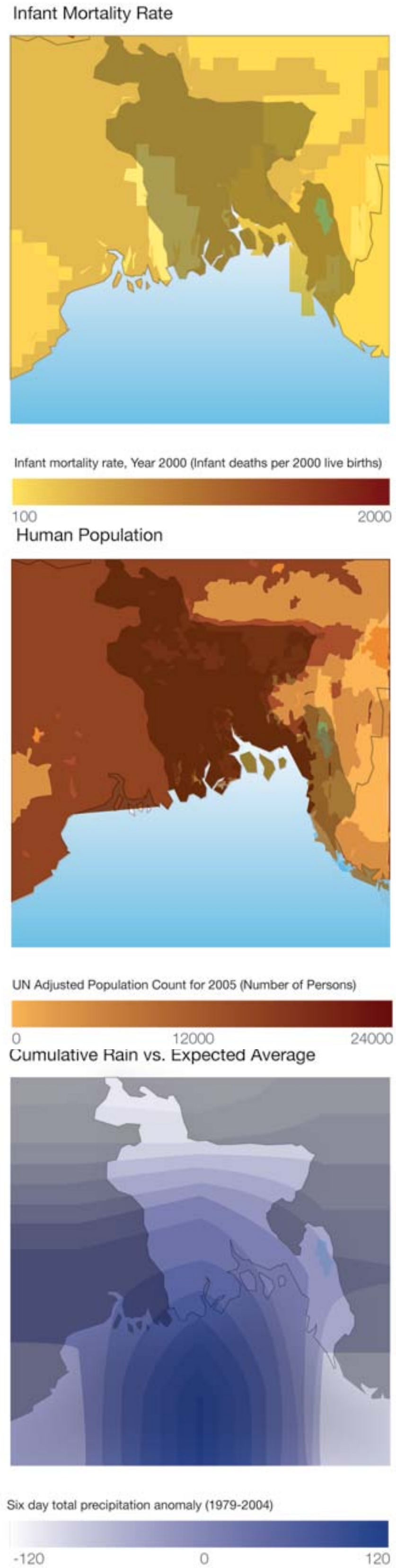


Figure 7: The IRI-IFRC Map Room on 10 June 2010 for Bangladesh, indicating infant mortality rate, population (adapted from CIESIN data), and the six-day contextualized cumulative rainfall forecast.

In places like Bangladesh, where floods are frequent, improved preparedness is especially important and helpful to reducing suffering; UK Department for International Development/Rafiqur Rahman Raqu

Building the global Map Room

The creation of the IRI-IFRC Map Room represents a good example of the second step in this book's problem-solving framework – developing tools. An intensive three-day dialogue led partners to develop an action plan and to identify the potential 'quick wins' of interpreting forecasts in context. In this case, the development of a prototype online tool was the starting point, and subsequent revisions led to the IRI-IFRC Map Room's inclusion on the IFRC's web platform, globally accessible to all Red Cross/Red Crescent staff.

Four years earlier, in 2006, the IFRC headquarters and the Red Cross/Red Crescent Climate Centre had begun discussions with the International Research Institute for Climate and Society (IRI) on how to make better use of climate information to improve IFRC's disaster preparedness and response. The idea was that increasing interest in the implications of long-term climate change should be complemented by better use of forecasts on seasonal timescales. During initial discussions, it was determined that the Red Cross could also benefit from applying climate information at an even shorter timescale – i.e. the use of the climatology for interpreting the six-day rainfall forecasts that the IFRC was monitoring on a regular basis.

Disaster risk managers were well aware that similar rainfall forecasts could have very different implications depending on where and when the rain was expected to fall. Average weekly rainfall during the four-month Bangladeshi monsoon season is 120 mm (Ahmed and Kim, 2003). In other parts of the world, for example in northern Chile, mean annual rainfall is just 14 mm. The huge disparity between what is normal in these and other parts of the world means that disaster risk managers using a global tool must know a great deal about the local context of the information they receive in order to be able to use it effectively.

To remedy this, IFRC and IRI worked together and developed an online tool – the IRI-IFRC Map Room. The tool demonstrates how an individual forecast compares to normal conditions in a specific location. It includes weather forecasts at one-to-six-day timescales as well as probabilistic forecasts up to three months in advance. These are delivered on similar maps so they can be easily accessed and interpreted by disaster risk managers. Rather than showing how much rain is forecasted to fall in one location, the map shows how the forecasted rain compares to a history of rainfall in that location. This gives disaster risk managers the context they need to know how rare any particular forecasted event might be.

As disaster risk managers are primarily concerned with extremes, there was a specific request from the IFRC for forecasts of such events. A product of this nature, which indicates areas in which extreme rainfall is more likely during the upcoming season was not readily available, so research had to be conducted before it could be developed. The current product includes forecasts providing the probabilities that the seasonal rainfall will be in the lowest 15 percent or the highest 15 percent of the climatological distribution. This knowledge is being transferred to meteorological agencies, such as in Tanzania, through targeted capacity building efforts (see box).

The Map Room also includes two other features. These indicate the relative exposure and vulnerability of the population based on population density and infant mortality rates, respectively. Accordingly, the Map Room makes it easy for disaster risk managers to interpret where predictions indicate more or less rainfall than normal, how often past rainfall has exceeded the amount currently forecasted, and whether the population is particularly vulnerable. This allows users to quickly see where conditions are not typical and where disasters might occur.

The IFRC integrated the Map Room into its Disaster Management Information System (DMIS) and now monitors it on a daily basis. When the Map Room reveals a forecast for unusually heavy rainfall, the IFRC head office sends out an email alert. Local Red Cross offices can also use the Map Room, but they are also encouraged to contact local meteorological and hydrological organizations for more detailed information about the likelihood, timing, severity, location, and potential impact of extreme rainfall events.

Whereas the Map Room was designed to help the IFRC headquarters get a sense

Developing capacity for impact at scale

Disaster risk managers have integrated climate information into decision-making over the past few decades in response to specific problems or events, such as the impact of drought in the Greater Horn of Africa. Unfortunately, the development of this knowledge, practice and tools has not been systematically translated for widespread adoption. The momentum currently surrounding climate services strives to capitalize on this existing experience to create a comprehensive and systematic model of partnerships to support the use of climate information at scales appropriate to the relevant problem.

For example, although the IRI-IFRC Map Room provides useful information to help disaster risk managers take action at the global scale, it is not meant to replace regional, national or local processes. In fact, when based on the lessons learned at the global scale, the development of map rooms and monitoring frameworks at more local scales can help disaster risk managers protect even more lives and livelihoods. Ultimately, the development of partnerships, knowledge and information at different scales will further improve disaster risk management efforts.

As part of developing such capacity, the IFRC and the African Centre of Meteorological Application for Development (ACMAD) signed a cooperation agreement on World Meteorological Day, 23 March, 2009. This agreement between a humanitarian organization and a meteorological institute was the first partnership of its kind in sub-Saharan Africa, its goal to reduce the impact of disasters through better risk identification, response, preparedness and prevention.

To accomplish this, a Help Desk was established with a dedicated weather surveillance scientist on standby during the critical July-August-September flood season in West Africa, to send alerts to a designated IFRC counterpart in Dakar whenever potential flood producing rainfall was forecast in the region. Additionally, the Help Desk provided various types of climate information to assist the IFRC regional office in its disaster planning and preparedness activities:

- Short-range tailored climate risk bulletins provided once every two days to enable earlier targeted action as a result of warnings of flood risk in the region. These include data on accumulated rainfall over the preceding three to five days, information on the developing weather situation illustrated by a series of satellite images, and 24- to 72-hour storm forecasts of rainfall amount and expected path over time, indicating areas at heightened risk of flooding.
- Special 'very short-range' bulletins to facilitate flood risk analysis, forecasting weather over the next six hours. The two-part bulletin includes an analysis of the storm systems in real time, and indicates the associated risk of these developments.
- Ten-day climate risk bulletins summarizing the weather over the last 10 days and providing an outlook for the next 10 days. It also analyzes rainfall statistics on daily, 10-day, and seasonal scales.

This partnership was the culmination of a year long process following IFRC's use of ACMAD's seasonal forecasts to request funds ahead of predicted flood events in West Africa. Based in part on this information, the IFRC prepositioned reusable disaster relief items in strategic outposts. In the face of the devastating floods that followed, the Red Cross was able to rapidly assist flood victims. In some cases, early dissemination of information to local communities also facilitated evacuation, saving lives compared to the losses in the previous year's floods.

As a result of this experience, the IFRC West Africa regional office became more interested in incorporating climate information into their operations. Throughout the rest of the 2008 rainy season, IFRC reached out to ACMAD's climate scientists, inquiring about likely atmospheric conditions in given countries and requesting additional information to help update its contingency plans. First, IFRC identified its climate information needs, and ACMAD's capacity to respond to these needs, and the partnership was formed based on what ACMAD could readily provide, taking on an important role in their day-to-day operations (Tall, 2008).

Since its inception, this has enabled the early warning of out-of-season rains in 2009, floods related to the La Niña event in 2010, and sporadic episodes of storms and strong winds. All this information was disseminated through the IFRC network of national societies and sub-national relays all the way down to the volunteers operational at the community-level.

This partnership marks the first time that ACMAD provided operational climate information directly to an end-user, and the constant interaction and feedback from IFRC has helped them develop a better sense of what information and in what format to include in advisory bulletins. This learning process is still ongoing, building capacity for early warning and early action in West Africa, a region vulnerable to more frequent and severe climate-related shocks.

This type of collaboration is essential if the use of climate information for improved disaster risk management is to be successful at meaningful development scales. The partnership has proven to be an enriching experience for both communities, as they work together to achieve a common objective of saving lives and livelihoods, and represents positive action toward using climate information in effective disaster risk management.

The Map Room helps the Red Cross decide where in the world relief supplies may be most needed, allowing them to take immediate action; Alex Wynter/IFRC

of where in the world they should focus their attention, in most cases knowledge and information at the local scale is more accurate and more detailed than the global information provided by the Map Room. As a result, the Map Room sometimes fails to capture even large events. This is an important reminder that it cannot replace two-way communication between local offices and headquarters, nor local knowledge and capacity.

It also illustrates the need for tools and procedures to be developed at the regional, national, and local scale. Rather than employing global-scale information, smaller-scale map rooms could access more detailed information and local expertise and thus provide more refined information than the global version. In addition, local disaster risk managers can also develop procedures for monitoring different kinds of information at the appropriate times, making it easier for them to anticipate hazards that might turn into disasters (see Monitoring Changes in Climate and Weather in Asia, Chapter 1).

Collaboration on the global Map Room led the IFRC to formalize its work with IRI in the form of the Partnership to Save Lives. Through this, climate researchers at IRI continue to work with specialists at the Red Cross/Red Crescent Climate Centre to develop new integrated solutions for better-informed disaster preparedness and response at global, regional, national and local scales. In addition to the Map Room, this partnership has led to a range of different initiatives, including a Help Desk to provide technical backstopping and interpretation of weather and climate information, a concentrated research effort focused on understanding information gaps and needs, several jointly hosted workshops to broker dialogue and build capacity in regions around the world, a masters-level internship program, and the provision of climate information on various timescales to national Red Cross and Red Crescent societies as part of the Preparedness for Climate Change Programme.

When the IFRC first consulted with IRI on the development of the Map Room, the two groups worked together to identify the needs of disaster risk managers for climate information. The Red Cross also provided information on the conditions in which decisions are made and suggested how they would like information to be presented. Based on back and forth consultation between IRI and the IFRC, changes were made over time to ensure the Map Room better serves Red Cross disaster risk managers, and the current version of the Map Room is now very different from the one originally rolled out in 2008.

Tailoring climate information to improve decision-making

Changes to the IRI-IFRC Map Room were made based on regular discussions and feedback between the partners. Tailoring information required changes in the language, presentation and content that was not originally foreseen by the producers of the information. The iterative development of the Map Room was essential to making the information more useful to disaster risk managers. Tailoring of information thus paved the way for the Red Cross to use the site to prepare actions that mitigate and manage the impacts of climate-related disasters.

Experience with the IRI-IFRC Map Room shows that information can more easily inform action when it is integrated into existing decision-making frameworks. The Disaster Management Information System (DMIS) was created in 2001 to help meet the IFRC's need for quick and efficient decision-making by its staff throughout the world. It is a web-based tool that allows users to access real-time information and disaster trends from a host of online internal and external resources, tools, and databases (see Figure 8). It is the result of a major effort by the IFRC to address the complexity of information exchange in the humanitarian community, and to support an efficient disaster preparedness and response for the whole network.

Locating the Map Room in the DMIS made it immediately accessible to the entire global IFRC community. Incorporating the tool into the DMIS also indicated the trust the Red Cross had in the value of the information, and ensured that it was taken seriously by a range of stakeholders. Just as importantly, this accessibility provided an opportunity to receive more feedback and to improve the way the information was presented. Integrating information into existing frameworks has thus increased access to, and trust in, climate information, making it easier for disaster risk managers to act.

The Map Room also serves as an illustration of how the tailoring of information for specific users helps disaster risk managers prepare for action. This involves selecting only what users need to know, and presenting information in a way that is quickly and easily digestible to the user.

The most important change was in reducing technical language used in the Map Room, which the Red Cross now describes as "more disaster-manager oriented". As seen in Figure 9, the original version gave users options to view data including the "Six-day total forecast precipitation percentile (ESRL)" and the "PiC: reversed tendency between seasonal forecast and 3-month precipitation observation (IRI)". Although descriptions of the data were available, the Red Cross suggested that a change in language might make it easier to use. As of December 2010, the Map Room now greets the user by asking them "What would you like to know?" The easily understandable options that return the same information as those above, now include questions such as "Where is unusually

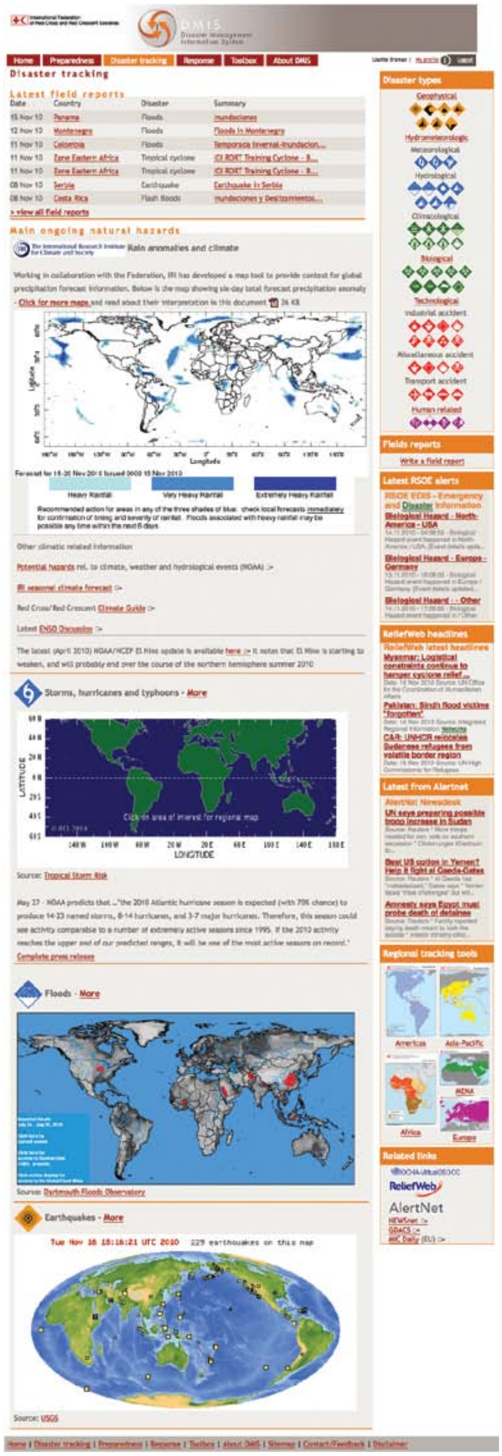


Figure 8: IFRC's Disaster Management Information System (DMIS)

heavy rainfall expected?" and "Is it likely that unusually wet or dry conditions will end?" The information displayed in the Map Room has not changed significantly since it was first developed, but it is now much easier for disaster risk managers to use.

