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Climate Information and Forecasting for Development

Lessons from the 1997/98 El Niño

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Kelly Sponberg

December 2000

A report prepared jointly by the
Office of Global Programs, NOAA, and
The Environment Department, The World Bank

The World Bank

THE WORLD BANK ENVIRONMENT DEPARTMENT

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Contents

Foreword

People the world over have been successful in adapting to climatic conditions and thriving settlements are found in a wide variety of climates. Yet, large populations remain highly vulnerable to climatic factors, in particular to climate variations and extreme weather and climate phenomena. Droughts, floods, and storms can wipe out entire harvests and, often within hours, destroy years of human effort. And in most cases it is the poor that suffer most.

In recent years there has been significant progress in our ability to monitor and forecast climate phenomena. The advent of more accurate and reliable forecasts goes hand in hand with an emerging trend in disaster management—both inside and outside the Bank—in which predominantly reactive strategies are gradually replaced with more proactive and forward-looking approaches. Taken together, these developments provide a unique opportunity for developing countries to reduce their vulnerability to adverse weather and climate phenomena and to take better advantage of benign weather spells.

Making sure that developing countries can enjoy the full benefits of improved climate information and forecasting poses substantial challenges. Over the last few years the development community has learned a lot about the difficulty of pursuing disaster prevention in the face of harsh emergencies. The growing experience with knowledge dissemination—summarized in the World Development Report 1998/99—has taught us about the institutional, organizational and capacity-related challenges of applying knowledge-intensive processes in developing countries. And the scientific community is working on refining forecasts and packaging them in more accessible and policy-relevant forms.

We are still at the beginning of a long process, and the Bank could play a useful role in making it happen. This report—a joint effort between the Bank and the U.S. National Oceanic and Atmospheric Administration—takes stock of experiences so far and sets out a road map for the tasks ahead.

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The views expressed in this report are solely those of the authors and do not necessarily represent those of the World Bank Group or the NOAA Office of Global Programs.

Acronyms and Abbreviations

CLIPS	Climate Information and Prediction Services (WMO)
CRED	Center for Research on the Epidemiology of Disasters
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Niño/Southern Oscillation
FEWS	Famine Early Warning System
GDP	Gross domestic product
GP	Good practice
HDI	Human development index
IDB	Interamerican Development Bank
IDNDR	International Decade for Disaster Reduction
IFRC	International Federation of Red Cross and Red Crescent Societies
IMF	International Monetary Fund
IRI	International Research Institute for Climate Prediction
NOAA	National Oceanic and Atmospheric Administration (United States)
OGP	Office of Global Programs (NOAA)
SST	Sea surface temperature
TAO	Tropical Atmosphere/Ocean
USAID	U.S. Agency for International Development
WMO	World Meteorological Organization

Executive Summary

Human welfare and development are heavily influenced by climatic factors. While not all climate variations are necessarily bad, the direct economic loss from extreme weather events amounts to billions of dollars each year. Poor countries and their inhabitants are particularly vulnerable to variations in climate. As many as 95 percent of all disaster-related casualties occur in developing countries, and after an event the recovery often takes years. Natural disasters can significantly derail the process of social and economic development.

The World Bank has always supported reconstruction in countries affected by natural disasters. With over US$9 billion in emergency lending over the last 10 years, disaster assistance has become a major activity for the Bank. Given the high vulnerability of Bank clients, however, it has been recognized that the current practice of reactive emergency assistance in the aftermath of an event is no longer sufficient. A forward-looking approach to disaster management is needed, in which natural hazards are screened, analyzed, and dealt with in an integrated fashion and in as routine and efficient a manner as are other risks affecting development. Work to initiate this paradigm shift is under way. This paper argues that the effective use of climate information and forecasting should become an integral part of the new paradigm of comprehensive disaster management.

There has been dramatic progress in our understanding of the climate system and our ability to monitor and forecast weather events. Longer-range forecasts of many phenomena can now be produced at a time scale, reliability, and spatial resolution that make them useful for planning purposes. Forecasts of El Niño Southern Oscillation (ENSO) events are one such example, and their use for disaster management is the main focus of this paper. The applicability of climate information and forecasting is far broader though, and many of the ENSO lessons will carry over to other applications. Agriculture represents the most successful use of longer-range climate forecasting to date. Agricultural climate information is increasingly used to advise farmers on planting decisions, resulting in such major benefits as increased yields and forestalled food shortages.

The emergency recovery loans that the Bank provided in the course of the 1997/98 El Niño offer some good examples of how to use climate information and forecasting in a disaster mitigation context. But they also underline the technical and institutional challenges that have to be overcome. Like all knowledge-intensive processes, the use of climate information and forecasts requires strong local institutions, well-functioning procedures for information dissemination, and the trust and motivation of end-users. Assisting developing countries in creating this institutional environment constitutes perhaps the most pertinent role the Bank can play in promoting the use of climate information and forecasting.

If the Bank wants to promote the systematic use of climate information and forecasting, a series of measures would have to be initiated. On a policy level, the Bank would have to deepen its efforts to build a comprehensive, natural hazard-risk reduction strategy, and integrate climate information and forecasting as a key instrument into this new strategy. To keep abreast of scientific developments, the Bank would have to seek partnerships with the scientific community and regional and international centers of excellence, share good-practice examples, monitor progress, and exchange experience about the use of climate information and forecasting in development.

These policy changes would have to be complemented by measures to raise awareness among Bank staff and build the necessary internal capacity to assist client governments competently. This may include:

- The systematic and comprehensive evaluation of past and present activities in order to learn lessons and develop a code of good practice
- Knowledge management activities such as training, outreach, and information sharing through thematic groups
- Targeted studies to gain a better understanding of the costs and benefits of climate information and forecasting, develop performance indicators and test methods to integrate forecasting into natural hazard management

The Bank already has some initial experience with the use of climate information and forecasting in, for example, Peru and Zimbabwe. These early examples could be drawn upon to initiate a small number of pilot projects in selected, highly vulnerable countries. Chosen carefully, such pilot investments would not only demonstrate how climate information and forecasting can best be incorporated into Bank work, they would also contribute directly to poverty alleviation and sustainable development in the countries concerned.

Introduction

Climate is a pervasive factor in social and economic development. Although we barely notice it, human activity is heavily shaped by the climate in which we live and the climate variations that we experience—both across regions and over time. This close dependence is most obvious in agricultural, forestry, and tourism sectors, where expected returns directly depend on climatic factors. But the significance of climate goes further. Ultimately, almost all economic activity is affected by climate, including, for example, construction (design of buildings and roads), municipal service provision (water supply), public health (prevalence of diseases), and the financial sector (insurance).[1] The better we can adapt to climate conditions, the better the prospects for economic development. A good understanding of climatic phenomena, and the ability to use that information in decisionmaking, are important elements of that adaptation process. This paper examines new opportunities to use climate information and forecasting to help sustainable development.

The primary, but not exclusive, focus of this paper is a particular climatic phenomenon that has a wide impact across the globe—the El Niño/Southern Oscillation, or ENSO. ENSO has been observed for centuries but recently gained wide prominence in the context of the 1997/98 El Niño event. This was one of the strongest El Niños ever recorded, with estimated structural losses of US$36 billion, much of it in developing countries (see chapter 1). What sets ENSO events apart from other climatic phenomena is not only their impact, but also our rapidly growing capacity to forecast them with increasing accuracy. A new array of technological instruments as well as large increases in modeling capacity allow, for the first time, fairly reliable predictions of ENSO.

The Bank was actively involved in the reconstruction following the 1997/98 El Niño and, to a lesser extent, in preceding efforts at impact mitigation. Overall, it provided almost US$360 million in emergency recovery loans to eight affected countries. Not least because of this involvement, the 1997/98 El Niño serves as a case study of the practical feasibility of using climatic forecasts as a disaster mitigation tool. Practical experience from these projects can help to better gauge the needs of forecast end-users in terms of accuracy, timing, and reliability. Perhaps more importantly, it also helps to identify the institutional, technical, and capacity constraints that need to be overcome to realize the full benefits of forecasting climate conditions.

This paper mainly focuses on what one might call ENSO-related natural disasters, resulting from extreme climatic events. However, many of the forecasting tools that will be discussed can also be applied to moderate climate variations.[2] Seasonal to interannual forecasting, including El Niño seasonal forecasts, is increasingly used to assist farmers in their planting decisions, for example in

Africa. Experience in this type of forecasting applications, which cover both moderate and extreme climatic variations, is growing rapidly. [3]

In the context of natural disasters, climate information and forecasting should be seen as part of a broader strategy for natural risk management. Climate forecasts are only one of many instruments available to mitigate natural disasters, and the role they can play in this context depends on the overall strategy adopted for risk management and disaster preparedness. This paper thus adds a new element to the ongoing discussion on efficient disaster management.[4]

1 Climate Variability and Development

Understanding climate variability and El Niño

Every year throughout the world, the seasons change.[5] The cycle may involve winter, spring, summer, and fall. It may also consist of a wet and a dry season, or a more complicated pattern of annual changes. Humans have been quite successful in recognizing and expecting this annual fluctuation of temperature and precipitation.

There are, however, seasons of a different sort, or deviations from our annual expectations. The term *climate variability* is often applied to this category of seasons with which we are less familiar. Climate variability is a general term for changes that can occur every few years or even on a timescale of decades or centuries, and because the change is often slow (possibly hidden in annual cycles or even occurring between generations), our knowledge of these other seasons is not yet complete. Moreover, it has only been within the past few decades that global monitoring systems have been established.

One of the strongest causes of climatic variability on the timescale of seasons and years is El Niño, a quasi-periodic event that generally occurs every three to seven years. It is part of a larger phenomenon called El Niño Southern Oscillation (ENSO). ENSO is the result of a complex set of interactions, in which the atmosphere and the tropical Pacific act in concert to cause climate fluctuations around the globe:

> *"The partners in this dance are the atmosphere and ocean. But who leads? Which one initiates the eastward surge of warm water that ends La Niña and starts El Niño? Though intimately coupled, the ocean and atmosphere do not form a perfectly symmetrical pair. Whereas the atmosphere is quick and agile and responds nimbly to hints from the ocean, the ocean is ponderous and cumbersome and takes a long time to adjust to a change in the winds."* [6]

The two phases of ENSO are El Niño and La Niña.[7] During an El Niño, a warm pool of water in the equatorial Pacific migrates from its usual position in the west toward the coast of the Americas. Movements of the warm water body in turn alter associated atmospheric circulation (see appendix A for a more detailed description). The result is exceptionally heavy rains over the deserts of Peru, while drought occurs over the rainforests of Indonesia.