Text was added, for example to explain that the map does not distinguish between rainfall and snowfall. The Map Room also now explains that because a forecast shows rainfall over large areas, it should not be used to forecast cyclone tracks, local rainfall, or as a flood forecast. Text also instructs users to check local forecasts for their area for the timing and severity of rainfall if a forecast for heavy rainfall is indicated for their region.

Convenience and efficiency has also been improved. Ensuring that the most frequently requested map was the default displayed on the homepage saves disaster risk managers time, and the default map was changed to show areas where unusually heavy rainfall is expected. Similarly, the site was made easier to use when a feature was added to automatically refresh maps when new variables or areas were chosen.

The clarity of maps was improved in a number of ways. Maps were made more intuitive by changing the color scales, with drier conditions represented by graduated shades of brown and wetter conditions by graduated shades of blue. Qualitative descriptions replaced numerical descriptions throughout. For example, areas with rainfall amounts falling in the 90–95th percentile were re-labeled 'heavy rainfall', those in the 95–99th percentile as 'very heavy rainfall', and those above the 99th percentile as 'extremely heavy rainfall'. Similar changes were made to the seasonal forecast maps where percentiles expressing probabilities in the seasonal forecast for wetter or drier outcomes were converted into measures representing low, medium and high confidence.

Calculating how heavy the rainfall forecast was in comparison to average conditions involved a more substantive change. While this was originally calculated with respect to long-term averages for the five-day period when the forecast was made, there was concern that this method resulted in too many 'false alarms' for heavy rainfall. To remedy this, a new calculation method was developed with a larger sample size in order to improve the accuracy of the predictions.

Integrating climate information into user-developed platforms for food security

The food security community requires information tailored to its specific needs. In East and Central Africa, this community has developed two tools to better link early warning information and effective response. These frameworks are used to process a range of data, including climate information, and analyze current and future food conditions through several different approaches. Linked to effective partnerships and networks, integrating climate information into existing

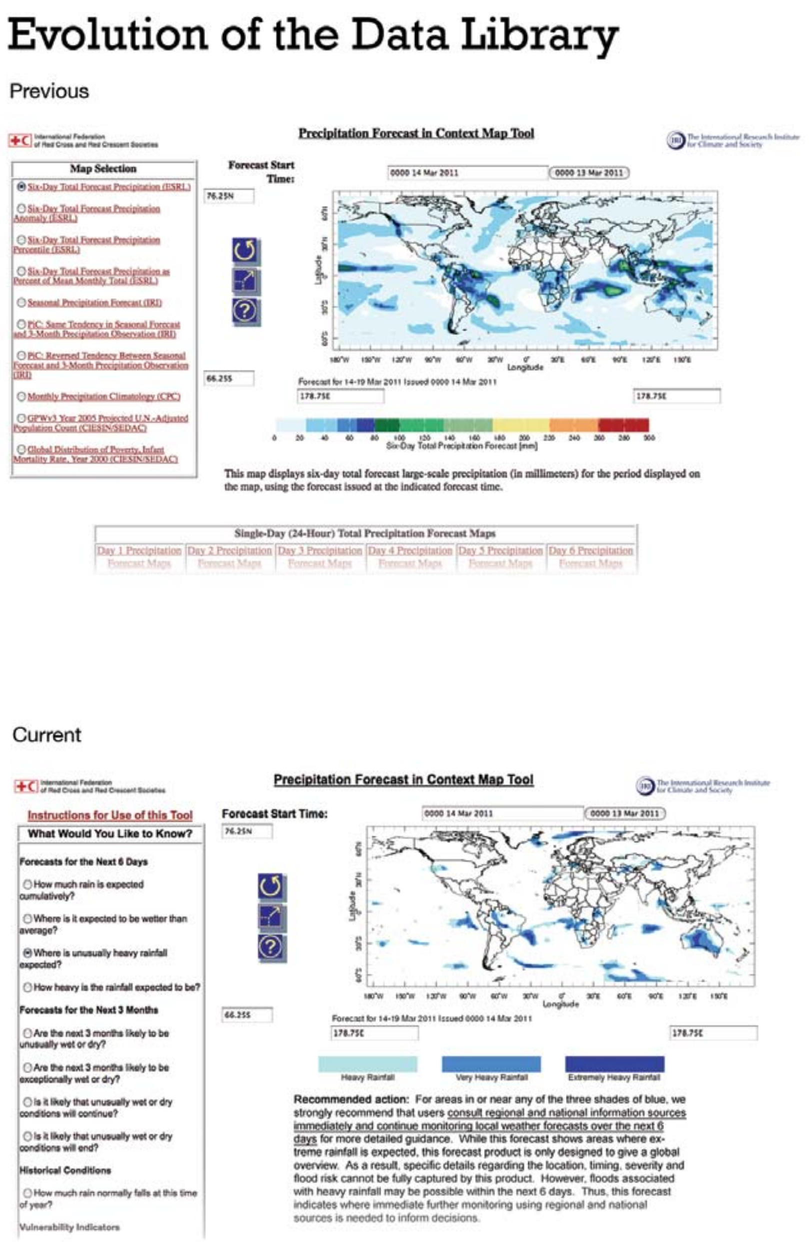


Figure 9: Comparison of the original IRI/IFRC Map Room, and the version after extensive partner feedback.

Improvements being made in forecasting floods need to be transferred to disaster risk managers in ways that are useful, timely and easy to understand; SALTBONES, Olav A./Røde Kors

user-designed platforms and tools has proved to be especially useful.

Food security planning requires climate information that is tailored and presented in different ways to meet specific user needs. In East and Central Africa, user-developed tools such as the Food Security Outlook process and the Integrated Food Security Phase Classification (IPC), have proven to be critical in strengthening links between early warning information and effective response, by translating early warning data into projected food security conditions. Climate information is just one of the many different kinds of information such tools use to inform existing decision-making frameworks and help disaster risk managers prepare to take action.

The Food Security Outlook process provides decision makers and planners with a clear picture of the potential food security situation over the coming months based on all available early warning data. The output is a set of maps, timelines, populations potentially affected, etc., which provide a foundation for contingency planning that disaster risk managers can use.

This process is led by the Famine Early Warning System Network (FEWS NET), a project that has been funded by USAID and active for more than 20 years. FEWS NET includes food security early warning teams in over 25 countries and a network of partners including USGS, NOAA and NASA who provide operational climate services for food security early warning. It collaborates with international, regional and national partners to provide early warning information on emerging food security issues.

FEWS NET also plays an active role in tailoring, disseminating and applying climate information, specifically for the food security sector. It actively participates in both food security and climate forums and maintains a good working relationship with organizations in both sectors. As a result, FEWS NET has developed an understanding of the needs and constraints of both climate and humanitarian communities and frequently serves as an intermediary between the two.

The Outlook process analyzes current and future food security. It gauges current food security using a suite of food security outcome variables including household food deficits, climate observations, food prices, livelihood disruption, acute malnutrition, and mortality. Once the current conditions are known, future events most likely to affect food security are assumed, and the potential impact of these shocks is analyzed, taking into account ongoing interventions and possible coping strategies. This provides decision makers with possible scenarios and early warning information regarding developing food security crises. FEWS NET often seeks to build consensus with partners, including governments, UN agencies, and NGOs, at various points in this scenario development process.

Climate information is incorporated into the Outlook tool through the scenario-development process using analog years. Once seasonal rainfall forecasts are made, national and regional meteorological agencies are able to identify past years that had similar forecasts and atmospheric conditions. Making this comparison allows FEWS NET to make informed assumptions useful for scenario development, such as future rainfall and how it may affect crop and pasture production and, ultimately, food security. This method is often complimented by the use of modeling tools such as the Forecast Interpretation Tool (see box).

This scenario development approach provides decision makers with an early indication of what situations are most likely to develop in the coming months. However, it does not present all events that have a chance of occurring, and focuses on impacts resulting from one series of informed assumptions. By using it, too much confidence may be placed on a seasonal forecast. In addition, when using analog years only a limited sampling is chosen and this may not fully capture the range of possibilities for the forecasted season. FEWS NET addresses these issues at the conclusion of its scenario development process by outlining broadly possible alternatives to the most important and most likely assumptions, and their potential impacts on food security. So, FEWS NET also typically releases additional

The Forecast Interpretation Tool

Seasonal forecasts can provide an early warning of food insecurity, but a lack of understanding of the implications of a forecast tends to limit their use. To overcome this challenge, the Forecast Interpretation Tool was developed by United States Geological Survey (USGS). It translates probabilistic rainfall forecasts into potential rainfall amounts and anomalies by randomly sampling a historical database using the probability distribution of the forecast as a guideline. In other words, if there was a forecast for a 20 percent chance of above normal rainfall, a 30 percent chance of normal rainfall and a 50 percent chance of below normal rainfall, the tool would take 20 percent of its samples from below normal rainfall years, 30 percent from normal rainfall years and 50 percent from above normal rainfall years. Based on this sampling a new median and probability distribution function for rainfall outcomes is established. Using this analysis, probability maps can be generated indicating locations that are likely or unlikely to attain critical rainfall amounts conducive to certain crops (Husak *et al.*, 2011), therefore supporting more informed risk management decisions. Such information helps to inform actions such as rationing water, distributing seeds, and preparing for droughts or floods.

The Forecast Interpretation Tool is typically used in the conjunction with seasonal forecasts such as those resulting from Climate Outlook Forums. The Forecast Interpretation Tool resulted in useable information for early warning and contingency planning when it was applied to a seasonal climate outlook from March to May 2009 in the Greater Horn of Africa region. As Figure B4 demonstrates, the outputs of the tool make it possible to identify areas with high risks of extreme rainfall, as well as those that could improve agricultural yields. In this example there is an increased likelihood for significant rainfall deficits in southeastern and northern Kenya, eastern Ethiopia, and south and central Somalia. However, the key production areas of western Kenya, central Uganda and parts of the 'belg' crop growing areas of Ethiopia were likely to have favorable conditions for maize production.

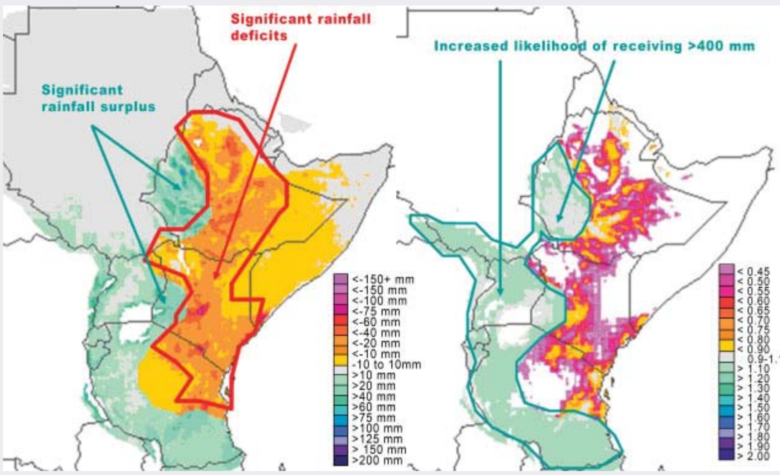


Figure B4: Seasonal rainfall median anomalies (left) and the ratio of forecast probability of receiving more than 400 mm over the historical probability, describing the chance for favorable maize conditions for the 2009 rainfall season (right) in the Greater Horn of Africa (Husak *et al.*, 2011).

climate information along with regularly updated Outlook reports.

The culmination of this process is a Food Security Outlook Report, which at times is produced in conjunction with food security partners such as the WFP, where current and projected food security outcomes are classified using a 'food insecurity severity scale' displayed on user-friendly maps (Figure 10). This allows comparisons to be drawn between existing conditions and probable future outcomes.

The conclusions are distributed via country and regional food security coordination systems. Through an online interface, regional and national maps are complimented by a range of additional resources including information on livelihood zones and market analysis. The FEWS NET website also highlights current weather hazards identified through a weekly Weather Hazards Assessment by NOAA, NASA, USGS and others. These weather hazards are overlaid on current food security conditions to provide a

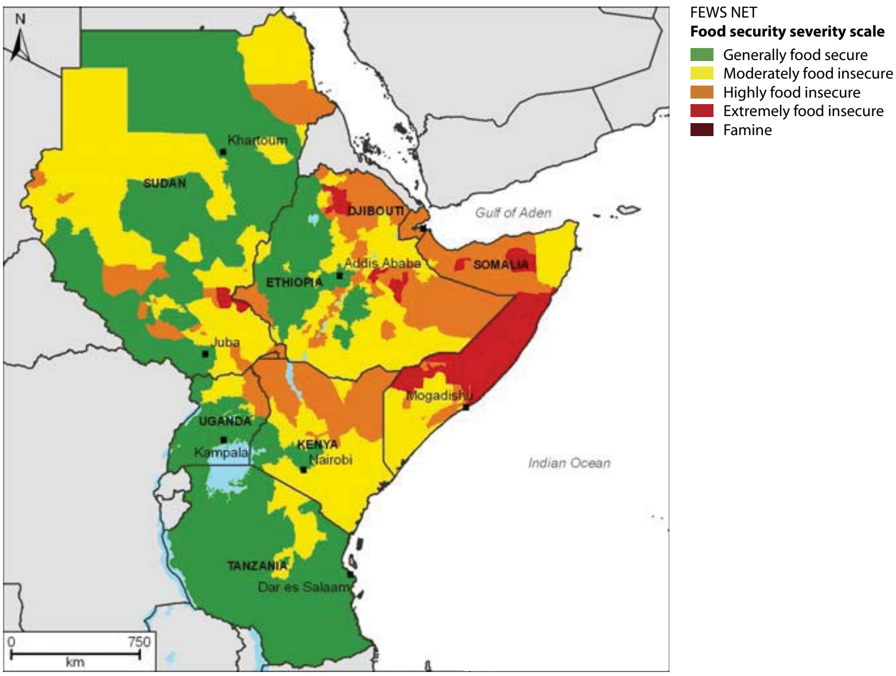


Figure 10: The most likely food security scenario for East Africa, April to June 2010, as a user-friendly map, one of the primary outputs of the Food Security Outlook process (FEWS NET).

* The names and boundaries of these maps do not imply any official endorsement or acceptance by the UN.

context for interpreting the potential impact of emerging weather hazards on food security.

Longer-term seasonal monitoring and assessments of crop growing conditions are made using satellite rainfall estimates, crop-water satisfaction models, and satellite-observed measures of vegetation health, as primary triggers for disaster response.