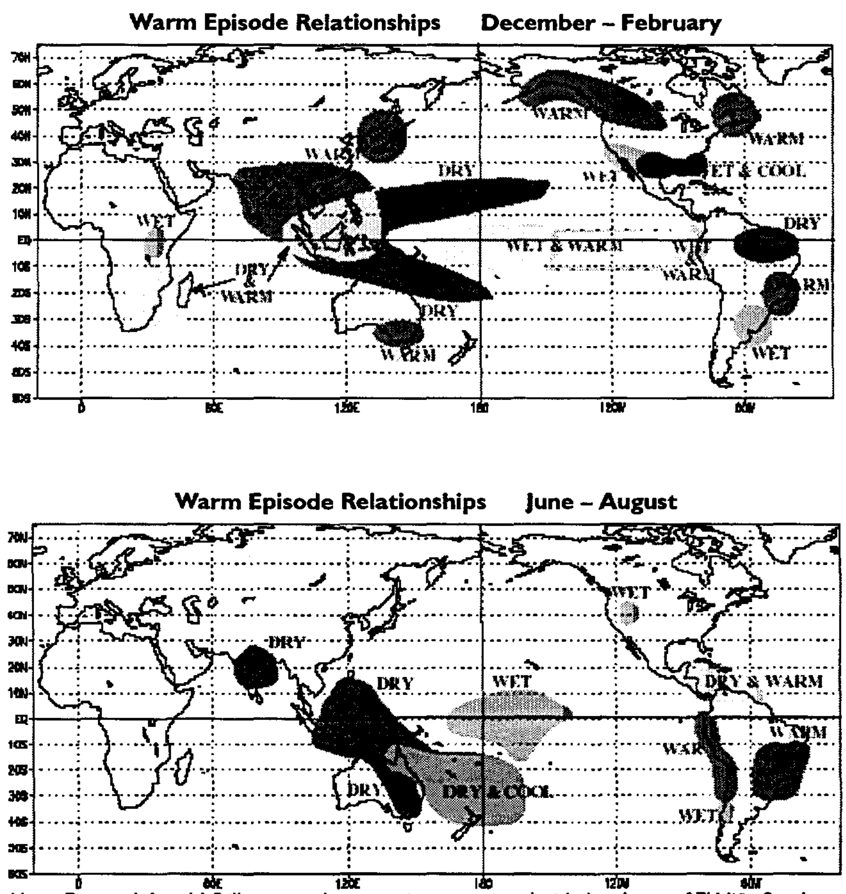
Because an El Niño involves shifting an enormous amount of energy across the Pacific (heat that drives the circulation of the atmosphere), the impacts related to a warm event are felt worldwide. During a La Niña, the warm pool of water moves in the opposite direction, pushing further westward than its usual position, again with worldwide impacts. The regional or local anomalies in precipitation or temperature that result from El Niño and La Niña are referred to as teleconnections. The typical pattern of these teleconnections, depicted in Figures 1.1 and 1.2, shows what conditions can be expected in different parts of the world in the two phases of the ENSO cycle.

The costs of climate variability

While climatic fluctuations undoubtedly affect human systems, the effects need not be necessarily negative. Fluctuations in rainfall and temperature can provide great benefit to many sectors and economies. And systems may be as much affected by persistent but slight changes in regional conditions as they are by extreme weather events. For example, changes in temperature may not directly lead to a drought or heat wave, but might nonetheless cost (or save) money in terms of the number of days in which energy is used to heat or cool structures.

Nevertheless, particularly sharp changes in temperature and precipitation most often result in substantial human, ecological, and economic losses. This is particularly true for the more vulnerable populations of developing economies. The 1997/98 El Niño event is a case in point. According to one study, direct

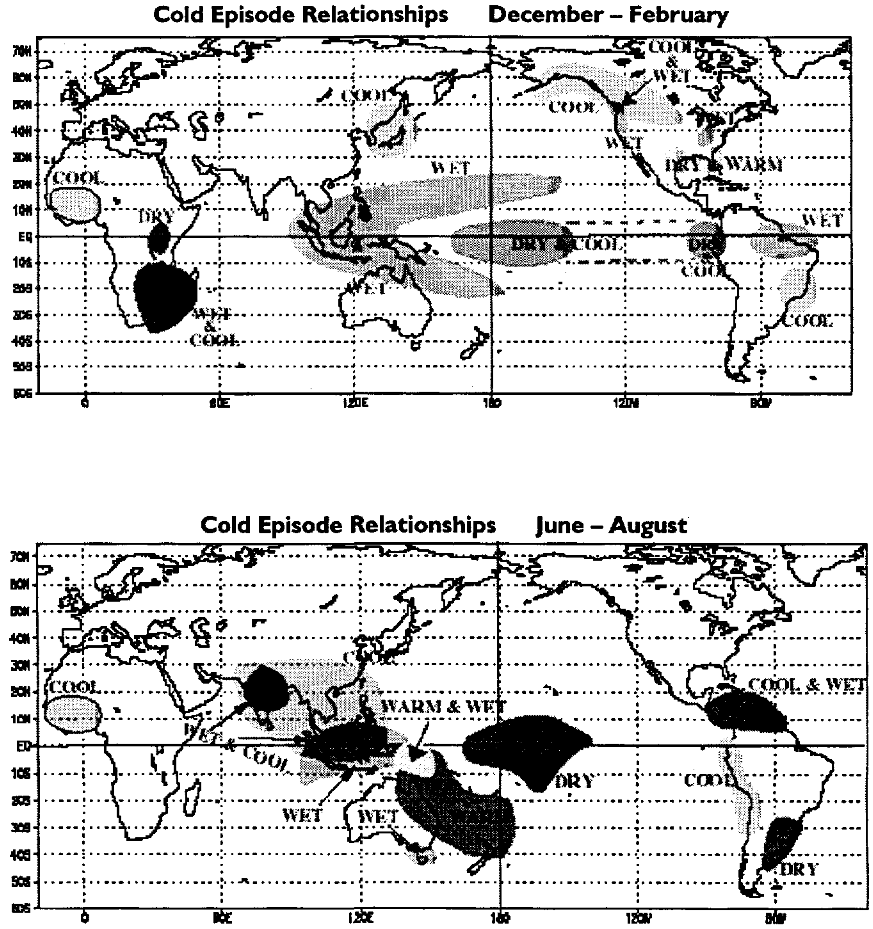
Figure 1.1 El Niño teleconnections



Note: Figures 1.1 and 1.2 illustrate teleconnections associated with the phases of El Niño Southern Oscillation (ENSO). The term teleconnection describes ENSO's ability to affect global climate and weather. Terms such as dry, wet, warm, and so on, refer to changes in the expected seasonal weather for various regions of the globe. This depiction is only illustrative, and does not include competing phenomena that might enhance or cancel regional effects of ENSO in any particular year.

Source: NCER-CPC, Washington DC, USA.

Figure 1.2 La Niña teleconnections



Note: La Niña conditions are often illustrated as simply the opposite of El Niño. In truth, the switch between El Niño and La Niña is unlikely to be that linear.[8]

Source: NCER-CPC, Washington DC, USA.

structural losses amounted to US$36 billion; there were 21,000 fatalities reported, and another 130 million individuals were affected.[9] Table 1.1 provides a breakdown of the recorded impacts by region and illustrates the impacts of the worldwide ENSO teleconnections displayed in Figures 1.1 and 1.2.[10]

The El Niño of 1997/98 was the strongest ever recorded and, as such, is an extreme example. But even for average years, natural disaster losses are very large. For the years 1996–98, for example, Munich Reinsurance has estimated worldwide losses related to all natural disasters at US$60 billion, US$30 billion, and US$90 billion, respectively.[11]

Estimates like these are illustrative and should not be taken as absolute measures of loss. A strong tendency exists to only examine the extremes associated with the impacts of climate variability. The broader costs and benefits of simply living with climate variability are not, and cannot currently be, measured. But even as an indication of the social costs of extreme climate events, the figures quoted above are probably too low for several reasons.

For one, they only concern the direct structural losses from extreme events. Excluded are indirect and high-order losses, many of which have yet to be quantified. Environmental factors such as climate interact with pre-existing economic, political, and social conditions, and this often exacerbates existing vulnerabilities. For instance, Indonesia faced multiple challenges during the timeframe when it was faced with the 1997/98 El Niño: the Asian economic crisis, the collapse of a regime that had ruled for 32 years, and severe environmental problems such as drought and forest fires.

The successive character of some climatic events also affects the type and severity of impacts. The forest fires in Indonesia during 1997–98 claimed 9.75 million hectares of land according to some estimates.[12] The La Niña event that

Table 1.1 Regional impacts of the 1997/98 El Niño

Reported Impacts Of The 97/98 El Niño	*Africa*	*Asia*	*Europe*	*North America*	*Oceania*	*South America*
Dollar Loss (millions) (1,000=1 billion)	120	7,915	341	5,431	5,752	17,028
Mortality	15,390	4,890	202	200	53	1,083
Morbidity	96,802	27,000	-	-	-	254,414
Missing Persons	2	4,849	-	-	12	2,000
Injuries	901,902	14,762	127	171	5	414,033
Affected (in 1000)	8,155	95,315	20,000	539	4,669	817
Displaced/Homeless (in 1000)	1,358	2,463	8,4	131	54	634
Acres Affected (in 1000)	756	13,192	1,898	18,500	7,994	39,875
Houses Damaged/Destroyed	921	1,943,901	40,686	6,324	6,289	104,840
Households Affected	-	-	8,869	-	700,099	-
Affected Cities, Towns, Villages	-	40,059	2,850	-	700	50
Roads Damaged/Destroyed (km)	-	-	2,402	-	-	2,100
Animals Lost	78,500	13,148	8,300	-	-	-
Bridges & Culverts Damaged/Destroyed	8	32	1,072	-	-	-

– No data available.
Source: Sponberg, K., *Compendium of Climate Variability* (Draft), Silver Spring, Maryland: NOAA Office of Global Programs, 1999.

followed (normally associated with above-normal rainfall) created concern that heavy rains would result in landslides and flooding without the normal land cover to hold soil and absorb moisture. Fortunately, the landslides and floods that did ensue were, for the most part, localized and did not create a national disaster.