The Integrated Food Security Phase Classification (IPC) tool was created in 2004 by the FAO Food Security Analysis Unit for Somali. Since then, a wider group of organizations have worked to adapt it for use across the Greater Horn of Africa and globally. It aims to provide a standardized consensus-based approach to classify and communicate current and future food security conditions and risks of the situation deteriorating, by integrating food security, nutrition, and livelihood information to draw conclusions about the severity of a crisis and the implications for food security response. This process results in a single map that communicates the severity of food insecurity and the potential risk of further deterioration (Figure 11).

It considers early warning information separately from current food security conditions, and forecast information is used to inform the potential risk of the current conditions deteriorating. Climate observations are used to evaluate the emergence of shocks to food production and livelihoods. When a possible hazard is identified, it is interpreted in relation to local livelihood and vulnerability patterns to predict potential risks to food security. However, as it does not contain guidelines on how to translate such early warning information into future impacts, the process still involves a certain level of subjectivity.

The system provides a common platform for discussion, as a joint effort in which sectors such as food security, nutrition, and health must work together to integrate data. This collaborative effort allows a shared conclusion regarding the situation and priorities for action, and facilitates consensus between analysts, implementing agencies and donors, leading to more effective and timely response and better coordination between agencies. In addition, interaction with the climate community allows climate scientists to understand the specific needs of the food security sector.

An updated version of the IPC tool is currently in development and planned for release. Amongst other changes, this platform intends to have a mechanism for distinguishing between chronic and acute food insecurity, as well as a revised scale for classifying acute food insecurity. FEWS NET and the IPC leadership are working closely together on this process. In the future, the revised IPC process and FEWS NET's Outlook tool are expected to share a more similar approach.

FEWS NET's Outlook and the IPC share a number of common features. By classifying food security situations according to a standardized system, these tools provide a mechanism for comparing places in need. This is critical for implementing agencies, governments and donors to appreciate how the severity of a situation compares from one place to another when setting priorities and allocating limited resources. In addition, as these tools are generated regularly, they can be used to enhance understanding regarding how a crisis has evolved over time. This is complemented by the use of early warning information, helping to highlight potential future populations in need. This feature enables decision makers to target areas for additional monitoring and planning and paves the way for effective response.

As this shows, the integration of climate information into user-developed tools is a critical part of disaster risk management and preparing for action. Both of these food security tools combine a vast amount of data and

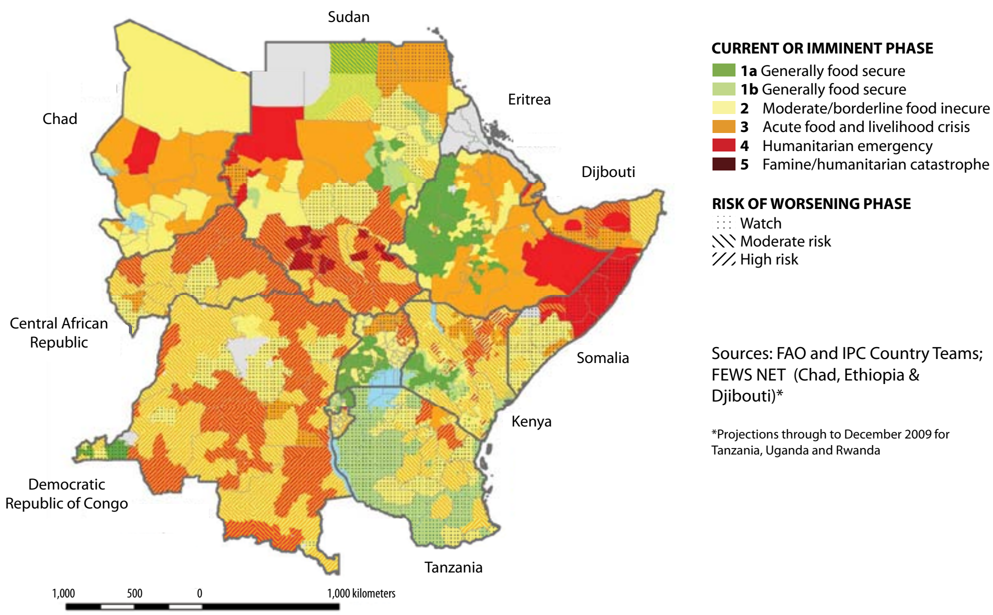


Figure 11: A unified map for East and Central Africa displaying the severity of food insecurity and the potential risk of further deterioration (from the Food Security Nutrition Working Group, projections through to December 2009 for Tanzania, Uganda and Rwanda).

Dialogue between humanitarian organizations and climate experts in East Africa

User-developed platforms are useful in helping disaster risk managers prepare actions to mitigate and manage the impacts of climate-related events, but in many cases the knowledge, information and resources required to build them are prohibitive. A useful starting point is to develop the capacity of disaster risk managers to use and understand climate information, as well as developing the capacity of climate scientists and meteorological services to understand the context in which disaster manager operate so that they can better anticipate the types of information that will be useful.

One effort to facilitate mutual understanding at the boundary between climate scientists and humanitarian organizations took place during a two-day workshop in Kenya in 2009. Organized jointly by OCHA, IRI, IFRC and the Red Cross/Red Crescent Climate Centre, the workshop brought together a range of experts from UN and non-governmental organizations, including the Kenya Meteorological Department and the IGAD Climate Prediction and Applications Centre. The humanitarian community was able to give climate scientists feedback on the packaging of information, and to suggest ideas to guide research and the development of new prediction tools. This collaboration was also designed to give humanitarian workers a better sense of the kinds of climate information tools available for use in disaster risk management.

The workshop explored some of the many challenges associated with decision-making under uncertainty. During this interaction, climate scientists were able to field questions and gain perspectives on the experience of disaster risk managers accustomed to making fast-paced decisions with sometimes-limited information. They were also able to carefully explain the meaning and margin of error associated with probabilistic forecasts. The group also explored factors that prevented disaster risk managers from making better use of climate products already available. These included the overly technical presentation of most forecast information and the need for information at higher geographic and temporal specificity than was readily available. Humanitarian actors also indicated that because forecasts were not accompanied by thresholds for action, it was difficult to know how to use them in preparedness and planning.

To mitigate some of these problems, workshop leaders explained strategies for pairing climate information for contingency planning efforts, taking participants through a series of different steps. They provided informational maps and seasonal forecasts, as well as information on population, infant mortality and food insecurity, and encouraged discussion regarding which information was useful. Participants were asked to conduct a risk analysis in which they assessed the likely geographic scope of a potential disaster, the number of people that might be affected, a region's underlying vulnerabilities, and the severity of potential impacts. After this, participants prioritized preparedness measures.

The seasonal rainfall forecast map provided a useful context for laying boundaries for the scenario development in contingency planning exercises, so that the disaster risk managers were able to be more specific. For example, the 2009–10 forecast highlighted that the year's El Niño event was not likely to be as severe as in 1997–98, so this information had the potential to shape the scenarios that would be developed as part of contingency plans.

However, participants also noted that they still had difficulty using seasonal forecasts to determine what areas would be worst affected and how many people would be impacted. Additionally, they relied on information that indicated vulnerability and population density to fully assess the risk. Participants were also dissatisfied with the population and infant mortality maps, indicating they were too coarse and out of date. Participants wanted better lead times of climate-information (Figure B5). These ideas are explored in more detail in Chapter 1 (see for example 'Identifying risks and vulnerabilities in Haiti' and 'Monitoring climate and weather changes in the Asia-Pacific region').

In this way, the workshop helped develop knowledge and understanding at the boundary between climate information users and providers. This 'boundary knowledge' implies an understanding of both climate information and disaster risk management. It helps disaster risk managers to understand the information that is provided, motivates them to seek out new and different information that might be useful, and helps them make effective decisions based on that information. In this way, capacity building and the development of boundary knowledge helps disaster risk managers to be better prepared to mitigate and manage the impacts associated with climate events.

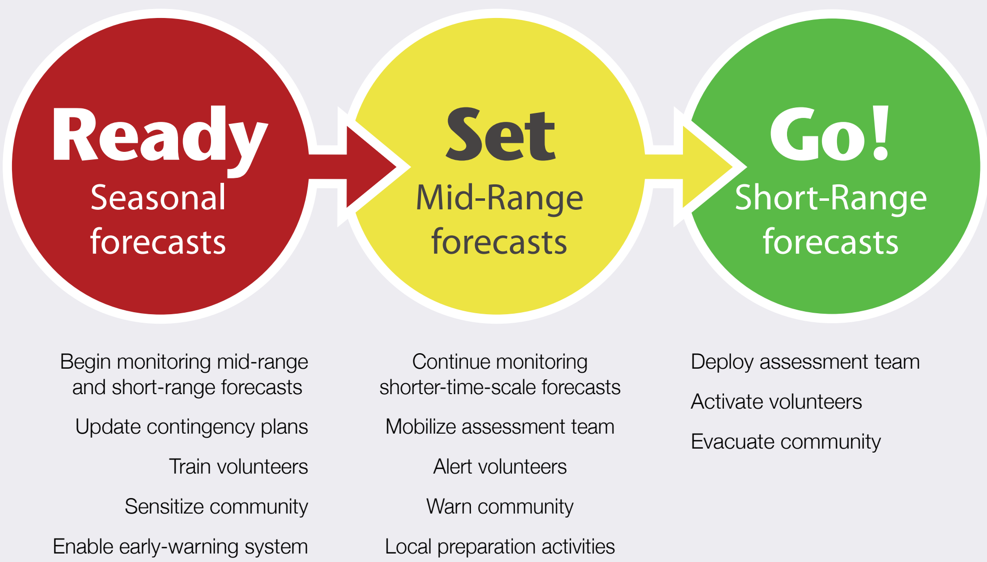


Figure B5: Ready-Set-Go tool demonstrating actions to be taken with seasonal, intraseasonal and weather forecasts.

incorporate climate information as one part of the analysis. In essence, climate information is able to add value to the existing decision-making framework. A critical step in this procedure is the translation of observed and forecasted climate anomalies into anticipated changes in crop production. The livelihoods framework then proactively identifies the anticipated impacts on vulnerable populations. As the food security community helped to develop the tools, there is immediate support for the use of climate information as it is integrated into their own system.

Learning to use probabilistic forecasts through games

Games simulating disasters, potential responses, and their effects can help disaster risk managers to understand to complexity of the problems they face. They also provide opportunities for disaster risk managers to become more comfortable using different types of climate information in managing risks. In contrast, games can also help climate scientists understand the context in which disaster risk managers operate and their needs. Both climate scientists and disaster risk managers are able to use games to explore the consequences of different strategies.

Well-designed games, like disaster risk management measures, involve decisions with consequences. Yet, unlike humanitarian decisions, the consequences of making a wrong choice while playing a game leads to learning, but no 'real' losses. Disaster risk managers can use games to improve their decisions in real-world situations by allowing them to test assumptions and gain a better understanding of the value of climate information. So, climate scientists can use games to help them understand the user perspective and the challenges in using probabilistic forecasts to actually make decisions.

Two games developed as part of an ongoing collaboration between the Red Cross/Red Crescent Climate Centre and the Parsons School for Design illustrate how game-based activities can help communicate complex ideas and facilitate collaborative learning and action. The first is called *Weather or Not* (see Figure 12), where each participant plays the role of a Red Cross disaster manager facing a simple but challenging decision – whether or not to preposition tents to shelter people likely to be left homeless by possible floods. In the game, scientists report that a storm of unprecedented magnitude is approaching. There is some chance the storm will miss the local watershed. If it does not, the storm will bring intense rain, inundating the community and destroying the only bridge that connects this community to the distant city where tents are stored.

A sequence of forecasts is communicated in probabilistic terms – i.e. a 70 percent chance of floods – and each participant has a few seconds to make a decision regarding whether or not to take action. A simple randomization process captures the stated probability and determines if the flood actually

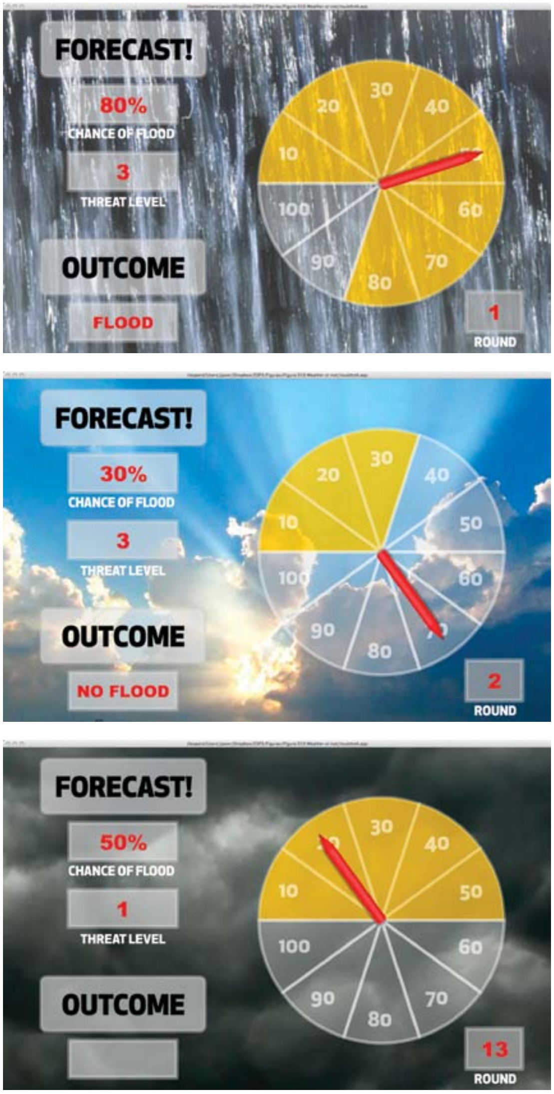


Figure 12: *Weather or Not* risk management game.

materializes. In each round, people see who turns out to have made the 'right' decision. There are four possible outcomes for each player, based on choice and flood occurrence:

- Success: Shelters are ready by the time people have to leave their flooded homes.
- Nothing happens: No prepositioning and no flood. No problem.
- Act in vain: Tents are set up but there is no flood. Resources are wasted and trust is diminished.
- Fail to act: People are left homeless and the bridge is destroyed, making relief tasks difficult and costly.

This game, in which a science-based forecast is turned into a yes-no decision, provides a simplified way for forecasters to experience the very real challenges faced by disaster risk managers once a forecast is issued. Forecasters recognize that actual forecasts are not as simple as in the game, and understand the need to improve the prediction tools. Similarly, after playing the game, disaster risk managers understand that at present, their default option is often to do nothing until the disaster materializes. Science offers them opportunities to act in preventive ways, while carefully weighing up the consequences of action and inaction in the face of climatic and other uncertainties. In some instances, the consequence of inaction may far outweigh the costs of action. In others, low cost or 'no regret' actions (i.e. actions that will be beneficial regardless of outcome) can be identified and pursued. Over time, it is acceptable to occasionally act in vain in order to save lives, livelihoods and resources through forecast-based decisions.

A second game called *Early Warning, Early Action* is designed for groups of six to eight players. A forecast card is drawn with

Role playing games allow people to explore the consequences of certain actions without any losses associated with 'wrong' decisions; Eric Holthaus

a plausible prediction, e.g. "There is a 70 percent chance that strong winds in excess of 120 kilometers per hour will hit the coast of Senegal within 12 hours." One player is the decision maker, who receives advice from the other players on how to prepare for the likely event. Advisors can take actions described in pre-made cards, e.g. "Take your children to their grandparent's home which is safer," or create their own action card.

In the first round, the decision maker chooses one of the action cards presented without discussion. This is designed to mimic the real world, since from household to national government levels, people often make decisions without any consultation. In subsequent rounds, the role of the decision maker rotates, while increasing levels of consultation and debate enable the decision maker and his or her advisors to discuss implications of the forecast and compare the pros and cons of each preparedness choice. The game is designed to raise awareness of the disparities in the knowledge and trust surrounding science-based predictions. It also brings up issues regarding the relative weight of various decision criteria, the role of 'no regrets' strategies, and the need for further dialogue.

This game also illustrates the extent to which disaster risk managers must understand the strengths and weaknesses of forecasts at different timescales if they are to use them to act responsibly. In addition, the game illustrates the risks and consequences of acting or not acting. *Early Warning, Early*

Action requires more skill than *Weather or Not*, because it allows disaster risk managers to develop no-regrets strategies such as warning and preparing local people, training local disaster risk managers, and developing alternatives where benefits will occur regardless of outcome.

These games are designed to help disaster risk managers learn to understand complex forecasts, and to help climate scientists understand the real context that disaster risk managers face. In game scenarios, the losses associated with 'wrong' decisions are obviously not as costly as in the real world, so disaster risk managers are able to explore the consequences of different strategies. Such games provide an opportunity for them to become more comfortable using forecasts across timescales with differing lead times to preemptively manage risks – an important step in preparing for action.

Establishing thresholds for action

Making decisions based on probabilistic climate information is not easy. By providing disaster risk managers with guidelines on the types of actions that should be undertaken given different forecast probabilities, thresholds for action can help reduce some of the burden on them. Establishing such thresholds is made difficult as it requires a good understanding of how well seasonal forecasts have corresponded to the occurrence of past floods, droughts and associated impacts. Linking thresholds to actions is also not trivial.

Disaster risk managers are required to make decisions based on forecast information – i.e. whether or not to preposition stocks in response to a forecast for a 50 percent chance of enhanced rainfall for the season. Decision makers will invariably act differently if there is less confidence in the forecast, such as if there is only a 30 percent chance of enhanced rainfall. This also raises an essential and overriding question regarding the use of climate information for disaster-risk management – how confident should the forecast be before action is taken?

Thresholds for action provide a critical protocol for disaster risk managers to move forward with preparedness measures based on seasonal forecasts of a given probability. Threshold-determined action is common practice given shorter time scale forecasts such as for hurricanes, prompting actions to evacuate an area. At the seasonal time scale, thresholds could be used similarly, taking pressure and accountability off individual disaster risk managers while allowing them to act faster, without having to weigh up the trade-offs for individual cases. Thresholds could also be re-evaluated and fine-tuned over time.

Unfortunately, systematically identifying the thresholds for actions is difficult, particularly given the range of actions that can be taken at different lead times and for different regional scales, and the uncertainty of the forecast outcome. Decision makers will have to be able to balance the cost of action and inaction given different choices, and counter that against the likelihood and consequence of a particular disaster occurring or not. In most cases, this will be interpreted intuitively by operational disaster risk management staff, for example, higher thresholds may be deemed necessary to justify higher cost interventions. Cost–benefit analysis may help, but undertaking them can be complicated by the lack of climate and impact data and the large set of measures which could be taken in aggregate.

When developing thresholds, it is useful to link particular seasonal climate forecast thresholds to the probability of occurrence of a disaster. This can be challenging where data are sparse, or where the relationship of rainfall in a given area in a given time period to flood or drought occurrence can be difficult to establish. A recent analysis of seasonal rainfall forecasts in southern and eastern Africa indicated a strong relationship between forecasts and occurrence of enhanced rainfall.

However, to be more useful for disaster risk managers, seasonal forecast thresholds should be translated into a measure of the probability of occurrence of a disaster. The aim is to inform disaster risk managers on how differing seasonal forecast threshold levels translate into disaster outcomes and 'false alarms'. The challenge of defining this threshold requires an understanding of how seasonal rainfall forecasts correspond to flood and drought, and in turn, to impacts on society.

Developing flood forecasting in southern and eastern Africa

The potential to make seasonal forecasts of heavy rainfall events was investigated at a recent workshop hosted by the Tanzania Meteorological Agency, and sponsored by the Red Cross/Red Crescent Climate Centre and the World Meteorological Organization. The workshop was conducted by the International Research Institute for Climate and Society and targeted at national meteorological services from Botswana, Malawi, Mozambique, Tanzania, Zambia, and Zimbabwe. Using their own daily rainfall records, delegates were introduced to methods for predicting changes in heavy rainfall risk at the national level.

Results for the Tanga region of Tanzania for example, indicated very promising levels of predictability for the number of extreme events in the October to December season, historically a period of frequent flooding associated with El Niño events. Given that the Tanga region is small and data from only a few stations were available, this result was very promising. It is reasonable to expect that even higher skill levels could be achieved if forecasts are made for even larger regions, although the usefulness of the forecasts may then diminish.

Nevertheless, based on the positive results, the Tanzania Meteorological Agency made an experimental forecast for the October to December 2010 season, and communicated the results to the Tanzania Red Cross. This work was critical because it allowed the forecasting of extremes in this region to be sustainable. New research regarding the forecasting of extreme events has helped disaster risk managers to better anticipate the hazards that may trigger disasters, but this type of information can only be produced at a meaningful scale when it is made by people in the region.

One attempt to establish thresholds for action occurred during testing of the Asia-Pacific monitoring framework (see Chapter 1), designed to help disaster risk managers monitor different information and identify changing risk factors. They stated that they preferred to have a fairly high level of certainty before taking action, and would only consider taking action based on a seasonal forecast if the likelihood of above- or below-normal rainfall outcomes was at least 60–65 percent – a very rare occurrence in the region.

Given the disparity between the willingness of disaster risk managers to act only in the face of high probabilities, and the low frequency of such, this effectively restricts their ability to use seasonal forecasts. What may then be needed is a range of actions given different forecasts. For example, increased awareness or training are 'no regrets' actions that could be taken when confidence is lower but still greater than climatology, whereas at higher levels of confidence the prepositioning of materials would be justified based on the heightened level of risk. In addition, it may also be instructive to present the information to disaster risk managers in terms of likelihood of disaster outcomes, helping to resolve some of the issues regarding interpretation.

Technical backstopping to improve understanding of ENSO impacts

A very useful service that climate scientists can provide to disaster manager is answering individual questions about the meaning or

Timely and tailored climate information can help humanitarian organizations deliver relief aid immediately after a disaster strikes rather than some weeks afterwards; IFRC

context of climate information. Such 'help desks' or other forms of offering immediate advice and response is proving to be increasing valuable, and should be further encouraged.

Even disaster risk managers who understand the use and value of climate information may find some aspects difficult to understand. They may want an expert to help them distinguish between conflicting reports, synthesize information on different time and spatial scales, or confirm that their understanding of a forecast or its possible impacts is correct. In such cases, technical backstopping helps disaster risk managers prepare to act. Technical backstopping in this case is the service that climate scientists provide to humanitarian organizations when they answer individual questions about the meaning or context of information. This can be provided through a range of formal or informal mechanisms, such as in the food security sector from the World Food Programme's Vulnerability Analysis and Mapping team.

Another example was recently set up by IRI in the form of a Help Desk supporting the IRI-IFRC Map Room. In its first full year of operation in 2009, it responded to questions on a range of topics far beyond its initial scope of Map Room support, including impacts of climate change, methods to assess flood risk, possible consequences of sea level rise, the validity of seasonal forecasts, and the impacts of natural climatic variability. Then in May 2009 as El Niño (ENSO) conditions developed in the tropical Pacific region, the Help Desk received an increased number of questions about the nature and impact of the emerging ENSO event. Disaster risk managers were particularly interested to know how strong the El Niño effect would be, how and when it would affect their region, and how they might best prepare. The Help Desk responded systematically to each of these questions, but they also used them to understand and better respond to the needs of disaster risk managers.

In one case, the Help Desk provided the IFRC with information that helped them to issue an emergency appeal to support national societies in East Africa. Concern was sparked when the Red Cross noticed seasonal forecasts for a mild to moderate El Niño effect, associated with higher than normal rainfall in East Africa. Based on the experience of the last major El Niño in 1997, the Red Cross was worried that the current event would result in significant flooding in some parts of the region, and the potential for displacement, loss of livestock assets and increased incidence of diseases.

The Help Desk clarified that the 2009 El Niño event was not likely to have the strength or the impact of the 1997 event, but that East Africa was still likely to receive above-normal rainfall in 2009. Based on this and range of other types of information, including the forecast issued by the Greater Horn of Africa Climate Outlook Forum, and taking into account the extreme vulnerability of the region, the IFRC decided to issue their appeal. Though it was poorly funded, their early action was not in vain. East Africa did in fact experience flooding late in their rainy season and precautions taken ahead of time shortened the response between disaster and relief operations.

Help Desk staff also worked with the Red Cross/Red Crescent Climate Centre to provide region-specific El Niño updates, providing historical El Niño impacts, upcoming seasonal forecasts, and contact information for regional information providers and other essential resources for continued monitoring. This helped them benefit from the long lead-time of seasonal forecasts, as well as specifics weather reports regarding where and when extreme rainfall events might occur. This issuing of ENSO updates tailored to needs of the Red Cross/Red Crescent continued in 2010, including five La Niña reports to keep disaster risk managers aware of where they might expect impacts from the events.

In this way, the technical backstopping provided by the Help Desk helps disaster risk managers clarify their understanding regarding ENSO and other events, and their associated impacts, and to develop appropriate strategies to respond. In East Africa, the Help Desk was also able to support an emergency appeal for funding and to encourage the Red Cross to strengthen their communication with local information providers before impacts were felt. The Help Desk also allows IRI to gather information on user needs, and ultimately bring more user-friendly and actionable climate information to the Red Cross/Red Crescent.

Summing up

This chapter has explored cases in which disaster risk managers and climate scientists have worked together to develop tools to help them prepare for action. This involves identifying how climate information can be integrated into strategies to plan for and respond to climate-related disasters, such as the tailoring of climate information for the precise needs of disaster risk managers, or the integration of climate information into existing disaster risk management tools and platforms. In many of the cases, their capacity to interpret climate information was improved by working with probabilistic forecasts and identifying thresholds for action.

Experience with the IRI-IFRC Map Room showed that information can more easily inform action when it is integrated into existing decision-making frameworks. As a result of close interaction between scientists and disaster risk managers, useful climate products were identified, but this was only the beginning. Over two years, climate information was refined through an iterative process, in terms of substance and presentation, to make it more understandable and to more accurately reflect user needs. These were put into the IFRC global information portal, making it available to IFRC throughout the world.

The Map Room provides useful information to help disaster risk managers take action at the global scale, but it is not meant to replace regional, national or local processes. In fact, when based on the lessons learned at the global scale, the development of equivalent tools and monitoring frameworks at more local scales, with local information and partners, can help disaster risk managers even more in their role of protecting lives and livelihoods.

Technical backstopping or a dedicated help desk is one of the key parts of continued

Are seasonal rainfall forecasts good indicators of flood risk?

Flooding is by far the biggest cause of all weather- and climate-related natural disasters, and so any advanced warning of an increased risk of such events can be extremely valuable for preparedness action by governments and humanitarian organizations. However, the nearest that most seasonal forecasts get to providing an indication of changes in flooding risks is the probability that the accumulated rainfall over a three-month period will be above normal (one-third of times), below normal (one-third) or normal (one-third).

So, the occurrence of above-normal rainfall is frequently not severe. More fundamentally, there is no clearly defined relationship between forecasted and actual accumulated rainfall over any three-month period, and flood risk, or even with the occurrence of heavy rainfall events. It is quite possible for above-normal rainfall to occur without any flooding at all, when for example there is fairly frequent but never particularly heavy rainfall, and for flooding to occur even when rainfall is not above normal because rainfall is infrequent but heavy when it does occur. Given the already large uncertainty in seasonal forecasts, the additional uncertainty introduced because the forecasts do not provide direct indications of flood risk raises questions about their usefulness for disaster risk management.

Disaster risk managers however, would very much like to have seasonal forecasts of the *actual risk* of flooding. Such forecasts, when they become reality rather than experimental research, would presumably provide a more direct indication of flood risk compared to current seasonal rainfall accumulation forecasts. One example of the benefits of producing seasonal forecasts of heavy rainfall events in Tanzania is discussed earlier in this chapter, but it is also possible to assess the degree to which current seasonal forecasts provide useful information about changes in heavy rainfall. For example, if the probability for an above-normal rainfall season is increased, can it be assumed that the risk of heavy rainfall events also increases, and, if so, by how much?

Using daily rainfall data from South Africa and IRI seasonal forecasts for November to January representing part of the rainy season for most of the country, the frequency of heavy rainfall events can be compared for different probabilities in the above-normal category. Rainfall data are at a higher spatial resolution than the forecasts, and so a question is whether the frequency of heavy rainfall events occurring anywhere within the forecast regions increases, without trying to specify precisely where the heavy rainfall events may occur. 'Heavy' can be defined in numerous ways, and the definition can be based on the actual amount of rainfall and/or on its frequency. For example, it could be defined as 'more than 50 mm in one day' or as 'rainfall that is exceeded on average only once per year'.

Rainfall accumulations over different durations can also be considered. For example, a one-day total may be useful for representing flash flood risk, whereas a five-day total may be more useful for more prolonged flooding. A definition based on actual rainfall is problematic because in areas with a relatively wet climate, heavy rainfall occurs fairly frequently, whereas such rainfall events might not occur at all in areas that have a relatively dry climate. What may be more important is how unusual the rainfall is for a specific location. For the purpose of this analysis, 'heavy' rainfall was defined using a range of thresholds from the amount of rainfall that is exceeded on average only once every five years, to the amount that is exceeded on average five times per year.

The IRI November–January rainfall forecasts had probabilities for above-normal rainfall of 20–40 percent. This range is fairly limited, indicating that no forecasts indicated very strong probabilities of above-normal rainfall. However, the forecasts for this period were likely to be accurate. Figure B6 shows that the frequency of heavy rainfall events regardless of how 'heavy' is defined, generally increases as the forecast probability for above-normal rainfall increases. Although there are some decreases in the frequency of heavy rainfall as the forecasted probability of the seasonal total to be above-normal increases from 20 to 25 percent, in general the increases in frequency are marked. For a doubling of the forecasted probability from 20 to 40 percent, heavy rainfall events increase in frequency at least threefold in the one-day totals, and at least six-fold in the five-day totals. These increases in heavy rainfall frequencies are also much stronger for the heaviest rainfall events, and demonstrate that the standard IRI seasonal rainfall forecasts provide a very strong indication of changes in the risk of heavy rainfall events in South Africa for this time of year. It therefore seems reasonable to use seasonal forecasts as forecasts of the changing risk of flooding.