Lastly, there are inaccuracies in reporting. Different economies have varying sensitivities to losses associated with climatic variability; therefore, the awareness and reporting of these impacts are equally diverse. It is also likely that certain conditions or incentives that raise awareness about climatic variability (such as relief aid) can result in the "social amplification"[13] of impacts. A potentially more serious problem, particularly in rural or impoverished regions, however, is "social devaluation" of impacts. For many reasons, including absence of societal support or the comparative negligibility of losses relative to other pressing needs, many individuals and governing bodies fail to report impacts or describe their interaction with climatic variability. As a result some groups, and their interaction with their environment, are not covered by existing estimates. Burton and others[14] have previously noted that biases exist "toward overestimating losses from industrialized countries and underestimating losses in developing countries or in areas remote from centers of government and mass media."

Such methodological uncertainties—and a considerable variation across estimates—notwithstanding, there is a clear and consistent pattern of disaster-related losses reaching into the billions of dollars each year. And these impacts are not evenly spread across the continents. Developing countries face a disproportionate amount of natural disasters and an even higher proportion of the aggregate impact. Ninety percent of all natural disasters and 95 percent of disaster-related deaths occur in developing countries.[15]

The tallies are substantial by any standard, and they can significantly derail the process of social and economic development. In 1982, for example, Peru experienced a 12 percent decrease in gross domestic product (GDP). About half of that drop can be attributed to the El Niño event that struck Peru in 1982/83, according to an estimate by the International Monetary Fund.[16] In February 1990, cyclone Ofa hit Western Samoa, causing damages of about US$140 million. Less than two years later, the country was hit by another cyclone, Val, which imposed additional damages of US$300 million on the still fragile economy.[17] In comparison, the GDP of Western Samoa in 1989 was US$139 million.

But the development impact of natural disasters goes beyond the direct destruction of infrastructure and loss in GDP. As expressed by Clarke and Munasinghe,

> *Natural disasters destroy decades of human effort and investments, thereby placing new demands on society for reconstruction and rehabilitation. This halts and, in some cases, reverses economic progress. Large-scale natural disasters can have profound, negative impacts on long-term development, causing distress and increasing dependency.*[18]

Education is disrupted when schools are destroyed, social patterns and political processes are disrupted by the temporary loss of churches, governing facilities, and other public buildings, and reconstruction activities drain regular economic and development activities. Such losses are increasingly reported by humanitarian organizations. This change in thought reflects the realization that climatic variability does not exhibit its greatest impacts through minor or instantaneous losses and responses, but that it also has strong effects on long-term processes.

2 Forecasting Systems and Tools

Generating climate information: Types of forecasting tools

Forecasts can be divided into three broad categories that address either:

1) Specific phenomena such as El Niño (indices)
2) Regional anomalies in rainfall, temperature, and so forth (assessments)
3) The effects of climate variation on specific sectors (sector forecasts).

All three categories are of potential use to the World Bank and its client countries.

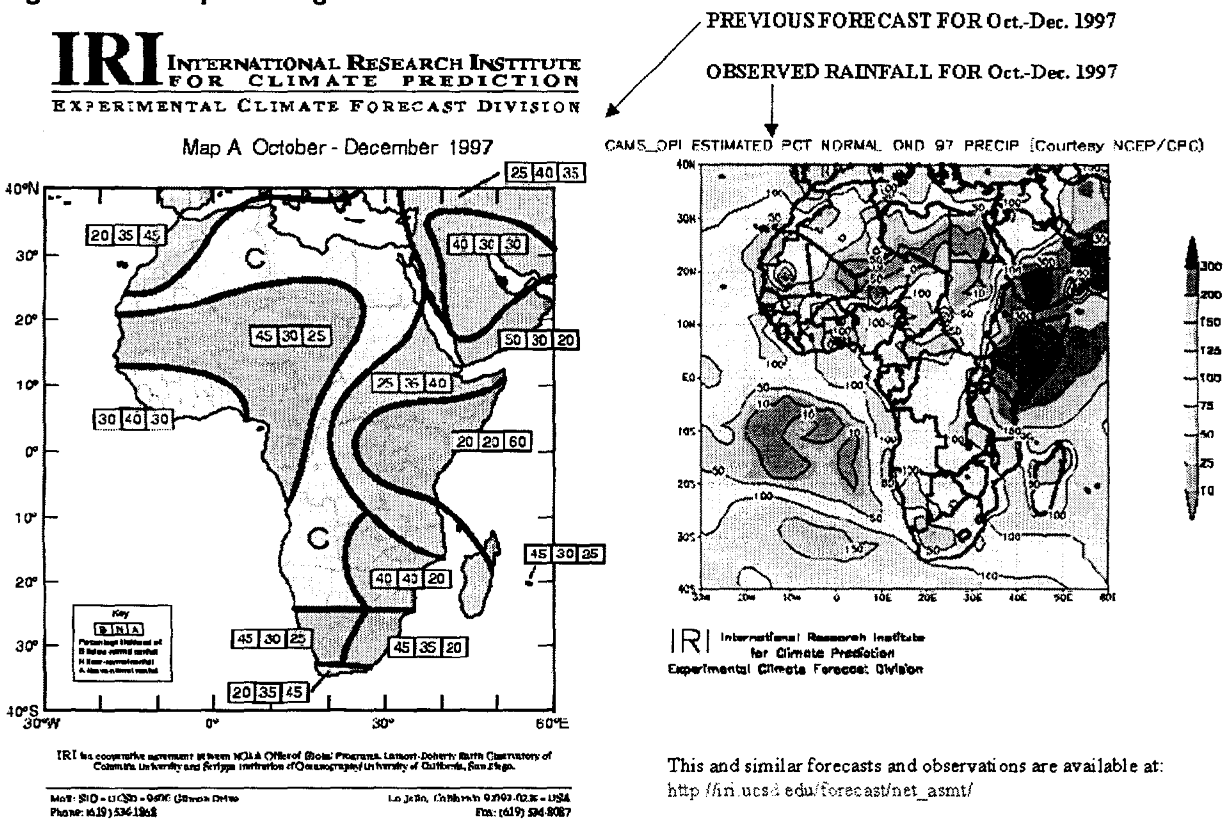
Indices are useful in noting the severity and duration of an El Niño event (or other phenomenon), but by themselves they do not specifically indicate changes in regional temperature or precipitation. Forecasts or observations of indices must be combined with an historical knowledge of typical impacts (as in Figures 1.1 and 1.2) to provide a rough estimate of regional anomalies. For instance, the USAID Famine Early Warning System (FEWS) currently uses sea-surface temperature (SST) to casually describe the relationship between ocean temperature and rainfall conditions.[19] Thus, indicators of SST can be used to predict future precipitation regimes. Again, indices are not forecasts of actual rainfall or temperature, but rather useful measures for approximating events or larger regimes that might result in variations in regional climate conditions.

Assessments, such as regional precipitation and temperature forecasts, monitor indices and then combine this information with global circulation models to provide some details about climate conditions. Other data, such as topography, may be used in the model to improve the forecast quality and/or resolution. Some forecasts actually combine several models and runs to produce a "composite" or "integrated" forecast. Such assessments are now operationally produced for three-month periods (for example, May–June–July) and done so that a three- to six-month lead is provided. These forecasts represent the overall state of climate conditions rather than a single climatic event (such as El Niño). In other words, the performance of these forecasts is not specifically linked to the signal strength or current phase of ENSO or another phenomenon but to the combined effect of all observed trends. Figure 2.1 provides an example of such a forecast. These seasonal forecasts may spatially cover a country or region, or provide complete global coverage.

Sectoral forecasts combine additional information with either indices or assessments or both. They are perhaps even more complex because they incorporate other systems such as markets, fisheries, planting cycles, or even human preferences. Sectoral forecasts are quite area specific and generally produced by the user rather than by scientific institutions or national meteorological services, who usually provide mainly the climate indices or assessments that feed into the sectoral forecasts.

To be useful for planning purposes, forecasting information has to be sufficiently reliable,

Figure 2.1 Example of longer-lead climate forecasts



Note: As an example of longer-lead climate forecasts, Figure 2.1 presents a forecast from the International Research Institute for Climate Prediction (IRI) showing the actual rainfall in the period of the prediction. IRI's mission is to provide experimental climate forecast guidance on seasonal-to-interannual timescales for use by affected communities around the world. Similar forecasts are also provided by other institutions, such as the European Centre for Medium-Range Weather Forecasts (ECMWF).
Source: International Research Institute for Climate Prediction.

accurate, and available at the right time. Recent years have seen significant progress in all three respects. The three- to six-month advance lead now provided by modern longer-lead forecasts is often enough to allow alterations in management decisions and leave time for disaster mitigation. The longer-lead forecasts of precipitation or temperature, such as ENSO, are concerned with the likely "regime" and are generally couched in terms of probabilities.

The variety of forecasts and models available might seem complex; sometimes, their statements may even be contradictory. It must be emphasized, however, that forecasts are not ready-made answers but decisionmaking tools. The veteran users of climate information accept that variances between the forecasts occur, as a result of different models, goals, data, and other factors. Nonetheless, together they provide an input into decisionmaking that would otherwise not be available.

Using climate information: A cycle of opportunities

The availability and quality of forecasts are only one part of climate prediction. Forecasts have limited value unless they are tested and used by decisionmakers. How forecasts are fed into the decisionmaking systems through dissemination and translation constitutes the other important part. This poses substantial institutional challenges. The effective use of climate information requires an infrastructure of institutions that observe, monitor, and forecast climate variations at the local level. But it also requires a system to disseminate information in a reliable and timely way, and in a form that is both understandable and relevant to end-users. And end-users must have the capacity, incentive, and motivation to apply the information. The development of forecasting must therefore be complemented by knowledge enhancement, capacity building, and the development of institutions capable of using or helping others to use climate information.[20] These efforts may in turn feed back and help to improve climate information and the quality of forecasts.

While forecasters around the world use similar techniques, there is no "one-size-fits-all" institutional solution. Climate information is being used in many applications in many regions of the world. In each case the institutional arrangements are different. They vary depending upon the specific needs and attributes of the region, sector, and climate threat or opportunity. Still, there is a general cycle that is common to most applications. In general, this cycle is characterized by a series of long- and short-term responses and evaluations.

Figure 2.2 illustrates the four phases that provide a generic conceptual overview of the processes and steps involved when using climate information.

Phase I, identification, can be characterized by an initial assessment of vulnerabilities, capacities, resources, and so on. For instance, what is the relative rate of occurrence of floods or droughts, and which has caused the most losses? The same phase also involves the development of long-term mitigation strategies (including refining the use of forecasting) and the identification of institutions or involved sectors that deal with the climate impacts. Once again, opportunities are as important as potential losses.