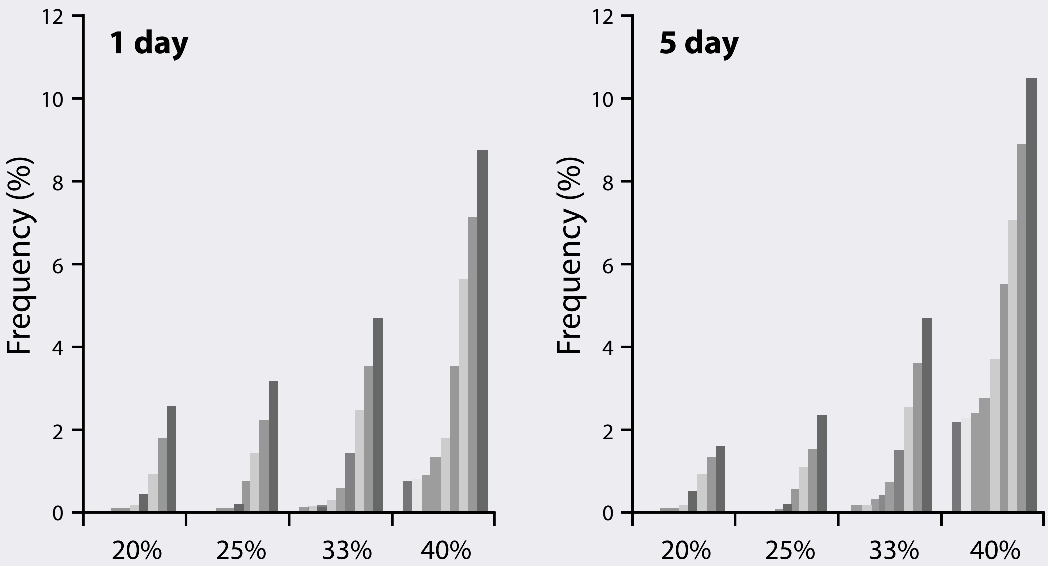


Figure B6: Relative frequencies of the occurrences of one-day and five-day 'heavy' rainfall events given different forecast probabilities for 'above-normal' November –January rainfall over South Africa.

The different bars for each probability represent different definitions of 'heavy rainfall'. From left to right, this is defined as the amount of rainfall that is exceeded, on average, once every five years, once every four years, once every three years, once every two years, once per year, twice per year, three times per year, four times per year, and five times per year.

interaction in regional or global partnerships. By enabling disaster risk managers to clarify their understanding of climate information, it allows them to develop appropriate strategies to respond to climate-related events. Technical backstopping provides disaster risk managers with the confidence they need to act, gathers information on their general needs and capacities, and ultimately also provides climate scientists with priorities for further development of tools and services.

Food security planning is another case where climate information must be tailored to meet the specific needs of users, and should be presented in formats that are readily accessible. In East and Central Africa, user-developed tools such as the Integrated Food Security Phase Classification and the Food Security Outlook process have proved critical in strengthening links between early warning information and effective response, by translating early warning data into projected food security impacts. Food-security monitoring tools process a range of information, including climate information, to analyze current and upcoming food conditions.

Disaster risk managers can also use games to improve their decisions in real-world situations, by allowing them to test out assumptions and gain a better understanding of the value of climate information. In addition, climate scientists can use such game exchanges to learn about the real-world context and consequences of the use of the information they provide, when disaster risk managers shoulder the burden of translating uncertain climate information into real action. Games are an effective and low-cost way for disaster risk managers and climate scientists to build capacity on how they can inform decisions, allowing decision makers to test different response and preparedness strategies given uncertain climate futures.

Establishing clear thresholds for action linked to certain probabilities would increase the timeliness of action and free disaster risk managers from unnecessary accountability to some degree. Unfortunately, linking specific actions to thresholds is difficult. One problem is that they are presented with complicated seasonal forecast probabilities, but this could be improved by presenting them with likelihoods of disaster outcomes given certain thresholds. Also, distinguishing which actions to take at different threshold levels can be problematic especially as many actions are grouped together in preparedness plans. Nevertheless, getting a better understanding of the cost, benefits and trade-offs of different strategies could help disaster risk managers make more balanced decisions, based on the likelihoods of consequences and avoided impacts, depending on different actions.

Chapter 3: Taking action

Integrating climate information into strategies and plans that result in real action to help mitigate, prepare for and respond to climate-related disasters is the focus of this chapter. The case studies show how disaster risk managers work with climate scientists to prepare appropriate solutions and implement plans. They also highlight some of the key barriers to action, as clearly demonstrated in the first case below. This chapter takes a closer look at where climate information is used to inform action, including challenges and opportunities. These also close the circle that started with problem identification, trying possible solutions, and developing tools – thereby completing the picture and allowing final conclusions to be drawn.

Forecasting dzuds in Mongolia

Seasonal forecasts were used to better understand the risk of Mongolia suffering a disaster due to a very cold winter and heavy snowfall reducing fodder availability. There was only a 20 percent chance of colder than normal temperature, and based on this forecast, it was decided that no action would be taken. In the end, an exceptionally cold winter followed, 8.4 million livestock died and the Mongolian government declared a state of emergency in 15 out of 21 provinces. Predicting the future is not easy and even low-probability events can and will still occur. This case illustrates the difficulties in using probabilistic information, as well as the importance of other factors such as vulnerability in making decisions.

In Mongolia, a dzud is a winter disaster that occurs when summer drought resulting in inadequate pasture and production of hay is followed by very heavy winter snow, winds and lower-than-normal temperatures. Dzuds occur when the winter conditions – particularly heavy snow cover – prevent livestock from accessing pasture or from receiving adequate hay and fodder, leading to large-scale livestock losses for the nomadic herding population. Mongolia experienced a series of intense dzuds between 1999 and 2002 and again in 2004-2005, so when 2009 proved to be a dry summer, the country was concerned that a severe winter would again reduce livestock populations. The regional Red Cross office wanted to launch an appeal for early action, but this could not be based on vulnerability alone.

To bolster their appeal for early action, they consulted seasonal forecasts in early December, including climate information from the International Research Institute for Climate and Society (IRI). This indicated that for the December to February (2009–10) winter season, most of Mongolia actually had a 45 percent chance of a warmer than average normal winter, with a 35 percent chance of a normal winter, and only a 20 percent chance of a colder than average temperatures. The IRI Help Desk also provided information on the strong long-term warming trend observed in Mongolia as a result of climate change. Given this forecast information, the Red Cross did not make an appeal for early action in December.

However, despite this forecasted shift in odds toward warmer temperatures, the winter of 2009–10 was very cold, with heavy snowfall across most of the country. Beginning from the end of December 2009, Mongolia saw a sharp and sudden drop of temperature combined with continuous heavy snowfall, recognized locally as dzud. The result was a loss of hundreds of thousands of livestock, leaving numerous herders without any source of livelihood. In mid- January 2010, almost US$150,000 was requested from the IFRC's Disaster Relief Emergency Fund (DREF) to support the Mongolia Red Cross in delivering immediate assistance (clothes, food, first aid) to some 6000 people. This was followed by an emergency appeal in March, requesting almost US$1 million in cash or in-kind services to support the Mongolian Red Cross to assist 13,600 beneficiaries for six months.

By May 2010, 8.4 million livestock had died and the Mongolian government declared a state of emergency in 15 out of 21 provinces. This case illustrates difficulties associated with taking action based on climate information, a key challenge being how to manage uncertainty. The probabilities were clear and the odds indicated there was only a one-in-five chance that the winter would be a cold one, but this experience underscores the fact less likely events can and will still happen.

Some of the uncertainty in this situation was derived from the fact that Mongolia's extremely cold conditions were the result of changes in the Arctic Oscillation, a pattern of atmospheric circulation where increases in atmospheric pressure in the polar regions

When summer droughts are followed by extremely snowy winters, Mongolian herd animals are unable to find fodder. The resulting disaster is known as a dzud; Enkhtor Dorjzovd/IFRC are associated with decreases in pressure at middle latitudes, and vice-versa. When the Arctic Oscillation is in its negative phase, a combination of high pressure over the Arctic and low pressure over mid-latitudes allows cold air to flow south, resulting in cold weather in Mongolia. However, although the Arctic Oscillation has a strong impact on weather in many areas at such latitudes, the phenomenon is essentially unpredictable at seasonal timescales. In addition, more consideration should have been given to the preceding summer drought.

Mongolia's 2010 dzud illustrates the difficulty of responding to probabilistic forecasts and of using uncertain information in decision-making, and highlights an important barrier to action. The 'certainty' or 'uncertainty' of potential climate events needs to be considered within the broader context of vulnerability and impact, and the basis for action or inaction must first and foremost consider vulnerability and impact assessments. That is, even when the uncertainty associated with climate information is understood and clearly communicated, it may still not provide an adequate basis for action. In this case, the absence of a clear indication of a coming cold winter, partly because of the long-term warming trend meaning less frequent cold winters, and partly because of the difficulty in predicting year-to-year increases and decreases in winter temperatures in this part of the world, the Red Cross was unable to issue an early appeal for dzud-preparedness funding.

Early warning leads to better pre-paredness and response in East Africa

Good early warning led to better flood preparedness and response in Kenya and elsewhere in East Africa. Thanks to partnerships developed between the Kenya and the East Africa Red Cross and a number of providers of climate information including the government, they were able to take appropriate action before and during serious flooding in 2009–10. Seasonal forecasts and knowledge of the effects of El Niño events put the government and humanitarian organizations on alert. Donors still did not respond adequately to advanced appeals, however, but use of core disaster response funds for preparedness activities was valuable, albeit inadequate. Also, despite improved understanding of seasonal forecasts, the exact timing of the rain still caught disaster risk managers off guard.

Kenya is particularly vulnerable to the effects of El Niño events, when associated weather patterns generally include above-normal rainfall during the country's October-December rainy seasons. Heavy rains during El Niño events in 1997–98 and 2002–03 resulted in the disruption of livelihoods, population displacement, loss of property and assets, damage to infrastructure, and death of people and livestock. As a result of these experiences, Kenya's disaster risk managers are now particularly alert during El Niño years, but this was not always the case.

Forecasts regarding El Niño impacts were first made available to the general public in 1997, but with no systematic means of distributing the forecasts, many disaster risk managers did not have access to the information. Even those who did see the forecasts had no experience using this kind of information or the potential implications, and there were no national plans or policies in place to effectively use this information at that time.

Unfortunately, the 1997–98 El Niño hit Kenya extremely hard. Torrential rainfall fell from October to December and resulted in over 1.5 million people being adversely affected (Government of Kenya, 2009). Heavy rainfall also continued through January and February, leaving no time for flood-affected populations to recover before the long rainy season of March to May began. By May, nearly a million people were still affected by flooding, and also by increased incidences in climate-sensitive diseases including Rift Valley Fever and malaria. The economic cost of damage to infrastructure totaled US$822 million, reducing annual GDP by 11 percent (Dilling and Lemos, 2011).

Over ten years later, the impacts of this disaster are still ingrained in Kenya's collective memory. Accordingly, disaster risk managers in Kenya's Red Cross take seasonal forecasts very seriously and have made large advances in preparing for flood events, and awareness and dissemination of seasonal forecasts has improved significantly. The Kenyan Red Cross have also developed partnerships with national and international meteorological organizations to ensure that they have the information they need to prepare for impending flooding, via their network of 62 branch offices and 70,000 volunteers distributed throughout the country.

The new decision-making processes were tested by the 2009 El Niño. By the time forecasts for this event were made, the Kenya Meteorological Department had already been working closely with the Kenya Red Cross for two years, with both present at relevant disaster management planning meetings. These include climate forecasting events such as the Greater Horn of Africa Climate Outlook Forum, an annual meeting that allows forecasters in the region to integrate national, regional, and international climate predictions into one consensus-based seasonal forecast.

Less formally, this partnership allows the Kenya Meteorological Department to keep the Red Cross office abreast of potential climate hazards directly by emails and telephone, and the Red Cross can consult the meteorologists whenever questions or concerns regarding information arise.

The IFRC East Africa regional office and the global headquarters have also developed partnerships with other climate organizations including the IGAD's Climate Prediction and Applications Center (ICPAC), African Center of Meteorological Applications for Development (ACMAD), and the International Research Institute for Climate and Society (IRI). As a result, they all provided the Red Cross with early forecasts of an impending El Niño event in 2009, bolstering the justification to take an increased risk of flooding seriously. By July, these forecasts showed that the probability of weak-to-moderate El Niño conditions continuing through the end of 2009 were more than three times higher as normal.

In August, a seasonal precipitation forecast for the entire region was developed and delivered at the Greater Horn of Africa Climate Outlook Forum, indicating that Kenya had an enhanced likelihood of above-average rainfall during the coming rainy season. At the same time, the Kenya Meteorological Department issued a national-level seasonal forecast stating that eastern Kenya and the Lake Victoria basin in the west were likely to receive above-normal rainfall.

In contrast to their experience during the 1997 El Niño, in 2009 the Kenyan Red Cross received multiple streams of information from national, regional, and global meteorological services. Access to information resulted from previously established partnerships and from a heightened awareness of the risks associated with El Niño. However, it still fell to the Red Cross to interpret the information and to determine how it could best be used.

Together with national agencies and other humanitarian organizations, Red Cross efforts played an important role in raising awareness and supporting planning for the expected flooding. It used the climate information provided by partners to take forwarding-looking actions including the development of a national level contingency plan, initiated several proactive preparedness measures, and worked with the World Food Programme (WFP) and the United Nations Children's Fund (UNICEF) to better meet people's needs in the region.

The forecasts also allowed the IFRC to launch two appeals in advance of the expected disaster. In September, a national level appeal was issued; this appeal integrated response measures such as food distribution, with preemptive strategies to increase food security by enhancing crop yields of subsistence farmers through the provision of seeds and fertilizer. There was also a regional 'East Africa: Preparedness for El Niño Floods' emergency appeal in October. Unfortunately, response was very poor, with less than US$40,000 received, or only 4 percent of the US$1 million requested.

Consequently, the IFRC was forced to rely on some US$170,000 from its Disaster Relief Emergency Fund, a pool of unrestricted money that ensures immediate resources are available for the Red Cross and Red Crescent to rapidly response to emergencies. Although it is well recognized that preparedness is key to timely response, IFRC disaster risk managers must carefully consider when to access funds in advance of an event, as they can run dry if donors do not replenish them. Nonetheless, preparations for the 2009 El Niño thus showed a marked improvement over the relative lack of preparedness witnessed in 1997.

When the 2009 rainy season came however, things turned out rather differently than was expected. During the 1997 El Niño event, heavy rains fell in October, but in 2009 it remained dry through to November. By the third week of December, there had still been little rain, and since the rainy season normally ends in December, people began to discount the forecast and rule out the likelihood of rainfall altogether. Disaster risk managers at all levels who had been on alert since September also began to let their guard down, suspecting that the risks associated with El Niño had passed.

However, during the last week of December, exceptionally heavy rains hit the region and continued unabated for nearly two weeks. Due to the delayed onset, disaster risk managers were caught off guard, and many disaster-response personnel were actually on leave at the time, thinking that the imminent threat had passed.

Despite this, the measures put in place before the season began did ensure that the IFRC was ready to act. As the Kenya Red Cross had strategically prepositioned key response resource, including 4000 non-food item kits, they were able to quickly distribute these needed items. They were also able to respond when many latrines were destroyed as a result of the flooding, contaminating drinking water sources and increasing the potential for outbreaks of waterborne diseases. Accompanied by a technical team, the Kenya Red Cross quickly deployed water and sanitation resources, and staff and volunteers excavated new facilities.

Advanced preparation by the Red Cross also helped some farmers take advantage of the opportunities presented by the rains. Although the flood-producing rainfall was destructive in many parts of Kenya, it was a blessing in the Ukambani region, for example, where farmers had received subsidized seeds through the Kenyan Red Cross national-level appeal based on forecast information. The Red Cross, in partnership with the Kenyan government and the World Food Programme, had distributed seeds to this drought-prone region hoping that above-normal rainfall would help them bring in a bumper crop. In the end, these preparations paid off, and by the end of February 2010 it was estimated that the US$500,000 worth of seeds had resulted in a harvest worth approximately US$3 million.

Partnerships the Kenyan Red Cross developed with local, regional and international climate information providers improved their response to the flooding caused by the 2009 El Niño event. At the same time, it is clear that despite this, disaster risk managers had expected the El Niño impacts to mimic those of 1997–98, which in some ways caught them off guard.

There are clearly still challenges to interpreting forecasts. Many humanitarian organizations continue to state that it is difficult to understand seasonal forecasts and to translate them into potential humanitar-

Rain-dependent farmers in Kenya may find climate information useful in helping them decide what and when to plant, allowing them to take advantage of good years and reduce losses in bad years; Curt Carnemark/World Bank

ian impacts. The likelihood of above-, near-, or below-normal rainfall through the use of probabilities causes difficulties, and in some instances, such technical packaging can lead to users oversimplifying or even misconstruing the meaning of a forecast. Furthermore, this example clearly shows that the impacts of El Niño events can vary greatly, which was not clearly conveyed.

This is underscored by a somewhat over-simplified interpretation of the impact of El Niño in the region. Whereas El Niño is a dominant source of climate variability, the information that reached the humanitarian community did not stress that it is only one of several factors that shape regional climate. For example, sea-surface temperatures in the Indian Ocean also play a significant role and can influence the magnitude of El Niño impacts (Nakamura *et al*., 2009). Yet, in some instances, the term 'El Niño' was mistakenly used to refer implicitly to a flood event – illustrating problematic oversimplification of the regional impacts of El Niño in East Africa. As such, perceptions of risk based on previous experience may override the more detailed picture provided by the seasonal forecast and other climate information products.

After the event, some members of the humanitarian community in East Africa admitted that they did not completely understand the probabilities associated with the seasonal forecasts they used in planning. In addition, despite the fact that the forecasts indicated that the 2009–10 El Niño was very unlikely to reach the magnitude of the 1997–98 event, the general perception of risk in Kenya was dominated by the memory of the outcomes of the earlier flooding. Disaster risk managers were also challenged by the fact that forecasts indicated a relatively weak shift in the probability of higher-than-normal rainfall, despite the fact that there was a high probability of an El Niño event.

Improved and sustained dialogue between the climate and humanitarian communities would help to ensure that forecasts, and their uncertainty, are completely and properly understood. Predicting the future is not straightforward and prone to error, but developing a common and realistic view of possible disaster outcomes allows for better preparation, a key element of a successful emergency response, alongside adaptability and improvisation.

To inform action, it is also important to communicate that different levels of information are needed at different times in the disaster risk management cycle. Although a seasonal forecast does not predict the actual rainfall, it does suggest several very critical pieces of information as a basis for action. In this case, these were that (1) the flood risk was high, (2) the drought risk was low and an extended rainy season was possible, and (3) there was an increased risk of waterborne diseases.

In that sense, the Red Cross was successful in prioritizing flood preparedness in the areas most prone to flooding, and in providing sanitation kits to help minimize waterborne disease. These actions did not require the complete certainty of how much rain and where it would fall, and this case study shows how through the process of monitoring and preparedness, different levels of action were taken.

Despite the lack of response to the emergency appeal, disaster risk managers were still able to effectively use the limited response funds available. Preparedness appeals do not always achieve expectations, but they have great communications value. However, allowing disaster response funds to be used in part for preparedness activities was useful, if inadequate, in this case where there was a clear threat.

Using climate information to take action in the Pacific

Forecast information for Pacific Islands was translated twice before reaching national Red Cross societies. The extra steps of simplifying the information so it can be better understood greatly increases its use by those on the ground, and better informs decisions for tangible actions to protect the health and well-being of vulnerable communities affected by climate variability and change. National societies in Kiribati and Tuvalu made use of climate information for enhanced preparedness by using the seasonal early warning information to develop and enhance relationships with their meteorological services and with government partners with the capacity to support and build upon the Red Cross's risk reduction efforts.

La Niña is a natural part of climate variability, and refers to a colder-than-average period in the equatorial Pacific (the opposite of warm El Niño events). Over time scientists have observed that some islands in the Pacific tend to experience drought during La Niña events, while others experience above normal rainfall and heightened flood risk. Due to their limited water resources, droughts affecting Pacific Islands can be particularly problematic, having implications on food security, water and sanitation, health and livelihoods.

The La Niña event that emerged in June 2010 developed into a moderate-to-strong event and was projected to last through the early months of 2011. On 31August 2010, the Red Cross/Red Crescent Climate Centre and IRI through their Partnership to Save Lives, began issuing a series of monthly global La Niña updates for the Red Cross/Red Crescent. The updates contain seasonal forecast information for the coming three months in a format tailored to user needs, helping the Red Cross identify how this particular La Niña event, combined with other factors in the climate system, is likely to affect various areas.

When the IFRC Regional Office for the Pacific received this information, a training officer adapted the information further specifically for the needs of national Red Cross societies in the Pacific. The language was simplified, also drawing on information from regional information providers such as the Australian Government Bureau of Meteorology, enabling him to include forecast maps detailing each of the Pacific islands in his briefing notes to national societies.

National societies were urged to contact their national meteorological agencies to monitor conditions and local forecasts, and to contact their national disaster management offices for a coordinated response. For island nations with heightened flood risks, the national societies were urged to prepare by: restocking disaster relief container items with non-perishable items such as drinking water containers; monitoring water and food quality, access to safe water, sanitation, drainage, health education, and hygiene promotion; strengthening early warning systems for vulnerable areas (evacuation training, training volunteers, etc.); revisiting disaster management plans; and identifying the most vulnerable communities. Island nations projected to have increased drought risk were advised to develop their national drought plan, observe any sign of drought impacts happening already that would trigger activation of the drought plan, and conduct basic hygiene awareness programs like hand washing and water conservation suitable to their own country.

The IFRC noted that the La Niña updates from the Red Cross/Red Crescent Climate Centre and IRI were extremely useful and 'not too technical'. Importantly, the updates prompted IFRC and national societies in the region to engage directly with national meteorological services and regional information sources such as the Pacific Island Climate Update and the National Institute for Water and Atmospheric Research (NIWA), for timely updates and alerts. The updates were also shared with partners such as UNOCHA and Fiji's National Disaster Management Office, to enhance their awareness of the situation and coordinate actions, and these partners and national Red Cross societies have been extremely receptive and appreciative of the information. In Kiribati and Tuvalu, where the projection was for drier than normal conditions, the information also prompted drought preparedness activities in advance of the current dry period that would otherwise not have taken place.

Upon receiving the message from IFRC, the Kiribati Red Cross first contacted their national meteorological service to confirm the forecast information. The forecast was then discussed with the Kiribati Red Cross Secretary General, and it was agreed an effort was needed to raise awareness about typhoid, a waterborne disease known to spread in times of drought if available water supplies become contaminated. The Kiribati Red Cross informed the ministry of health and requested their support in doing awareness-raising activities on the disease. Together, three volunteers, two staff and the Secretary General along with four representatives from the Ministry of Health went to seven communities to raise awareness about typhoid, reaching more than 1000 people in two days. Communities were informed about typhoid prevention, treatment, causes, and the link to drought conditions currently being experienced. Communities were also encouraged to conserve drinking water and maintain hygiene practices to minimize health impacts in times of scarce water resources.

The Tuvalu Red Cross also promptly made contact with their local meteorological office, the National Disaster Management Organization, and the water authority. As a result, they received daily weather updates, updates on the water supply, and established partnerships with key stakeholders for collaboration. Since the only water resources in Tuvalu come from the rain and the sea, the Tuvalu Red Cross decided to conduct an awareness raising campaign about water management over the radio, being the main means of communication and the best way to reach populations on remote outer islands. Through the radio announcements, people were informed that the only fresh water resource is rain, and if it does not rain for a number of weeks, water shortages will result. Thus people knew to purchase water from the government, and to conserve water by bathing in the sea.

Building long-term community resilience in Kenya

As an analysis of historical climate records indicated that drought occurrence was becoming more frequent in Taita Taveta, Kenya, an appropriate risk management response was developed to increase one community's resilience to drought and decrease food insecurity. This was achieved through the development of an irrigation canal network, effectively enhancing their assets and livelihood outputs.

For the past two decades, the World Food Programme has worked with vulnerable communities in Kenya to improve food security by enhancing resilience to climate-related hazards. These efforts had previously been incorporated into emergency response operations, but a series of devastating droughts led to greater attention to longer-term relief and recovery programs emphasizing capacity building within communities to mitigate future drought.

In 2006, community members in the district of Taita Taveta, Kenya voiced concerns that free food distribution with no work output required did not provide a permanent solution or help address the cause of the district's food security problems. They suggested that their community was experiencing a regular cycle of drought, more frequent and severe in recent years that limited people's ability to lift themselves out of poverty. Changes in seasonal rainfall patterns and more erratic rainfall had also made it difficult to rely on traditional rain-fed farming methods.

The District Steering Group, responsible for assessing, addressing and coordinating food security issues at the local level, consulted with the Arid Lands Resource Management Programme, led by the Government of Kenya, to verify the issues raised. The government's historical records, documenting monthly rainfall totals as well as precipitation patterns during the planting season, supported the observations.

As a result, the World Food Programme joined with the Government of Kenya, World Vision and the community to address the climate-related risks that were exacerbating food insecurity in Taita Taveta (WFP, 2010). The partners instituted a Food for Assets program, allowing people hardest hit by chronic food shortages to be given food while participating in risk-reduction and resilience-building projects. The activities were intended to reduce people's vulnerability to climate-related risk, while at the same time creating assets that boost their chances of growing or buying enough to feed their families in the future.

In one major activity, the community rehabilitated the Njoro Kubwa irrigation canal, built in 1948 but which had become blocked over the years. The program also worked to extend the canal network deeper into farmland where irrigation water had not previously been available. Over three years, more than 4500 people were provided with food while they worked on irrigation canal improvements. Importantly, 460 households

Increasing long-term food security: beneficiaries of the Food for Assets program perform regular maintenance on a canal network in Kenya; David Kamau, WFP

have at least 230 hectares of land between them that can now be irrigated, and time spent finding water has been reduced by up to two hours each day (WFP, 2010).

A functioning canal network buffers the community against direct climate impacts. During heavy rainfall, runoff is captured in the canals and saved for drier periods, and farmers have a source of water for their crops and animals should the rains fail. Since the project's inception, the community's food security levels and ability to withstand weather-related hazards has significantly improved, crop production have increased by 33 percent and household income has increased by an average of 45 percent.

By understanding and addressing climate risks, including changes in seasonal rainfall and its increased variability, the World Food Programme, World Vision and the Government of Kenya have helped part of the district to gradually decrease their vulnerability to climate shocks and their need for repeated food assistance.

Sharing risks in the Caribbean

Sharing risk is one means to reduce the impacts of climate-related disasters. Using insurance mechanisms can offset the impacts, and index insurance greatly speeds up payouts and the rapidity of implementing response measures. Joining them together would

Beans, tomatoes and maize flourish in the fields of Taita Taveta thanks to resilience-building measures; David Kamau, WFP

appear to offer multiple benefits. Many small countries and territories in the disaster-prone Caribbean decided to do just this, and set up the Caribbean Catastrophe Risk Insurance Facility. The following shows how this helped trigger a quick response following a disaster in one small island, and the potential of such a scheme for other regions and other climate-related disasters.

Governments, relief agencies and local communities bear most of the costs of responding to large-scale disasters. To deal with escalating costs, governments are increasingly using insurance mechanisms and weather indexes to help them manage risk more effectively. This subject was the topic covered in great detail in the previous book in the series published by the International Research Institute for Climate and Society (Number 2, Hellmuth *et al.*, 2009). These offer payouts when extreme weather events occur, offering the key advantage of speeding injections of cash allowing for more timely response. Another advantage is the ability to make concrete plans even before disaster strikes, knowing that funds will be available when they are needed. Such a risk-sharing scheme in the Caribbean provides a good example of the experience and benefits offered.

Tropical Cyclone Earl passed close to Anguilla on 30 August 2010, bringing with it heavy rains and winds of more than 160 kilometers per hour. It tore off roofs, brought down power lines, destroyed boats and ships, eroded beaches, and caused significant flooding of government and other buildings. Anguilla was provided with some early warning forecasts on the potential impact of Earl by the Caribbean Catastrophe Risk Insurance Facility (CCRIF). As a result, emergency agencies were put on standby and emergency shelters were opened in advance of the storm, and this preparedness was attributed with a reduction in damage and loss of life.

Anguilla is one of 16 member countries and territories that participate in CCRIF, the world's first multinational index insurance scheme. It spreads the risk, and thus the cost, of hurricanes and earthquakes across the Caribbean region. As the risk of natural disasters occurring in any given year are distributed throughout the Caribbean region, the cost of coverage for the pooled portfolio is less than the sum of the costs of individual coverage for all the members. This 'risk spreading' or pooling of country-specific risks reduces individual insurance premiums by almost half compared with the cost if a government were to approach the reinsurance market independently.

Less than 24 hours after the hurricane passed Anguilla, CCRIF determined that an insurance payout would be made and indicated the approximate amount to the government. Two weeks later after verification of the payout calculations, more than US$4 million was transferred to the government. This amount was paid based on its catastrophe insurance policy for hurricanes which forms part of the country's disaster risk management strategy, and represents almost 20 times the annual premium of US$225,000 that the Anguillan government pays for hurricane coverage. The money went into a special recovery fund, expenditure from which is controlled by a newly-convened committee to ensure transparency and fiscal control.

The innovation of CCRIF is in the use of an index that transforms the measured intensity of the hazard to a loss estimate, based on wind speed and storm surge for hurricanes, and shaking intensity for earthquakes. Therefore payouts can be calculated and made very quickly because there is no need to wait on loss adjusters to estimate damage after an event, which can take a long time. The payout determination for Anguilla was made based on projected government losses calculated using storm data from the US National Hurricane Center, within a catastrophe loss estimation model that underpins CCRIF's policies.

The model includes a representation of the value and distribution of government exposures that replicates, as closely as possible, the actual way in which losses occur on the ground. In particular, as a low-lying island, Anguilla is at risk of coastal storm surges and wave damage, which have both short- and long-term detrimental impacts on the tourism-based economy. Sharing the risk with other countries in the Caribbean, and the immediate disbursement of resources, allowed Anguilla to recover more quickly than it would have done in the absence of this strategy.

Summing up

The real proof of success with climate-informed disaster risk management is whether it results in improved outcomes, typically measured in saved lives, livelihoods and assets. Clearly however, as this chapter has demonstrated, certain challenges must be overcome before action, whether it is preparedness, response or mitigation, can be successful.

In Mongolia, the risk of dzuds based on seasonal forecast information was deemed too uncertain to provide a basis for action, despite identified vulnerabilities. The Kenya case however, shows that disaster risk managers can improve mitigation, preparedness and response when provided with clear and actionable climate information. Conversely, where there is ambiguity, action can be less efficient. Seasonal forecast information provided early warning in the Kenyan example, resulting in improved and more advanced preparedness activities. However, the implementation was delayed in some instances because the possible timing of the rains was not fully understood.