Phase II involves a continual monitoring of climate conditions. Having already identified important vulnerabilities and fluctuations, this phase evaluates whether a threat (such as El Niño-related flooding) is developing. As certain threats arise, more forecasts or monitoring systems may be necessary, particularly sector-specific models. For instance, if Peru is faced with an El Niño, perhaps it would be necessary to also monitor soil moisture, or the silting of sewer or irrigation systems. Note that the monitoring and forecasting of climate conditions, particularly regional fluctuations in rainfall and temperature, need not always be in-country or local. For instance, flooding of the Nile in Egypt is not dependent on local conditions, but rather on the rainfall and runoff in upstream regions and the source.

Phase III entails taking mitigative or responsive actions. These are relatively short-term or tactical reactions that take place immediately before, during, or after the actual event. They may include dredging waterways, reinforcing dykes, changing crops or planting strategies, and so forth. Humanitarian assistance occurs during this phase.

Figure 2.2 Schematic process of using climate information

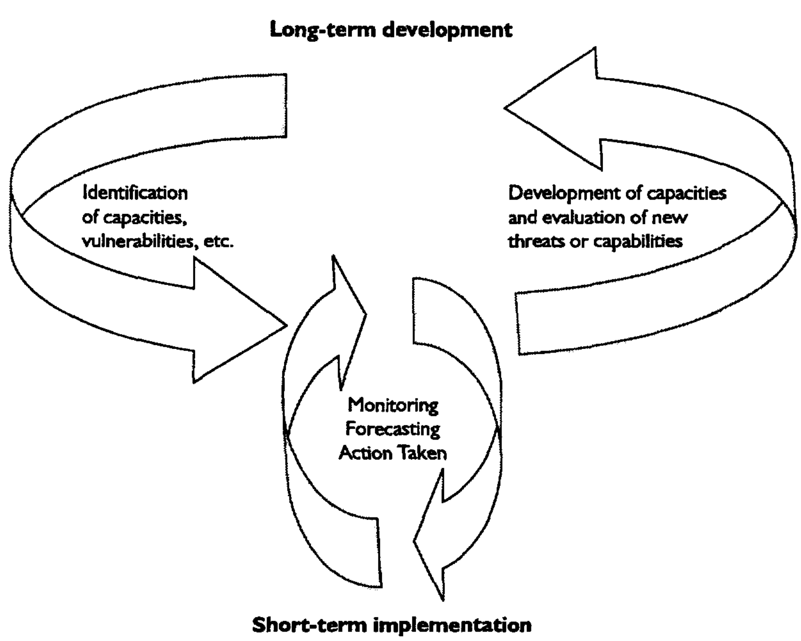
I	⇒	**II**	⇒	**III**	⇒	**IV**
Identification		**Monitoring**		**Action**		**Evaluation**

Phase IV involves an evaluation of performance during climatic variations, including feedback from the users of the forecasts. This may include valuing institutional responses as well as identifying infrastructure needs. Improvements may be entirely sector specific and may have little to do with improving forecasts or monitoring systems.

These four phases really comprise a cycle characterized by short-term implementation and longer-term development (see Figure 2.3). Because ENSO climate forecasts are most reliable with a three- to six-month lead, they can only really be used to manage short-term decisions in, for example, water management, humanitarian assistance, planting strategies, and so forth. However, adequately applying climate forecasts and information requires knowledge of human systems, be they economic, political, or otherwise. In the process of applying climate information, needs and partnerships are often identified, and the short-term process may thus provide the impetus for further longer-term development. Even after an action is taken, monitoring and examination of forecasts should continue, as climate fluctuations are an ongoing phenomenon. For example, the end of an El Niño event does not immediately preclude the occurrence of another climate extreme. Countries like Vietnam and Thailand have, on occasion, experienced 18 months of drought and moderate to extreme floods. Similar examples exist throughout the globe.

The long-term part of the cycle is the development of institutions and awareness. As noted earlier, the process of forecasting is quite illuminating in regard to the needs for product dissemination, interpretation, and implementation. In addition, this part of the whole cycle should be characterized by a constant identification of changing conditions and formulation of strategies. Impacts from a previous event, climate related or not, may enhance or decrease vulnerability to future events. Obviously the diligence required to maintain these activities necessitates either

Figure 2.3 The long- and short-term cycle of climate forecasting



formal or informal institutions as well as a trusted knowledge base.

Box 2.1 provides a rough framework on how to initiate the development of forecasting capacity.

Assessing forecasting capacity: The 1997/98 El Niño

Climate forecasts can have significant value to governments, consumers, and industry, but these benefits are highly dependent on the quality, accessibility, and ease of use. Moreover, forecasts can have the greatest success when they are combined with monitoring and sector-specific impact information for use in decisionmaking. To provide a sense of whether current forecasting capacity meets these requirements, we examine the recent case of forecasting in the 1997/98 El Niño event.

The 1997/98 El Niño represented the first time an event of significant magnitude was predicted with reasonable accuracy and sufficiently ahead of time, and that pertinent information was widely distributed. Many different measures can be used to judge the success of these forecasts and their use; however, measuring success is complicated by the localized and differing economic, social, and climatic conditions of various regions and countries using the information. Moreover, incorporating climate information into decisions at any level of government is still in its early stages in many of the most vulnerable countries.

The 1997/98 El Niño event was a significant climatic event. By May of 1997, it was widely accepted and acknowledged that a strong El Niño event would occur in the near future. However, many of the severe impacts did not materialize until the second half of 1997, and in some cases the lag time associated with teleconnections meant that in some regions the full brunt of climatic anomalies was not realized until early 1998, creating a problem with the perception of the warnings' accuracy. In terms of operational use, forecasts of regional

Box 2.1
Key Steps in the Development of Forecasting Projects

The following list contains five steps that may be used in considering investments in climate information and forecasting to reduce vulnerability to climatic variations:

1. Assess vulnerability to climate risks (on a country, regional, and/or sectoral level)

2. Assess opportunities for vulnerability reduction; forecasting may be one of the tools

3. Assess forecasting capacity by evaluating the following aspects:

- Monitoring of local variables, measuring systems
- Use of international monitoring systems and modeling products
- Translation of observations and rough forecasts into local forecasts
- Linking the forecasts to biology, hydrology, and so forth (sectoral models)
- Dissemination of the information
- How the information is used (including periodic review and user feedback).

4. Assess bottlenecks, where improvements can be made and what they would yield relative to other development opportunities. Consider opportunities for regional and international cooperation.

5. Make sure the proposed improvement fits into general risk management for a given country, region, or sector.

precipitation and temperature, such as those produced by the regional Climate Outlook Fora and the IRI, adeptly included the likelihood of a strong warm event into their forecasts. While the accuracy of probabilistic forecasts is difficult to determine, the process of forecasting seemed to work well, and forecast information was used directly in real-time decisionmaking. Many of the forecasts were, at least qualitatively, quite accurate.[21]

The ability to make predictions about an ENSO event has many different determinants, and an important factor is geographic location. The ENSO signal generally fades with increasing latitude and distance from the Pacific. Seasonal variation over countries such as Peru and Indonesia is correlated relatively strongly with El Niño and La Niña events, as they are at ground zero. The impacts associated with changes over the Pacific are much more predictable for these areas than for regions farther away from the center of the phenomenon, such as the Middle East or Europe. However, ENSO is only one, albeit important, building block in a complete explanation for all anomalies in rainfall or temperature. Many different climate patterns interact with ENSO to determine actual temperature and precipitation patterns and the likelihood of extreme events, such as the Pacific Decadal and the North Atlantic and Arctic Oscillations.

As noted above, how effectively the forecast information is integrated into decision processes also depends to a large extent on the existence of well-functioning institutions. In this respect, the experience of the 1997/98 El Niño is mixed. While several governments in developing countries took heed and initiated strong advance measures, damages could have been even lower had governments in other countries been able to respond more quickly.

Further improvements in the accuracy and detail of seasonal and interannual climate forecasts, and tailoring of the forecasting products to the users' needs, can be expected in the future. The following improvements can be anticipated:[22]

- Continued physical climate system research into the dynamics of ENSO and other ocean/atmosphere interactions outside of the equatorial Pacific that have a significant influence on regional and global climatic patterns
- Improved forecast detail with computer models more accurately able to capture key climate system mechanisms and as computing power increases
- In certain regions, improvements in forecasts (based on historical data) resulting from compiling more complete and longer data sets of precipitation and temperature
- Additional tailoring of forecast products to specific needs
- Further exploration of the nature of decision processes in climate-sensitive sectors and further exploration of user needs, interests, and activities in these sectors.

The economic value of climate information and forecasting

Accurate and timely forecasts hold the promise for improving economic and other social well-being in both good and bad years.[23] Households and firms in the agriculture, forestry, tourism, transportation, energy, and public health sectors would see the benefits of improved forecasts, and climate information and forecasting can also strengthen efforts for the long-term mitigation of natural hazards. But to what extent can the current generation of forecasts live up to this promise and provide benefits that justify the costs of investments in climate and forecast information systems?

The benefits of using improved climate and information forecasting systems have been estimated using both empirical and qualitative approaches. For various institutional and technical reasons and because of a lack of data, empirical estimation in particular has proven difficult. The lack of completed benefits studies, especially in developing countries, is not surprising considering the early stage of forecast use. Institutions disseminating and helping to explain climate and forecast information are increasingly being put in place. And decisionmakers are learning about timing and techniques for using the forecast information. Therefore, large data sets (across regions and time) that can be used for comparative benefit estimates do not yet exist. The studies that have been done are generally small-scale, on a national or subnational level, focusing attention on the specific political, economic, and climatic circumstances of the area under examination.

A key challenge for estimating the benefits of using forecast information in private and public decisions is to distinguish between the effects of improved information and other measures that are taken to reduce the impact of ENSO events. The difficulty is exacerbated by the fact that climate information and accompanying measures often complement each other. Thus, when impacts are reduced, not all of the reduction can be attributed to utilization of climate information. Another difficulty is the disaggregation of estimates and accounting for the distributional effects of improved forecasts. Finally, impacts of ENSO-related events vary across ENSO cycles, and the effectiveness of climate information and forecasting systems change over time. Ideally, estimates of benefits should capture the evolution of all mitigating technologies over time.

The range of estimates is wide, but the numbers confirm that large benefits can be achieved, depending on the geographic and economic circumstances. The variance in estimates in the literature results from differences in analytical methods, study questions, level of aggregation, and the way results are reported. Mjelde and others (1998) provide an extensive review of the pertinent economic issues surrounding the valuation of climate and information forecasts, particularly in the agricultural sector. [24] The greatest number of completed benefit studies is available for the agricultural sector, primarily in OECD countries, and mostly at the farm level. Results vary depending on type of crop, region, country, assumption of aggregate crop price increases, and delineation of institutional responses. For example, Solow and others calculated that US$230 million (in 1995 dollars) of annual benefits in net society welfare were attributed to using ENSO-based forecasts for the entire U.S. agricultural sector.[25] Another example of benefits for U.S. agriculture is provided by Hill and others, who found regional differences in the value of ENSO-based forecasts, ranging from a low value in Illinois to almost US$1.20 per acre in Oklahoma.[26]

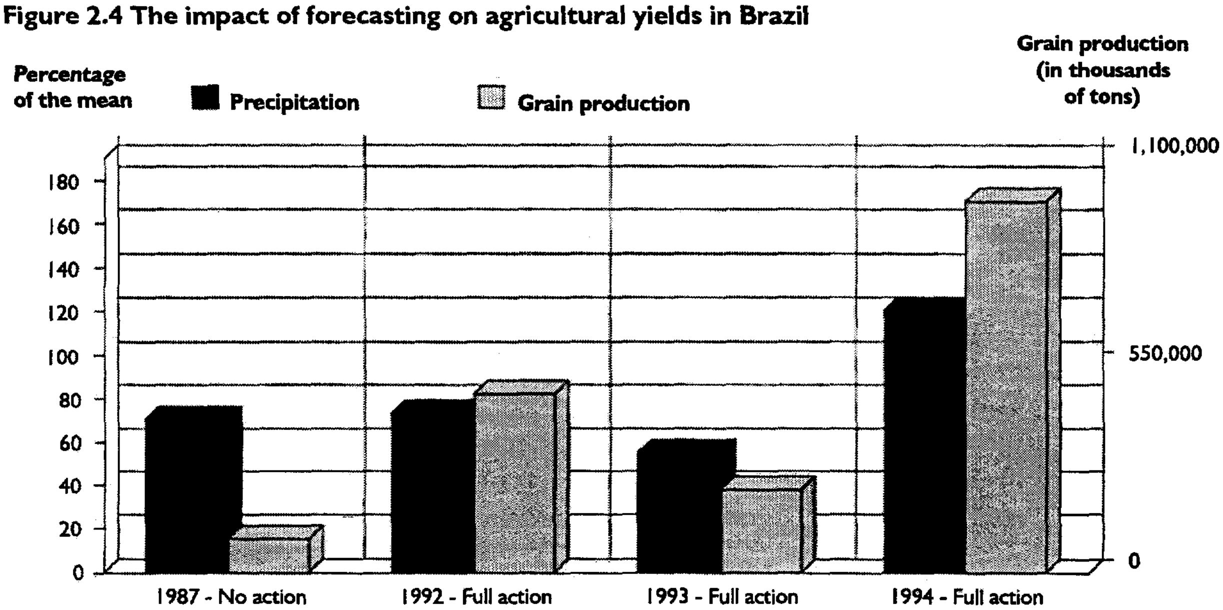
Caution should be used in uniformly extending developed country estimates to the poorest areas in the developing world. Using climate information and forecasting in effective planning efforts, along with early warning systems in many countries, can save a large number of lives and prevent wholesale destruction of property, evidenced by drought mitigation in Southern Africa during the 1997/98 ENSO warm event.[27] However, there is evidence that some problems faced by the poorest people in developing countries cannot be significantly altered using improved information systems. Kates has assembled several data sets for the poorest populations in Africa to illustrate the difficulty of adaptation in the developing world.[28] Two effects are worth noting. First, systematic structural problems in government policies and institutions can deter the positive effects of improved information. And, second, the ease with which markets bring the use of improved information at almost no cost to farmers, ranchers, and fisherman does not hold true in the poorest areas of the world.

To present a more complete picture of the benefits of climate information and forecasts in developing countries, we provide two concrete examples of simple benefit studies:

1) One qualitative example is the use of climate forecasts in agricultural production in northeast Brazil. Yields and precipitation have been compared for the years 1987 and 1992–94 (see Figure 2.4). In 1987, severe drought in northeastern Brazil corresponded to low yields. It was a year in which no forecasting was available. By comparison, in the early 1990s forecast information was accessible and used in production decisions. This comparison illustrates that yields were higher in the years with available forecast information. Moreover, during years with above-normal rainfall, yields increased substantially. This suggests the possibility that climate information can be used to identify and take advantage of opportunities, not just to alleviate losses from adverse extreme events. However, rainfall is not the only variable affecting production. Other important contributing factors include government agricultural policies, prices of other agricultural inputs, availability of insurance mechanisms, and ability of subsistence farmers to utilize forecasts, among others.[29]
2) Harrison and Graham[30] provide another example of the value of forecasting in developing countries. In an international project to develop applications of seasonal forecasting in Southern Africa, they found that the regional potential annual value of those forecasts is on the order of US$100–$1,000 million, which compares very favorably to the associated annual costs of around US$5 million.

To summarize, the value of climate information and forecasts can be quite high in many areas of the world—households and firms can directly benefit. The pattern of benefits is uneven, varying across different regions, sectors, and times. Improved information has a high potential use in disaster mitigation as well as economic production in sectors such as agriculture, forestry, and transportation, where production can be tailored more closely to the vagaries of weather using improved forecasts and other information products.

Figure 2.4 The impact of forecasting on agricultural yields in Brazil



Note: Figure 2.4 shows grain production in northeast Brazil related to rainfall, in several years.
This figure is based on preliminary research. For more information on northeastern Brazil's use of ENSO-based forecasts, see National Research Council. *Making Climate Forecasts Matter*, Report of the Panel on the Human Dimensions of Seasonal to Interannual Variability, Washington, D.C.: National Academy Press, 1999.

3 Lessons from the Bank's 1997/98 El Niño Lending

Chapter 1 outlined the widespread damage the 1997/98 El Niño caused all over the world. The World Bank assisted in El Niño prevention and reconstruction efforts in eight countries, providing loans ranging from US$5 to $150 million, for a total amount of US$358.6 million. The geographic distribution of the loans reflects the global nature of El Niño. Five of them went to Latin America, two to Africa, and one to East Asia. The emergencies, which resulted from both El Niño and the subsequent La Niña, included floods, droughts, and frost.

Details on the loans and the ENSO impacts in the recipient countries are shown in Table 3.1. One of them, the Peru El Niño Emergency Assistance Project, is presented in more detail in Box 3.1.

The main instrument of Bank assistance was emergency recovery loans. Intended to restore assets and productivity after a major disaster, they use abbreviated procedures to ensure a rapid response. These loans may be exempt from performing, among other things, a full economic evaluation and environmental assessment. Emergency recovery loans can have three major foci. First, the rapid rebuilding of economic, social, and physical systems within a limited period, normally three years. Second, strengthening management and implementing capacity. Third, instituting such measures as early warning systems or disaster-resilient technology to prevent or mitigate the impact of future emergencies. A mixture of all three elements is found in the eight El Niño assistance loans.

Table 3.1 The World Bank's 1997/98 El Niño emergency recovery loans and their context

	LOAN		*IMPACT*			
Country	*Loan (million US$)*	*Board date*	*Type of ENSO impacts*	*Mortality*	*Persons affected*	*Direct structural loss (million US$)*
Argentina	42	1/98	Flood	-	290,000	3,000
Bolivia	25	4/98	Flood, drought	135	-	1,200
Ecuador	60	12/97	Flood	280	96,533	2,538
Guyana	9	10/98	Flood, drought	-	34,523	-
Kenya	40	7/98	Flood	6,562	-	11
PNG	5	4/98	Drought, frost	-	1,200,000	-
Peru	150	11/97	Flood, drought	295	350,000	3,600
Uganda	27.6	5/98	Flood	552	50,000	-

Note: Losses are only those reported by humanitarian assistance groups, not necessarily total losses.
–: No data available.
Sources: World Bank project documents and Sponberg, K., *Compendium of Climate Variability* (Draft), Silver Spring, Maryland: NOAA Office of Global Programs, 1999.

Box 3.1
The Peru El Niño Emergency Assistance Project

The 1997/98 El Niño was first detected in May 1997. The magnitude of the event mirrored the devastating 1982/83 El Niño, which resulted in US$1 billion of damages in Peru. Based on this experience, the government quickly decided to take early steps to reduce the impact of the disaster, which was expected to include heavy rainfall and flooding in the northern coastal areas with extensive damage to electricity, roads, schools, hospitals, housing and other infrastructure services, and drought conditions in the Andean highlands, with shortages of food and forage for humans and livestock alike.

In September 1997, the government of Peru requested assistance from the World Bank to assist in the emergency. In November, the Bank's board approved a US$150 million loan for an El Niño Emergency Assistance Project, which was complemented with US$150 million from the IDB and US$100 million from the Peruvian government. The objectives of the project were to:

- Reduce the loss of human life and deterioration of living standards that may result from the floods and/or droughts caused by the 1997/98 El Niño event
- Minimize the loss of, or damage to, economic and social infrastructure
- Enhance institutional capacity to forecast and respond to future El Niño phenomena.

The project consisted of three phases. First, a prevention phase, including flood protection and drought mitigation measures. Second, a limited emergency phase. These first two phases cost about US$50 million. The third phase, estimated at US$339 million, includes reconstruction of key public infrastructure, resettlement of families from flood-prone areas, and a rural works program. In addition, the project provides support for the preparation of a comprehensive strategy for disaster forecasting and management and assistance to improve Peru's capacity to forecast and respond to future climate-related disasters. These components will cost only US$6.9 million, but are considered very important to prevent or reduce damage from future disasters, and promise a high rate of return.

The forecasting component is aimed at strengthening the capacity of several Peruvian institutions (including the Meteorological and Hydrological Service, the Geophysical Institute, and the Marine Institute) to forecast regional climatic changes and respond to local impacts of El Niño. Project components include acquisition of equipment to monitor Peru's atmosphere, hydrology and ocean, computer equipment, and training, including numerical modeling courses and exchanges with foreign institutes. In May 1999, a seminar was held at the World Bank, where several representatives from the Bank, the Peruvian government, and the institutes involved discussed these proposals with experts from various branches of U.S. NOAA, invited by the NOAA Office of Global Programs. This is a good example of the role the Bank could play in facilitating collaboration and bringing together government, local forecasting institutions, and the international scientific community.