Decisions to protect communities from climate variability and change were better informed in the Pacific thanks to forecast information undergoing being adapted to user needs. In the Caribbean, through an innovative risk-spreading program, a clearly defined weather-index triggers a quick payout, allowing disaster risk managers to have immediate access to resources, allowing for more efficient and timelier response. In Taita Taveta, Kenya, concern about recurrent droughts led to a shift towards risk reduction activities, including the rehabilitation of irrigation canals that emphasize building the capacity of communities to mitigate future drought.

Translating climate information into forecasts of potential impacts is sometimes not possible, and unless it can be done, it makes it very difficult for disaster risk managers to act on it. In addition and very importantly, donors are frequently reluctant to fund preparedness measures based on advanced warning from climate information. Despite these challenges, however, disaster risk managers have found ways to take decisive action and use climate information to help them prepare for, respond to, and mitigate the impact of disasters.

Concluding lessons and recommendations

This book has explored the use of climate information for disaster risk management, and the findings have repeatedly highlighted the importance of partnerships as a critical ingredient for success. The case studies and analysis drew upon emerging experience, capturing new and innovative practice in striving to improve disaster risk management through the improved use of climate information. The resulting findings and recommendations will enable others to gain from their experience, as diverse groups and communities of practice come together to build valuable climate services for improved disaster risk management.

Climate-related disasters are growing in number and severity, with increasing impacts on economies, lives and livelihoods. Climate change is an additional factor, adding a further degree of uncertainty to decision-making. These trends have made the shift from simply responding to emergencies toward the need for strategies and policies that emphasize preparedness and prevention of disasters, even more urgent. One element of that shift is a better use of climate information to anticipate disasters and act ahead of time to reduce their impacts. That demand fits well with the recent efforts of climate information providers, research institutes and information users to provide more useful information to society, by organizing themselves around the concept of climate services.

The book has employed a three-step problem-solving framework as a practical means of demonstrating the challenges and opportunities facing disaster risk managers in using climate science in their work.

1. Identifying problems and possible solutions. This includes identifying risks and vulnerabilities, relying on humanitarian expertise, and understanding the relationship between the climate and socioeconomic context.
2. Developing the tools. This includes integrating climate information into existing decision-making frameworks, developing tailored climate information and user oriented tools in partnership, developing boundary knowledge, and ensuring new knowledge products have technical backstopping to avoid costly misinterpretation and to build capacity over time.
3. Taking action. The final stage requires understanding the real opportunities and limitations of climate information. This requires translating often uncertain information into potential impacts and actions, and overcoming the lack of resourcing for preparedness and prevention. Ultimately

it means taking action based on climate information to reduce climate risk, and mitigate, prepare for and respond to climate-related disasters.

Those in the humanitarian and climate information fields share a common objective of protecting lives and livelihoods, which can best be realized by closer and more effective collaboration. In each of these stages, partnerships were found to have been essential to success. Disaster risk management and climate science both require very specialized knowledge and skill sets, which must be combined to navigate the best way forward. Much of the process of working together necessarily involves gaining a greater appreciation and understanding of the needs and limitations confronting both disaster risk managers and climate information providers.

This concluding section distills the lessons learned, and provides guidance to disaster risk managers, climate scientists, and others planning to invest in climate services for disaster risk management in the future. Many of the lessons are not unique to disaster risk managers and also apply to other sectors looking to integrate climate information into decision-making.

Improved use of climate information to reduce the suffering of vulnerable people is a key developmental aim – and transferring this knowledge and practice is necessary to meeting the challenge at scale; Abir Abdullah/Oxfam

Lessons learned

- **Information platforms help disaster risk managers quickly and easily identify and monitor risks and vulnerabilities.**

Having to deal with a range of complex and conflicting sources restricts the value and use of climate information for disaster risk managers. Trusted 'one-stop shops' can provide an easily accessible, tailored and quality-controlled suite of hazard and vulnerability data, which can help decision-making and enable more effective decisions. When combined with well-trained 'boundary specialists' – staff in humanitarian agencies with strong climate knowledge or staff in climate agencies that fully understand the context of humanitarian applications – these tools can help provide earlier and more accurate early warning. In Haiti, a team of scientists and practitioners developed just this kind of solution to facilitate decision-making in a complex emergency. The Asia-Pacific case study also provides an example of the development of a one-stop-shop monitoring framework designed to monitor risk and prepare for action in advance, in routine operations.

- **Existing information platforms should be strengthened by explicitly linking climate information to possible actions, including through the development of thresholds and triggers for action.**

Although decision makers in Haiti responded favorably to the information platform, strengthening links between early warning information and adequate response would improve the means for disaster risk managers to take action. Establishing thresholds for action linked to pre-defined probabilities for the likely occurrence of disaster conditions would make it easier for disaster risk managers to act. However, such thresholds are difficult to establish, because climate information must be correlated to potential impacts, and because disaster risk managers need to weigh up costs and benefits of action and inaction given a certain probability of occurrence. At a seasonal timescale in the context of flood preparedness, one of the challenges is that most forecasts only provide information on accumulated rainfall over a three-month period, rather than individual extreme rainfall events that causes flooding.

However, validation efforts in South Africa demonstrated a strong correlation between seasonal rainfall forecasts for enhanced rainfall and realized extreme rainfall. In Asia, threshold levels selected by users based on traditional seasonal forecasts indicated that climate information would only be a cause for action in very few cases – suggesting a need for both capacity building and identifying differing actions and strategies given different thresholds. Correlations between thresholds and potential impacts are used in index insurance, e.g. wind speed or rainfall are used as proxy information for potential damages. In the case of the Caribbean index insurance scheme (CCRIF), such risk-sharing helps to mitigate impacts on potential victims of climate-related disasters because resources are immediately available when a particular threshold is exceeded. The use of climate information as a trigger for insurance payouts reduces the lag time in resource distribution, allowing for quicker response.

- **Integrating climate information across time scales into disaster risk management systems can help reduce risk and improve response.**

Disaster risk managers are constantly dealing with uncertainty and risk, balancing limited resources against the potential consequences of disasters. In 2009, the Food Security Outlook process provided a powerful example of how the integration of historical trends, seasonal forecasts, and real-time climate observations can motivate early and effective disaster response. This process allows disaster risk managers to establish and maintain the readiness to respond, while using early warning data as seasonal forecasts to focus and scale up preparedness measures as uncertainty decreases. This approach has been found to

Effective partnerships and platforms allow for better coordination and implementation be more effective than a constant process of scenario development and contingency planning for each potential hazard based on the static information in those scenarios. The monitoring framework developed for the Red Cross Asia-Pacific Disaster Management Unit (DMU) is an example of a method that allows decision makers to keep abreast of developing situations by monitoring weather and climate information across time scales, allowing disaster risk managers to become aware of, and respond earlier and appropriately to changing risks.

- **Integration of climate information into user-designed decision-making frameworks enables the information to immediately add value to complex decisions.**

Disaster risk managers factor a complex array of information into their decisions, most of it relating to the social, political and financial environment, and the practicalities of implementing particular activities (including logistics). When climate information can be integrated seamlessly into that decision-making rather than being supplied as a standalone item, it can be more easily incorporated into the development of strategies and decisions. User-developed platforms are advanced in food security, as demonstrated by some of the tools presented in Chapter 2. These incorporate a range of climate and non-climate information to produce an analysis of food security situations and needs, fostering durable relationships between users and producers of climate information. For these tools to be successful, however, they must be based on sound principles of disaster risk management and on good climate science. Processes such as the training workshops in Kenya which brought together humanitarian actors and climate scientists, demonstrate the demand for this type of interaction.

- **Development of trust between climate and humanitarian communities is paramount to success at regional, national and local scales, and is fostered through capacity building.**

Targeted efforts are needed to build the capacity for integrating climate information into disaster risk management practice, partnerships and policy at regional, national and local scales. This requires the provision of credible information, and an understanding of the opportunities provided by the information as well as the limitations. Educating both climate information users and providers helps each party to understand the challenges associated with developing effective solutions, establish realistic expectations, and thus foster trust and ultimately improve outcomes. Tools that are incorporated into user platforms, including the Map Room, have proven useful partly because they were explicitly designed to meet user requirements, rather than simply supplying what science happened to produce. The development of regional partnerships between humanitarian organizations and regional climate institutes is another important step in the right direction. Such partnerships should be broadened with a wider range of partners, and seen as continuous processes, fine tuning the interaction and increasing trust based on common experience.

- **Problems that stem from the divergence between the needs of disaster risk managers and the abilities of climate science providers are often revealed and solved through a process of careful collaboration, which can also result in the identification of new products and topics for further research.**

Tailoring of information to meet specific needs is an essential step in enabling disaster risk managers to quickly understand and effectively use the climate information. In some cases, new research may be required in order to develop climate information products that can improve prevention, preparedness or response. This is demonstrated by the IRI/IFRC Partnership to Save Lives, triggering new research into seasonal forecasts of the likelihood of extremes within a season. In most cases, however, gaps in information can be more easily identified and solutions produced with little to no new research, as was the case in the same partnership with a dedicated Map Room which put existing weather and climate forecasts into context with improved presentation.

- **Institutions at the boundary of providers and users of climate information help to build common ground between disaster risk managers and meteorological services.**

Institutions at the interface between users and providers of climate information have some expertise in both disaster risk management and climate science and are thus able to communicate well with both communities. Such boundary institutions, which may either be applications-oriented units in science institutes or science-oriented units in humanitarian and development organizations, can act as intermediaries by facilitating interactions and communication between the various and often diverse partners. Technical backstopping, such as that provided by help desks, demonstrates the important role that boundary institutions play in translating and distilling climate information to enable better decision-making.

- **Games provide a low-cost opportunity to test knowledge and assumptions, building capacity of both users and suppliers of climate information.**

Well-designed games can simulate decision about if and how to take action based on climate information without real cost or consequence. Such games can help raise awareness and build capacity to absorb information among disaster risk managers. But they can also facilitate more meaningful dialogue between climate information providers and stakeholders making decisions about disasters.

Effective response to disasters is important, but it is not enough. Reducing disaster risk in the long term by building the resilience of local communities is now seen as essential; SALTBONES, Olav A./Røde Kors

Discussions about the strategic use of climate information to optimize the chances of winning the game can also influence the way information is presented by climate scientists. This usually makes information more actionable, and builds the capacity of humanitarian organizations to take and combine climate information and real world scenarios. Such games allow disaster risk managers and climate scientists to understand the limitations and potential opportunities of the information. Also, ensuring that disaster risk managers can use and understand the information contained in probabilistic forecasts helps them feel more comfortable taking actions based on them.

- **Disaster risk managers realize that effective relief is not enough – they are equally concerned about reducing disaster risks in the long term. As a result, they have begun to focus on resilience building, which targets solutions to the root causes of vulnerability rather than the immediate impacts of climate hazards.**

The rising costs and increased number of disasters are putting an increasing strain on the humanitarian capacity for effective disaster response. Global changes, including population growth and climate change, threaten to exacerbate the situation. In line with the Hyogo Framework for Action (UN, 2005), all humanitarian agencies are now also investing in disaster risk reduction, including enhancing response but also particularly addressing underlying risk factors related to the exposure and vulnerability of people and assets.

Evidence that preparedness and prevention can save more lives and protect more livelihoods is growing. The World Food Programme's Food for Assets program in Kenya is an example of a shift in investment strategy toward an emphasis on building the capacity of communities. In this case, people hardest hit by chronic food shortages were given food in exchange for participation in mitigating future drought by building infrastructure to protect them against climate hazards. This step was taken because it was clear that food distribution was not addressing the cause of one district's food security problems, and droughts were becoming more frequent.

In the future, these development efforts could also benefit from a more thorough incorporation of climate information. But this is only one example, and much more needs to be done to build a culture of prevention, including the provision of sufficient and sustainable resources.

Recommendations

- **Initial efforts to integrate climate information into disaster risk management should focus on immediate opportunities and potential 'quick wins', such as areas where seasonal forecasts are more reliable, and where humanitarian decisions can provide relatively strong and immediate returns on investment.**

Historically, disaster risk management has not systematically benefited from climate information or interactions with climate scientists. However, the changing mandates of both communities, coupled with increases in the cost and number of disasters and the additional burden of climate change, has necessitated more interaction. Processes that bring together partners to discuss needs, opportunities and limitations, are important steps, and if successful, foster longer-term sustainable relationships and improved outcomes.

- **Information should be integrated into decision-making platforms, making climate information easier to use by disaster risk managers in their daily activities.**

Integrating climate information into exiting frameworks is an effective strategy to help disaster risk managers deal with climate-related risk. The food security community has successfully integrated climate information into several existing tools and platforms –

allowing climate information to be directly incorporated into decisions alongside other important food security variables and determinants. The IRI/IFRC Map Room is another example which puts weather and climate information into context for decision makers, allowing users to immediately determine areas at risk. The Map Room is located in the IFRC's information portal, making it easily accessible to humanitarians around the world. Many disaster tools, decision making processes and procedures have been designed for post-disaster interventions, so are in need of revision to include early warning, preparedness and adaptation.

- **The relative contribution of seasonal, decadal, and long-term trends to current and future climate should be presented more clearly to better inform strategic decisions.**

Just as the weather varies over short periods, climate varies over longer time scales – from season to season, year to year, and decade to decade. Climate change adaptation strategies that do not take these differences into account may be ineffective. Climate variations over decades are particular to certain parts of the world, and in some areas have the potential for prediction. Although science is still far from being able to predict climate for a particular place over the next few years, looking at past climate records can help us understand how and why climate varies at annual, decadal and century time scales. Disaster risk managers need to understand that variations at annual and decadal time scales have a greater impact on climate variability over the next few decades than long-term climate change. It is also important for them to understand that annual and/or decadal variations could either enhance or counter the expected climate change trend. By carefully observing, analyzing, and modeling climate changes over the last 20–30 years, disaster risk management systems can predict potential risks over the next few decades. This can support adaptive management, whether the specific trends are anthropogenic or not.

- **Climate information providers can better support disaster risk management by increased interactions with users.**

Support for climate services as an important contribution to development, climate change adaptation, and disaster risk management agendas is growing. Building on the idea of weather services, climate services encompass a range of activities including generating and providing information on past, present and future climate, and on its impacts on natural and human systems. The examples presented in this book clearly demonstrate that the provision of useful, targeted and effective climate information requires close collaboration and interaction between climate providers and disaster risk managers. Such iterative interaction often results in the identification of new tools and the complete revision of how climate information is prioritized, packaged and presented.

- **Disaster risk managers should enhance their understanding of the potential and limitations of climate forecasts and information, as the development of realistic expectations is vital to good decision-making and to maintaining trust with information providers.**

Improved understanding and capacity with regards to how weather and climate information can be used for prevention, preparedness and response activities is vital. In some cases climate information could be simplified in its presentation or communicated better by climate scientists, but disaster risk managers also need to invest in a better understanding of the limitations, opportunities and uncertainties associated with the information. Where disaster risk managers failed to use or communicate relevant climate information, they and the at-risk communities they serve have been caught off-guard. However, unrealistic expectations can also prove harmful. Expectations about climate change that do not fully appreciate historical variations in the climate may lead to inappropriate strategic decisions. Conversely, opportunities can be missed if climate information is not well understood and disaster risk managers fail to take the information into account in decision-making. Dialogue between disaster risk managers and climate scientists, including capacity-building workshops, games and iterative production of knowledge products and tools, can serve to build the capacity of both communities.

- **Donor agencies should provide stronger support for disaster preparedness and prevention, including more systematic funding for early action based on relevant climate information.**

Although recent research and agreed international policies clearly state that risk reduction is a cost-effective intervention in disaster-prone regions, it still remains a relatively low priority within donors' humanitarian and development planning and programming budgets. This is a persistent obstacle to the development of a preventive culture, and risk reduction needs to be accepted as a necessity.

One aspect is the funding for disaster risk reduction as part of development strategies, but it also applies in the context of humanitarian relief funding. International humanitarian agencies are now looking for new mechanisms to enable access to donor resources given advanced warning, even if it means providing funding for disasters that have not yet occurred – and for which there is still some level of uncertainty regarding if and how they will materialize. The potential benefits of such systems are illustrated by the success of the 2008 West Africa emergency preparedness efforts by the IFRC which were triggered by a seasonal climate forecast.

Emergency appeals based on climate information have not been very successful to date in garnering donor funding ahead of time, but there are good examples of how climate information was used as a trigger for accessing internal funds. Immediate response accounts and common humanitarian funding pools can be reliable mechanisms to fund preparedness driven by good early warning. They can be improved and provided further in advance with good climate information, offering new and better opportunities for more cost-effective disaster risk management at a lower cost and with better humanitarian outcomes. Donors and other organizations could also benefit through the widening of preparedness funding windows to include more systematic integration of climate-informed early warning at a range of timescales.

- **Evaluation and impact studies need to be built into future project design and implementation, to assess the exact benefits of integrating climate information into disaster risk management.**

The case studies show that climate information can usefully be incorporated into decision-making. However, only one – that of West Africa flood risk management – provided any quantitative evidence to indicate the resulting economic benefits. More detailed economic analysis is essential if governments and donors faced with competing priori-

The ultimate goal is to reduce suffering, save lives and protect the livelihoods of vulnerable people; Shehzad Noorani/ World Bank ties and limited resources are to prioritize the provision of climate services over other development activities. Furthermore, an understanding of the economic impacts of climate variability and change can stimulate the creation of new products and services, such as the case of risk insurance in the Caribbean, where the clearly identified need for provision of quickly available funds in the event of a hurricane or earthquake, is now supported by a regional index insurance program.

- **Partnerships between climate scientists and disaster risk managers should be fostered. This interaction provides a vital opportunity for feedback and may also allow actors to identify new information needs and define questions for further research to improve future operational disaster risk management.**

Dialogue between disaster risk managers and climate scientists can lead to the identification of opportunities for using existing knowledge, as well as gaps in that knowledge. In some cases, the climate information that is most useful to disaster risk managers is simply not available and further research must be done. Throughout the book, examples have demonstrated that in partnership, disaster risk management can be enhanced through integration of climate information into disaster prevention, preparedness and response. Careful and iterative interaction leads to more appropriately tailored information and understanding of needs and limitations, mutual capacity development, enhancement of credibility and building of trust. At the same time, partnerships can help to overcome unwarranted expectations of the value of the information, by helping to build capacity and correct interpretation of the information.

A final word

The world is facing the challenge of rising disaster costs and risks, and needs to be better prepared for what is to come. This book presents cases and knowledge aimed at helping to identify where investments in the provision and use of climate information can better help meet these needs at global, regional and local scales. It describes how building new capacity, tools and partnerships between disaster risk managers and climate information providers can lead to improved disaster risk management, including prevention, preparedness and response.

Many barriers remain, but the cases where inroads are being made have one thing in common – strong partnerships. By working together, climate scientists are better able to meet the needs of disaster risk managers, and disaster risk managers are better able to use climate information for improved disaster risk management. Along with many other actors, this will allow these groups to be better able to achieve their common goal – saving lives and protecting the livelihoods of vulnerable people.

References

Ahmed R. and Kim I-K. (2003) Patterns of daily rainfall in bangladesh during the summer monsoon season: case studies at three stations. *Physical Geography* 24(4): 295–318.

Akilulu Y. and Wekesa F. (2001) Livestock and Livelihoods in Emergencies: Lessons Learnt frmo the 1999-2001 Emergency Reponse in the Pastoral Sector in Kenya. Working Paper No. 3. Feinstein International Famine Center, Nairobi.

Anderson S. and Choularton R. (2004) Retrospective Analysis of 2002/3 Crisis In Ethiopia: Early Warning And Response By Fews Net. The Regional Economic Development Services Office For East And Southern Africa (REDSO), Addis Ababa.

Andonova L. and Lugon R. (2009) Climate Information for Decision-Making: Institutional Changes for Effective Communication. Centre for International Governance, Geneva.

APEC (2008) Formulation of the Strategy for Disaster Risk Reduction and Emergency Response and Preparedness of the Asia-Pacific 2009-2015. Asia-Pacific Economic Cooperation, Lima, Peru.

AMCDRR (2005) Beijing Action for Disaster Risk Reduction. First Asian Ministerial Conference on Disaster Risk Reduction, Beijing.

AMCDRR (2007) Development without Disasters. Second Asian Ministerial Conference on Disaster Risk Reduction, New Delhi.

AMCDRR (2008) Kuala Lumpur Declaration on Disaster Risk Reduction in Asia. Third Asian Ministerial Conference on Disaster Risk Reduction, Kuala Lumpur.

Braman L., Suarez P. and van Aalst M.K. (2010) Climate change adaptation: integrating climate science into humanitarian work. *International Review of the Red Cross* 92(879).

Broad K. and Agrawala S. (2000) The Ethiopia food crisis: uses and limits of climate forecasts. *Science* 8:1693–1694.

Callaway J.M., Louw D.B., Nkomo J.C., Hellmuth M.E. and Sparks D.A. (2006) The Berg River Dynamic Spatial Equilibrium Model: A New Tool for Assessing the Benefits and Costs of Alternatives for Coping with Water Demand Growth, Climate Variability, and Climate Change in the Western Cape. AIACC Working Paper. International START Secretariat, Washington, DC.

Camargo S.J., Barnston A.G., Klotzbach P.J. and Landsea C.W. (2007) Seasonal tropical cyclone forecasts. *World Meteorological Organization Bulletin* 56: 297–309.

Cash D.W., Clark W.C., Alcock F., Dickson N.M., Eckley N., Guston D.H., Jäger J. and Mitchell R.B. (2003) Knowledge systems for sustainable development. PNAS 100(14): 8086–8091.

Choularton R. (2007) Contingency planning and humanitarian action: a review of practice. *Humanitarian Practice Network* 59.

CRED (2011) The International Disaster Database. Centre for Research on the Epidemiology of Disasters, Brussels.

DaSilva J., Garanganga B., Teveredzi V., Marx S., Mason S.J. and Connor S.J. (2004) Improving epidemic malaria planning, preparedness and response in southern Africa. *Malaria Journal* 3:37.

Dilling L. and Lemos M.C. (2011) Creating usable science: opportunities and constraints for climate knowledge use and their implications for science policy. *Global Environmental Change* (in press).

El Hassani T.A. (2002) Drought Preparedness and Risk Management in the Mediterranean Region. In, Water, Wetlands and Climate Change - Building Linkages for their Integrated Management. Mediterranean Regional Roundtable, Athens, Greece, 10-11 December 2002. IUCN Centre for Mediterranean Cooperation, and the Global Water Partnership.

EuropeAid (2009) Early warning > Early Action: An approach to address climate change. EuropeAid, Brussels.

FAO (2011) FAO Country Profile: Kenya. Food and Agriculture Organization, Rome.

Goddard L., Aitchellouche Y., Baethgen W., Dettinger M., Graham R., Hayman P., Kadi M., Martinex R. and Meinke H. (2010). Providing seasonal-to-interannual climate information for risk management and decision-making. *Procedia Environ. Sci* 1:81-101.

Government of Kenya (2009) Flood Mitigation Strategy. Government of Kenya, Nairobi.

GIZ (2007) Mozambique: Early Warning System Protects Effectively Against Natural Disasters. Deutsche Gesellschaft für Internationale Zusammenarbeit, Berlin.

Haile M (2005) Weather patterns, food security and humanitarian response in sub-Saharan africa. *Biological Sciences* 360: 2169–2182.

Hansen J.W., Hellmuth M.E., Thomson M.C. and Williams J. (eds) (2006) A Gap Analysis for the Implementation of the Global Climate Observing System Programme in Africa. IRI Technical Report No. TR/06/1. International Research Institute for Climate and Society, Palisades, NY.

Hellmuth M.E., Moorhead A., Thomson M.C. and Williams J. (2007) Climate Risk Management in Africa: Learning from Practice. Climate and Society No. 1. International Research Institute for Climate and Society, Palisades, NY.

Hellmuth M.E., Osgood D., Hess U., Moorhead A. and Bhojwani H. (2009) Index Insurance and Climate Risk: Prospects for Development and Disaster Management. Climate and Society No 2. International Research Institute for Climate and Society, Palisades, NY.

Husak G.J., Michaelsen J., Kyriadikis P., Verdin J.P., Funk C. and Galu G. (2011) The forecast interpretation tool – a Monte Carlo technique for blending climate distributions with probabilistic forecasts. *International Journal of Climatology* 31(3): 461–467.

IFRC (2008) West and Central Africa: Flood Preparedness. Operations Update. International Federation of Red Cross and Red Crescent Societies, Geneva.

IFRC (2009) World Disasters Report 2009: Focus on Early Warning, Early Action. International Federation of Red Cross and Red Crescent Societies, Geneva.

IFRC (2009) Syria: Drought. Information Bulletin No. 1. International Federation of Red Cross and Red Crescent Societies, Geneva.

IFRC (2010) Bangladesh: Landslides. DREF Operation. International Federation of Red Cross and Red Crescent Societies, Geneva.

IMF (2010) Reaching the MDGs: Macroeconomic Prospects and Challenges in Low-Income Countries. International Monetary Fund, Washington, DC.

IPCC (2007) Fourth Assessment Report. Intergovernmental Panel on Climate Change, Geneva.

Kelly C. and Khinmaung J. (2007) Prepare to Live: Strengthening the Resilience of Communities to Manage Food Insecurity in the Sahel Region. Tearfund, UK.

KFSSG (2009) Short Rains Assessment. Kenya Food Security Steering Group, Nairobi, Kenya.

Klotzbach P.J. and Gray W.M. (2010) Extended Range Forecast Of Atlantic Seasonal Hurricane Activity And Landfall Strike Probability For 2010. Colorado State University, Fort Collins, CO.

Kopcik C. (2009) Hurricane Season And The International Federation Of The Red Cross And Red Crescent Societies. A background document on hurricane operations in the Central America, Mexico, Panama and Caribbean region. Internship Report. Red Cross Red Crescent Climate Centre and the International Research Institute for Climate and Society, Palisades, NY.

Martin S.F., Fagen P.W., Poole A. and Karim S. (2006) Philanthropic Grant-making for Disaster Management: Trend Analysis and Recommended Improvements. Institute for the Study of International Migration, Georgetown University, Washington, DC.

Meinke H., Nelson R., Kokic P., Stone R., Selvaraju R. and Baethgen W. (2006) Actionable climate knowledge: from analysis to synthesis. *Climate Research* 33: 101–110.

Meinke H., Howden S.M., Struik P.C., Nelson R., Rodriguez D. and Chapman S.C. (2009) Adaptation science for agriculture and natural resource management – urgency and theoretical basis. *Current Opinion in Environmental Sustainability* 1: 69–76.

Mutter J. (2010) Disasters widen the rich–poor gap. *Nature* 466: 1042.

Nakamura N., Kayanne H., Iijima H., McClanahan T., Behera S.K. and Yamagata T. (2009). Mode shift in the Indian Ocean climate under global warming stress. *Geophysical Research Letters* 36(23).

NRC (2010) Assessment of Intraseasonal to Interannual Climate Prediction and Predictability. The National Research Council. The National Academies Press, Washington, DC.

Parry M.L., Canziani O.F., Palutikof J.P., van der Linden P.J. and Hanson C.E. (2007) Contribution of Working Group II to the Final Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, NY.

Patt A., Suarez P. and Gwata C. (2005) Effects of seasonal climate forecasts and participatory workshops among subsistence farmers in Zimbabwe. *Proceedings of the National Academy of Sciences (PNAS)* 102: 12623–12628.

Tadesse T., Haile M., Senay G., Bardlow B.D. and Knutson C.L. (2008) The need for integration of drought monitoring tools for proactive food security management in sub-Saharan Africa. *Natural Resources Forum* 32: 265–279.

Tall A. (2008) Climate Forecasting to Serve Communities in West and Central Africa: Bridging the Gap between the IFRC-WCAZ and the Climate Science Community. Red Cross/ Red Cresent Climate Centre, The Netherlands.

Tall A. (2010) Climate forecasting to serve communities in West Africa. *Procedia Environmental Sciences* 1:421–431.

UNDP (2008) Fighting Climate Change: Human Solidarity in a Divided World. United Nations Human Development Report. United Nations Development Programme, Geneva.

UNISDR (2009) UNISDR Terminology on Disaster Risk Reduction. United Nations International Strategy for Disaster Reduction, Geneva.

WFP (2010) Building the Future: Working to Safeguard Food Supplies in the Face of Climate Change – 2/5 Food for Assets: Repairing irrigation canals in Kenya. World Food Programme, East, Central and Southern Africa Regional Bureau, Johannesburg.

WHO (2000) WHO Expert Committee on Malaria. 20th Report. World Health Organization, Geneva.

WHO (2003) Africa Malaria Report. World Health Organization, Geneva.

World Bank (2004) Natural Disasters: Counting the Costs. World Bank, Washington, DC.

Worrall E., Rietveld A. and Delacollette C. (2004) The burden of malaria epidemics and cost-effectiveness of interventions in epidemic situations in Africa. *American Journal of Tropical Medicine and Hygiene* 71(2): 136–140.

Williams J. (2005) Sustainable Development in Africa: Is the Climate Right? International Research Institute for Climate and Society, Palisades, NY.

UN (2005) Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. United Nations, New York.

Acronyms

ACMAD	African Centre of Meteorological Application for Development
CCAFS	Research Program on Climate Change, Agriculture and Food Security (of the CGIAR)
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CGIAR	Consultative Group on International Agricultural Research
CIESIN	Center for International Earth Science Information Network
CIMH	Caribbean Institute for Meteorology and Hydrology
DMI	Disaster Management Information System
DMU	Disaster Management Unit (of the IFRC)
DRM	Disaster risk management
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FEWS NET	Famine Early Warning Systems Network
GDP	Gross domestic product
GFCS	Global Framework for Climate Services
HRC	Haitian Red Cross
IAWG	Inter-Agency Working Group for Emergency Preparedness for Central and East Africa
ICPAC	Climate Prediction and Applications Center (of IGAD)
IFRC	International Federation of Red Cross and Red Crescent Societies
IGAD	Intergovernmental Authority of Development
IOM	International Organization for Migration
IPC	Integrated Food Security Phase Classification (of the FAO)
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Center for Climate and Society
ITCZ	Inter-tropical convergence zone
KFSM	Kenya Food Security Meeting
KFSSG	Kenya Food Security Steering Group
KMD	Kenya Meteorological Department
KRCS	Kiribati Red Cross Society
MALOF	Malaria Outlook Forum
NASA	National Aeronautics and Space Administration

NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NGO	Non-governmental organization
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
RCCC	Red Cross/Red Crescent Climate Centre
SADC	Southern Africa Development Community
SARCOF	Southern Africa Regional Climate Outlook Forum
SMS	Short message service
UN	United Nations
UNDP	United Nations Development Programme
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
USGS	United States Geological Survey
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization

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