Prevention, emergency, and reconstruction

The objective of the eight loans was to help affected countries minimize the impact of the El Niño weather anomalies. This was achieved through a mix of prevention, emergency assistance, and reconstruction measures, with a clear emphasis on reconstruction. Still, most loans also included a preventive component. Two of the loans (Ecuador and Peru) were requested in September 1997, well in advance of the adverse consequences of the 1997/98 ENSO cycle. The Peruvian government, in particular, had already moved quickly in response to the forecasts. Both these two loans contained a range of preparatory measures to mitigate El Niño's impact. Flood prevention measures included river dredging, strengthening of river defenses, bridge strengthening, construction of temporary housing, and protection of archeological sites, while drought prevention consisted of water management measures such as the rehabilitation of wells, pumps and small irrigation systems, production of forage to mitigate the effects of a drought on livestock, and seed production programs to ensure the availability of seed for the next planting season. Four projects (Argentina, Bolivia, Guyana, and Papua New Guinea [PNG]) were started somewhat later, but still contained some damage prevention, while the two African loans only responded to the disaster after it had happened.

The World Bank traditionally leaves the actual emergency phase to other international organizations, such as the United Nations, and bilateral donors. However, in this case several of the loans did include some provisions for essential equipment, such as bailey bridges and temporary power plants required for managing an emergency response.

The main component in all the El Niño loans is the reconstruction phase. In the case of flood damage, this may include rehabilitation and reconstruction of public infrastructure such as roads, bridges, irrigation and drainage systems, river defenses and embankments, water supply and electricity, health facilities, and schools. In the case of a drought, it may include drilling of wells, rehabilitation of small irrigation systems, building earthen dams for preserving water, and procurement and distribution of seeds and other activities to ensure the regeneration of agricultural productive capacity for the next growing season.

In both the prevention and reconstruction phase, most El Niño loans were multisectoral, including, for example, infrastructure, water supply, drainage, irrigation, and health and education facilities (see Table 3.2). The two African loans have a relatively narrow scope: they deal mainly with transport infrastructure. The loan to PNG stands out because of its rural works program, which at the same time enhances the participation of rural communities in the maintenance of rural infrastructure and provides employment income to prevent food scarcity during emergencies, such as this El Niño's drought and frost. A similar program was also included in the drought component of the loan to Peru.

Improved disaster management and forecasting

Apart from prevention and reconstruction related to the current disaster (in this case the emergencies caused by El Niño), emergency recovery loans may also include components to prevent or mitigate future disasters. The Bank's Operational Policy on emergency recovery lending (OP 8.50) provides that:

> *"(Emergency recovery projects) include emergency-preparedness studies and technical assistance on prevention and mitigation measures, to strengthen the country's resilience to natural hazards or lessen their impact..."*

Improved disaster management can involve a range of technical, institutional, and behavioral adjustments. In addition to the introduction of climate forecasting, this may include the improved maintenance of structures, their redesign according to disaster-resilient standards, and the use of insurance and other risk pooling techniques.

The scope of future disaster preparedness and forecasting capacity building in the El Niño loans varies considerably. Table 3.3 presents an overview of the timing of the response to the current El Niño, and the attention to future capacity building in the eight El Niño loans. In the projects in Argentina, Peru, Ecuador, and PNG, improving future disaster management capacity is an explicit development objective. In Peru and Ecuador, the development objectives also include improvement of local forecasting capacity. Two projects (Bolivia and Guyana, both with limited attention to future capacity building) mainly refer efforts for future disaster mitigation to other projects, and point out the need to plan for such measures in the Bank's

Table 3.2 El Niño loans: Sectors involved in prevention and reconstruction efforts

Country	*Prevention*	*Emergency/reconstruction*	*Mixed*
Argentina	Transport infrastructure Health/education facilities Drainage Water defenses Emergency relief goods	Transport Infrastructure Water supply Health/education facilities Drainage Water defenses Sewerage Housing/resettlement	
Bolivia	Transport infrastructure Water supply Drainage Water defenses Emergency relief goods	Transport Infrastructure Water supply Health/education facilities Drainage Irrigation Water defenses Power supply Agriculture supplies	
Ecuador			Transport infrastructure Water supply Health/education facilities Drainage Irrigation Water defenses Electricity Sewerage Housing/resettlement
Guyana			Water supply Drainage Irrigation
Kenya		Transport Infrastructure Water supply Health/education facilities	
PNG			Transport Infrastructure Water supply Health/education facilities Drainage Irrigation Sewerage Agriculture supplies Rural Works
Peru	Transport infrastructure Water supply Drainage Water defenses Housing/resettlement Agriculture supplies Archaeological Sites	Transport Infrastructure Water supply Health/education facilities Drainage Irrigation Water Defenses Power supply Housing/resettlement Rural Works	
Uganda		Transport Infrastructure	

Note: For some loans, prevention and reconstruction were hard to separate, their sectors are listed under **Mixed** in the table.
Source: World Bank project documents.

Table 3.3 El Niño loans: Timing of response and future capacity building

Country	*Timing of response to current disaster*	*Addressing future disaster management capacity*	*Addressing future forecasting capacity*
Argentina	During	Yes*	Yes
Bolivia	During	Yes	Yes
Ecuador	Before	Yes*	Yes*
Guyana	During	Yes	Yes
Kenya	After	No	No
PNG	During	Yes*	Yes
Peru	Before	Yes*	Yes*
Uganda	After	No	No

Note: Table 3.3 shows the timing of the response to El Niño in the eight countries receiving World Bank loans, and the extent to which the loans address future disaster management capacity and forecasting capacity.
* These items were mentioned as explicit development objectives of the projects.

country assistance strategy. These loans, but particularly the African ones, were deliberately kept simple to increase the chances of a quick and successful implementation. Disaster management components may have been considered to be too complex to be included in the emergency operation. Other loans, in contrast, did include institutional support to improve disaster management capacity, the development of a disaster management strategy, or agricultural research to improve drought preparedness.

Some loans contained specific subcomponents to improve the ability of the country to forecast and monitor the effects of future El Niño episodes. These include specialized monitoring and computer equipment as well as technical assistance and training. Such investments are usually channeled to the local institutions already in place, such as the national meteorological service and other research institutes involved in climate and weather forecasting and hydrological modeling.

Better maintenance is identified as a key concern and major risk to project sustainability in almost all the project documents.[31] In the past, low standards of operation and maintenance have often resulted in a much lower level of preparedness than envisaged at the project design stage.

From the available documentation it was not possible to determine the design standards applied for the substantial reconstruction work or whether future disaster risk was factored in. Only the Uganda project provides for a technical audit of the road network (the area of investment) to determine the adequacy of standards in the future. Additionally, none of the projects explicitly addresses the fact that sensible reconstruction involves more considerations than just design standards. In some instances, the very location of a road or facility might have to be reconsidered.

It should not be surprising that insurance and other risk pooling schemes were not included in any of the surveyed loans. Such schemes require a fair amount of financial expertise, the development of which may well have gone beyond the scope of an emergency operation. But the Bank's encouraging initial experience with crop insurance suggests that extending these techniques to El Niño-related hazards may be a worthwhile consideration for the future.

Accounting for implementation capacity

An important limiting factor for successful emergency reconstruction projects is the implementation capacity of the borrower and its executing agencies. This issue, which was brought up in many of the project documents, is the main reason why the loans in Uganda and Kenya, and to a certain extent Guyana and Bolivia, were kept as simple as possible, and why improved disaster management and forecasting capacity building were not addressed in the two African loans. As stated in the Bank's Operational Manual, GP 8.50, this is consistent with Bank practice on emergency recovery loans:

> *Multiple objectives and major innovations have proved counterproductive when previous levels of production and economic activity are to be restored speedily after a disaster.*
>
> *To be successful, an emergency recovery loan must match needs with available resources, coordinate efforts, and fall within the country's implementation and institutional capacity, bolstered if necessary by outside technical support.*

However, while the approach chosen in the two projects in Africa is consistent with the general philosophy of emergency lending, it also requires that the development of forecasting capacity and improved disaster preparedness be taken up elsewhere in the lending program, perhaps through a special disaster management project.

Climate information and the El Niño loans

On the basis of the project documents, for the various loans the authors roughly assessed:

- The use of forecasting in the project itself and the extent to which preparatory measures were taken to prevent or mitigate the disaster
- The attention to future disaster preparedness
- The attention to future forecasting capability and early warning systems.

Then comparison was made of those assessments with general information about the country, including its level of development, the type of climate risks it faces, and the local strength of the ENSO signal for forecasting purposes. This analysis led to the following observations:

First, the use of forecasting to plan disaster mitigation is not clearly related to the type of extreme event addressed (mostly flood or drought). While one might think that the advance response to a flood is more difficult, since floods occur much faster and require much larger physical works, responding to droughts appears to be just as difficult.

One of the reasons may be that droughts can develop slowly without a threshold event to trigger a large response. For example, in Guyana the project documents mention that

> *The fact that the ENSO impact was in the form of a slowly-developing drought also contributed to the Government's initial measured response.*

Additionally, the use of forecasting was not related to whether the mitigated disaster was really due to the warm El Niño or actually part of the following cold La Niña phase, even though such a link was to be expected considering the longer lead time for La Niña forecasting.

Second, the projects with the highest use of forecasting in the current event also gave the most attention to future forecasting capacity (see Table 3.3). This may have to do with the actual opportunities to forecast ENSO in those regions, but also with the level of awareness about El

Niño and the presence of institutions able to promote and implement forecasting tools.

Finally, there is a clear correlation between a country's general level of development and the utilization of climate information and forecasting techniques. Obviously, a country's general level of development is difficult to establish. As an indication, Table 3.4 displays the per capita GDP and the Human Development Index of the eight countries covered. Kenya and Uganda are the least developed countries according to this measure, and Peru, Ecuador, and Argentina the most developed. This is roughly the same ranking as found with respect to the level of response afforded to the current disaster (advance mitigation or just response), the use of forecasting in the emergency phase, and the attention paid to future disaster mitigation and forecasting capacity.

Table 3.4 GNP and HDI of 1997/98 El Niño loan recipient countries

Country	*GNP/capita (US$, 1997)*	*HDI (1995)*
Argentina	8570	0.888
Peru	2460	0.729
Ecuador	1590	0.767
Bolivia	950	0.593
PNG	940	0.507
Guyana	800	0.670
Kenya	330	0.463
Uganda	330	0.340

Note: The Human Development Index combines data on adjusted real GDP/capita, life expectancy, literacy, and enrollment in education. Values range between zero and one, with a higher number denoting a higher level of human development.

Sources: For GNP data, World Bank, "World Development Indicators 1998," World Bank, Washington, D.C., 1998; for HDI data, UNDP, "Human Development Report 1998," Oxford, UK: Oxford University Press.

4 The Role of Climate Information in Development

Chapter 1 of this paper established the high vulnerability of developing countries to climate extremes. As argued in chapter 2, climate information and forecasting can potentially play a very useful role in reducing this vulnerability. The experience from the Bank's eight El Niño emergency assistance loans of 1997/98 confirms this potential (see chapter 3), but it also makes clear that the development community is still a long way from fully exploiting these possibilities. There are a number of reasons for this, many of which have to do with the relative novelty of the tools and the still evolving efforts to gain experience. This chapter tries to describe the current experience and attempts to provide some insight into what constitutes good practice. It makes recommendations on the scope of climate information and forecasting at project and country level, and on the development of specific forecasting operations. As throughout this paper, the focus is predominantly on applications in the context of extreme events. However, most of the lessons presented below also apply to forecasting of persistent yet modest changes in precipitation and temperature, such as for agricultural purposes.

The role of climate information and forecasting in development

A broad range of development projects is climate dependent and sensitive to climate variability. The list includes agriculture and rural development, water supply, hydropower, coastal development, infrastructure, and emergency assistance, among others. If climate factors are taken into account in the preparation of such projects, this is traditionally done by designing them to withstand historical weather patterns. This practice, if applied properly, is often adequate, although climate change will gradually reduce the validity of past trends and require the complementary use of model predictions.

The main entry point for additional uses of climate information and forecasting is at the portfolio level, particularly in sectors and countries that are known to be vulnerable to climate disasters. The use of forecasting should be initiated in a more strategic context and be based on an overall assessment of a country's vulnerability to natural hazards. Such integrated assessments should cover all natural hazards, climate related or others, and would ideally be carried out as routinely and regularly as the standard analyses of economic risks that are the mainstay of country assessments. A better understanding of natural hazards would in turn encourage the development of comprehensive risk mitigation strategies, which may include such measures as upgrading construction standards, building irrigation and drainage systems, changing to drought-resistant crops, improving governments' disaster-response capacity, and, in some instances, the development of new or improved climate information and forecasting systems.

In other words, the development of climate information and forecasting systems should be embedded in an overall disaster management

strategy in the case of disaster mitigation, or in economic and sector work in the case of sectoral applications like agriculture. In either case, climate information and forecasting would become part of overall country planning and the country assistance strategy, and in that context its merits relative to other pressing needs could be more systematically assessed.
Currently, the momentum to improve a country's forecasting capacity often only arises in the aftermath of a natural disaster. In Peru and Ecuador, for instance, it was the 1997/98 El Niño that provided the impetus and momentum to develop better forecasting capacity. Such windows of opportunity should be utilized to every extent possible.

However, emergency reconstruction projects are insufficient as the sole starting point for investments in a country's forecasting capacity. The emergency recovery loans that tend to be provided in these circumstances have time and implementation constraints that can make it difficult to include forecasting components. Recovery loans are aimed at quickly repairing damage and restoring economic activity. Swift implementation is essential. Forecasting projects, in contrast, require careful preparation, solid capacity and institution building, and expert technical assistance. Depending on the institutions already in place and the implementation capacity of the agencies involved, this can take time. The inclusion of a forecasting component in an emergency loan may then either compromise the quality of that component or slow down the implementation of other loan components.

Preparing forecasting projects

Despite more than 10 years of experience, applications of climate information and forecasting are still relatively new, particularly in developing countries. Although one can propose some general initial considerations for forecasting projects, such as outlined in Box 2.1, there is no standard prescription of how to implement a forecasting project. Different solutions are required in different circumstances. Nevertheless, a few general observations can be made.

Tailor projects to country circumstances

Perhaps the most important lesson learned from past experience is to be flexible wherever and whenever possible. It is tempting to use a country or regional experience with an information system as a prototype for direct application to another region or country. Yet forecasting projects are strongly situation specific, and project designs vary depending on the envisaged application, the type of forecast, the strength of the physical signal, and the institutions involved.

The regions with the strongest signal for climate variability are among themselves highly dissimilar. They have different infrastructure capacity, telecommunication systems, educational systems, and professional skills. Their natural endowments are different, as are their institutional approaches to sharing information and working together with neighboring countries. And they will have different expectations from and uses for climate information and forecasting. Climate information and forecasting projects need to be tailored to the specifics of the problem at hand.

Institutions are crucial

A lot of information is gained from global climate modeling. These facilities predict ENSO as well as the effects of ENSO and other ocean/atmospheric interactions on global climate. However, it is at the subregional and national to local levels that the association between vulnerability and climate extremes is best understood. Strong subregional, national, and local institutions are therefore key and need to be fostered for short-term monitoring, data collection and dissemination, and the provision of extension services.

Good institutions are also important for the dissemination and final use of climate information, and projects need to be sensitive to national policies that may work as barriers to effective use of such information. Insufficient access to micro-credits, for example, may prevent poorer farmers from taking full advantage of forecasts. Overlapping policies based on level of governance (local, state, and national) may dictate when reservoir managers make water supply decisions in ways that are at odds with the timing of the provision of climate information. However, while strong institutions are an important factor in designing investments in forecasting systems, their relative absence should not discourage investments. What is important, though, is that forecasting schemes are designed in accordance with local capacity. In countries with little capacity, there may be opportunities to start small, and gain benefits from relatively modest investments. In countries with forecasting institutions in place, more elaborate programs may be worthwhile.

Be responsive to client needs

Establishing credibility is essential when initiating and expanding climate information and forecasting systems. The best way of guaranteeing good returns on investment in climate information is to clearly identify the needs of the clients. Often existing information can be converted into a form that meets the needs of the users. Currently, reported model results, indices, and statistics are manifestations of previous user requests and do not cover the innumerable ways for reporting climate information.

Promote regional collaboration

Climate information and forecasting lends itself to regional applications. Over the course of several years of regional collaboration, joint benefits have already been realized by many countries that are served by coherent, well-designed regional systems. Although the Bank is mostly confined to working with national governments, there are good reasons to systematically explore opportunities for regional collaboration. The impact of climate variability is seldom restricted to one country. And even if a country is not impacted directly, it may feel economic consequences of disasters elsewhere.

Additionally, there are substantial operational benefits. There are economies of scale in the modeling of climate forecasts, and strong interdependencies between countries in the collection of data. Investments in regional systems may boost capability in several client countries, raising the base of capability throughout the region in a more cost-effective fashion than is feasible from direct investments in individual countries. Once the base of capability is established in the region, additional investments to individual countries can further improve their ability to use climate and related sectoral information designed to help boost economic growth and development.

The role of the Bank

The Bank can play an important leadership role in helping developing countries to take full advantage of the benefits of climate information and forecasting. This chapter outlines pragmatic ways to achieve this goal and improve the Bank's own capacity in this area. Some of the steps can be accomplished relatively easily in the near term, while others require more investment and a longer planning horizon to implement.

In a limited manner the Bank already uses "climate information" in, for example, understanding seasonal conditions for crop production. But it is not taking advantage of the most the recent technologies and information. Therefore, where it makes sense, the Bank could more effectively use climate information and forecasting in its policies and programs. This means integrating climate information and forecasting in regular bank work. To do this, a four-step strategy is proposed.

The first step of this strategy is to build experience and understanding by organizing existing practical experience and stimulating further learning. Several analyses can be undertaken to increase our knowledge about climate information and forecasting:

- Track current loans that incorporate climate information and forecasting components. As a part of this effort, the institutional response both with the Bank and the client country can be evaluated to reveal conditions that facilitated (or impeded) the use of climate information and forecasting for informed decisionmaking
- Design and test performance indicators for climate information and forecasting investments
- Develop a better understanding at the project level of the costs and benefits of climate information and forecasting investments by the World Bank
- Conduct hindcasting studies to evaluate the benefits that could have been gained if specific investments had been made, given past actual climate variability and economic conditions.

The second step entails pilot projects (or project components) to gain hands-on experience. Areas where pilots may be particularly fruitful and at the same time help to meet Bank objectives include:

- East Africa (for example, Ethiopia, Kenya, Tanzania, and Uganda) for problems related to food security and constrained agricultural production
- West Africa (for example, Mali or Senegal) for problems such as drought and flood that endanger food security
- Central and South America (for example, Ecuador, Honduras, Mexico, and Nicaragua) for problems such as floods and mudslides. National investments can be made that take full advantage of existing regional monitoring and response networks
- South Asia (for example, Bangladesh) for periodic flooding and other associated problems that lead to unusually large loss of life and disruption of agricultural production.

The third step is capacity building, both inside and outside the Bank. The use of climate information and forecasts requires strong local institutions, well-functioning procedures for information dissemination, and the trust and motivation of end-users. Assisting developing countries in creating this institutional environment is perhaps the most pertinent role the Bank can play in promoting the use of climate information and forecasting. To be able to do this, the Bank would have to increase its own internal capacity through training, knowledge management, and the development of a code of good practice. Awareness about forecasting opportunities could be raised among World Bank staff, so that they can be incorporated in more Bank projects. Experience and knowledge could be shared across thematic groups, central units, and regions.

As a fourth step, the Bank could intensify its dialogue with the scientific community (for example, the WMO, NOAA, and the IRI) and seek partnerships with regional and international centers of excellence. This effort could build on existing contacts.[32] It would help the Bank in keeping abreast of scientific developments and—consistent with the vision of the Bank as a knowledge bank—would contribute to global information sharing and the exchange of experience.

5 Conclusion

Many developing countries are highly vulnerable to extreme weather events and climate variability (and ultimately to climate change). In the wake of the 1997/98 El Niño event, the international development community has become increasingly aware of this vulnerability.

The Bank has a tradition of assisting client countries with reconstruction after a natural disaster. Over the last 10 years, the Bank has provided some US$9 billion in emergency recovery loans to countries affected by natural disasters. Recognizing that such a purely reactive strategy is no longer enough, the Bank is now starting to promote more comprehensive and proactive ways of disaster prevention and risk mitigation. These efforts are only just beginning, and the current practice is still wanting in many respects.

The effective use of climate information and forecasting should become an integral part of this emerging approach to improved disaster management. Our understanding of the climate system and the ability to monitor and forecast weather events has increased dramatically over the last few years, and further progress can be expected. Forecasts of many phenomena can now be produced at a timescale, reliability, and spatial resolution that make them useful for planning purposes and worthy of investments. The forecast of ENSO events is a good example, but it is not the only one.

Good climate information is now widely available in many forms, including electronic dissemination on the internet. Still, many challenges remain. As with all knowledge-intensive processes, the mere generation of information is not enough. Information also has to be transmitted to end-users and put in a form that is relevant to them. And end-users must have the technical, institutional, and financial capacity, as well as the incentive, to use it effectively. The Bank can play a useful role in helping to build this capacity, bridging the gap between knowledge providers and interested governments, and setting up partnerships between the international science community, regional and local experts, and governments.

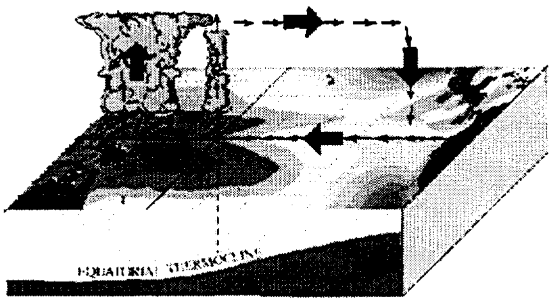
Projects like the Peru El Niño Emergency Assistance Loan are good examples of how such partnerships might work. But such projects have been few and circumstantial. Options to use climate information and forecasting are not systematically explored. To be able to capitalize on the available tools, climate information and forecasting should be imbedded into an overall risk management strategy for disaster mitigation and explored in economic and sector work for sectoral applications like agriculture. To this end, the Bank would first of all have to raise awareness among its own staff and educate them about the potential developmental benefits of climate forecasting. It would have to build the necessary internal capacity to competently assist client governments, develop project experience and a code of good practice, and intensify its collaboration with the climate scientific community.

In a world of limited resources, investments in climate information and forecasting have to compete with other projects in areas such as education, health, and the environment. How do they compare? Evidently, the areas of application have to be selected carefully and a lot depends on local circumstances, such as the strength of the signal (or, more generally, the quality and accessibility of forecasts) and the capacity and interest of local counterparts. But there are clearly many countries where investment in climate information would yield high returns. Most of the countries hit by the 1997/98 El Niño will be among them. The better use of climate information can have a broad development impact. It decreases the vulnerability and exposure of other development projects, thereby increasing their effectiveness. And it benefits the poor, who are by far the group most vulnerable to natural disasters. In other words, investing in climate information and forecasting can make a direct contribution to poverty alleviation and sustainable development.

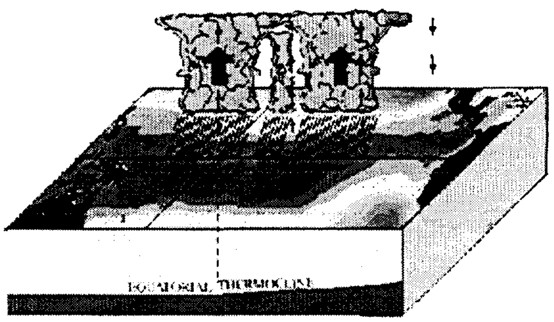
Appendix A
El Niño Southern Oscillation in a Nutshell

Figure A.1 El Niño southern oscillation in a nutshell

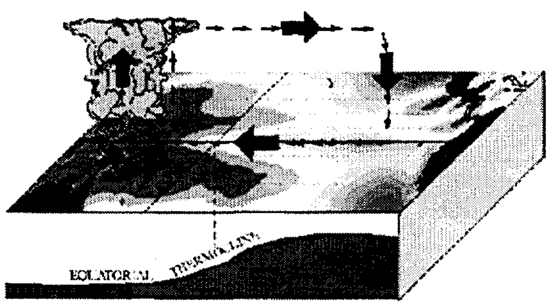
December – February Normal Conditions



December – February El Niño Conditions



December – February La Niña Conditions



The above figure gives a rough depiction of the atmospheric and oceanic circulation during various phases of the El Niño Southern Oscillation. During an El Niño the warm body of water pushes eastward along the Pacific, thereby also displacing convection and associated rainfall further east in the Pacific. As a result western parts of South America experience enhanced rainfall while the western Pacific suffers from dryer than normal conditions. Alterations in the Pacific also affect global circulation patterns. These changes are referred to as teleconnections. During a La Niña event the rainfall pushes farther westward than its normal position. The waters off the South American coast also become cooler than normal.

Appendix B
More Information

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C) Other sources of information

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D) Websites with seasonal climate forecasts

IRI	http://iri.ldeo.columbia.edu/climate/forecasts/net_asmt/
ECMWF	http://www.ecmwf.int/services/seasonal/forecast/

Notes

1. Burton, I., and M. K. van Aalst. "Come Hell or High Water: Integrating Climate Change Adaptation into Bank Work," Environment Department Papers No. 72, The World Bank, Washington DC, 1999.

2. Obviously, *disaster* is a relative term, and the distinction between moderate and extreme climate events is not clear-cut. Moreover, the severity of impacts depends on local factors (for example, soil, irrigation, and drainage conditions) as much as it depends on the intensity of the event itself. Nevertheless, one can think of moderate impacts as small deviations in precipitation and temperature, which may affect, for example, crop yields, fisheries, and the availability of water for irrigation or hydropower. Extreme events, in contrast, entail a sudden and radical shift in weather regime and lead to much higher levels of physical damage and loss of human life.

3. See, for example, Dilley, M. "Reducing Vulnerability to Climate Variability in Southern Africa: The Growing Role of Climate Information," in *Climatic Change*, April 2000.

4. See, for example, Gilbert, R., and A. Kreimer, "Learning from the World Bank's Experience of Natural Disaster Related Assistance," World Bank Disaster Management Facility, Washington, D.C., 1999; and R. Parker, "Natural Disaster, the Knockout Punch: A Policy Implementation Review and Future Strategy," World Bank Disaster Management Facility, Washington, D.C., 1999.

5. These sections draws heavily on Sponberg, K., "Compendium of Climate Variability" (Draft), NOAA Office of Global Programs, Silver Spring, Maryland, 1999.

6. Philander, S. G. "Is the Temperature Rising? The Uncertain Science of Global Warming," Princeton University Press, Princeton, New Jersey, 1998, p153.

7. See, for example, Trenberth, K. E. "General Characteristics of the El Niño-Southern Oscillation," in M. H. Glantz, R. W. Katz, and N. Nicholls, eds., *Teleconnections Linking Worldwide Climate Anomalies*, New York: Cambridge University Press, 1991. For the purpose of clarity and conciseness, the mechanics of the El Niño Southern Oscillation have been extremely simplified in this paper to exclude changes in wind direction, ocean circulation, thermocline depth, and so on.

8. Glantz, M. H. "Climate, Environment, & Disasters: The El Niño Example," presentation at the Conference on Natural Disasters and Policy Response in Asia: Implications for Food Security, Harvard University, Cambridge, Mass., April 30 – May 1, 1999.

9. Sponberg, K., "Compendium of Climate Variability" (Draft), NOAA Office of Global Programs, Silver Spring, Maryland, 1999.

10. These numbers do not include the summer of 1998 flooding in China. The summer floods of 1998 have been judged the worst in nearly 44 years, and there is speculation that the floods were caused by El Niño, although a clear link has not been established.

11. Sponberg, K., "Compendium of Climate Variability" (Draft), NOAA Office of Global Programs, Silver Spring, Maryland, 1999.

12. Fox, J. J. "The 1997–98 Drought in Indonesia," Draft paper prepared for the Conference on Natural Disasters and Policy Response in Asia: Implications for Food Security, Harvard University, Cambridge, Mass., April 30–May 1, 1999.

13. Kasperson and others. "The Social Amplification of Risk: A Conceptual Framework," in S. Cutter, ed., *Environmental Risks and Hazards*, Englewood Cliffs, New Jersey: Prentice Hall, 1994.

14. Burton I., R. W. Kates, and G. F. White. *The Environment as Hazard*, 2nd edition, New York: The Guilford Press, 1993.

15. Clarke, C. L. and Munasinghe, M. "Economic Aspects of Disasters and Sustainable Development: An Introduction," in Clarke, C. L. and Munasinghe, M., eds., *Disaster Prevention for Sustainable Development, Economic and Policy Issues*, Report from the Yokohama World Conference on Natural Disaster Reduction, May 23–27, 1994, The International Decade for Natural Disaster Reduction (IDNDR) and The World Bank, 1995, p. 1.

16. World Bank. Peru El Niño Emergency Assistance Project, Technical Annex. Report No T-7194-PE, World Bank, Washington, D.C., 1997.

17. World Bank. Western Samoa. Emergency Road Rehabilitation Project, Memorandum of the President, Report No P-5943-WSO, World Bank, Washington, D.C., 1993.

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19. "Sea Surface Temperatures (SSTs) have been correlated with long-term normal rainfall patterns for each region using FEWS station rainfall data for 1922–1995," quoted from (http://www.fews.org/imagery/sat_what.html#SSTAnDef). General FEWS information can be obtained at (http://www.fews.org).

20. On the challenges and rewards of using knowledge for development, see *World Bank: Knowledge for Development*, World Development Report 1998/99, World Bank, Washington, D.C., 1999.

21. NOAA. *An Experiment in the Application of Climate Forecasts: NOAA-OGP Activities Related to the 1997–98 El Niño Event*. Silver Spring, Maryland: NOAA Office of Global Programs, January 1999. p. 134.

22. Ibid.

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27. Dilley, M. "Reducing Vulnerability to Climate Variability in Southern Africa: The Growing Role of Climate Information," in *Climatic Change*, April 2000, forthcoming.

28. Kates, R. "Cautionary Tales: Adaptation and the Global Poor," in *Climatic Change*, April 2000, forthcoming.

29. For a discussion of recent research looking at the complex number of factors influencing public decision-making, contact Maria Carmen Lemos at the Latin America Center at the University of Arizona in Tucson.

30. Harrison, M. S. J, and N. E. Graham. "Forecast Quality, Forecast Applications, and Forecast Value: Cases from Southern African Seasonal Forecasts," *Nature* (in submission).

31. This issue is discussed extensively in Gilbert, R., and A. Kreimer, "Learning from the World Bank's Experience of Natural Disaster Related Assistance" (Draft), World Bank Disaster Management Facility, Washington, D.C., January 1999; and R. Parker, "Natural Disaster, the Knockout Punch: A Policy Implementation Review and Future Strategy (Draft), World Bank Disaster Management Facility, Washington, D.C., November 1998.

32. For instance, the WMO has signed a memorandum of cooperation with the World Bank and established a liaison there. U.S. NOAA's Office of Global Programs recently assisted in several World Bank projects, such as the Peru El Niño Emergency Reconstruction Loan and the preparation of this report.

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